TR NEWS

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COVER: Scanning tours have proved a successful strategy for evaluating, adopting, adapting, and disseminating innovative technologies and practices for transportation.

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.

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ALSO IN THIS ISSUE:

COMING NEXT ISSUE

Transportation Education and Training: Focus on Solutions is the theme for feature articles in the July–August issue of *TR News*. Authors examine developments and models for training and recruitment in the various modes and present successful case studies from the public and private sectors.

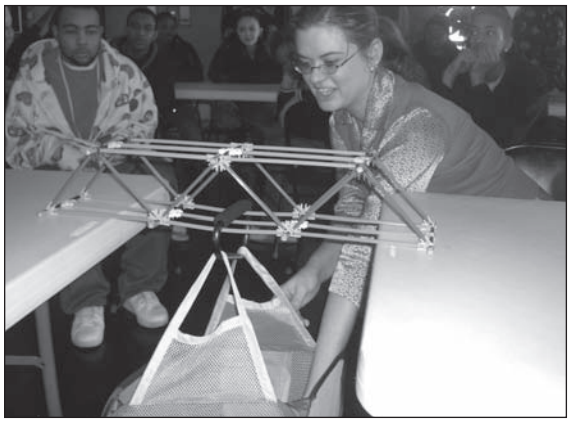


PHOTO: KENTUCKY TRANSPORTATION CABINET

Jennifer McCleve, a volunteer with the Kentucky Engineering Exposure Network (KEEN), helps students test the load-bearing capacity of a model bridge they have constructed. KEEN was developed by the Kentucky Transportation Cabinet to introduce bright, young students to engineering—and has proved successful.

Scanning the Home Front for Transportation's Best Practices

Program Facilitates State Agency Exchange of Information, Technology

CHRIS PORTER

The author is Senior Associate, Cambridge Systematics, Inc., Boston, Massachusetts.

In 2004, the National Cooperative Highway Research Program (NCHRP) proposed a domestic scanning program to facilitate information sharing and technology exchange among state departments of transportation (DOTs) and other transportation agencies and to identify actionable items of common interest. The model for the proposed program was the successful International Technology Scanning Program sponsored by the American Association of State Highway and Transportation Officials (AASHTO), the Federal Highway Administration (FHWA), and NCHRP.

The domestic program would sponsor site visits to different states by groups of transportation professionals who would meet with state transportation agency staff and other practitioners to learn about, document, and disseminate information on current practices of interest and importance. In July 2005, NCHRP completed a business plan for the program, establishing a template for the management and conduct of individual scans (*1*).

The following January, NCHRP awarded an initial contract to a consultant to conduct two pilot scans and to evaluate the benefits and lessons learned. The topics selected for the two pilot scans were

Don Toner (*left*), ROW Administrator for Texas DOT's Austin District, briefs the scan team on ROW and utilities relocation procedures.

Texas DOT's accelerated procedures to relocate utilities for the State Highway 130 project in Central Texas was a main topic of study for the pilot domestic scan team. The procedures allowed property acquisition, design, and construction to be undertaken simultaneously.

- Transportation asset management; and
- Right-of-way (ROW) acquisition and utilities relocation.

The pilot scans were conducted that summer, and reports were published in December 2006 (*2, 3*). An evaluation of the pilot scans was completed in June 2007 (*4*).

The pilots demonstrated that a domestic scan program could be valuable in assisting transportation professionals to improve the state of practice in the United States. NCHRP therefore has allocated additional funding of $1 million for the domestic scan program during Fiscal Years 2008 and 2009.

Program Objectives

Through continuing innovation, U.S. transportation agencies have produced substantial benefits to the nation—for example, through new materials for pavements and structures, new ways of collecting and analyzing information about transportation system users and the environment, and new ways of funding improvements in public safety and in the efficiency of travel. Personal contact with new ideas and their appli-

John Griffith, Administrative Engineer, Minnesota DOT, narrates a tour of the reconstruction of the I-494 corridor during the scan team visit.

cations is a key to the exchange of information. In the past, U.S. transportation professionals have visited colleagues in other countries and have returned with information that they have communicated to domestic colleagues, who have applied the new knowledge and techniques to improve domestic practice.

These experiences have shown that the scan approach is productive, encouraging the spread of information and innovation. Many participants in the international program have noted that new ideas are emerging in state and local transportation agencies around the United States and that faster dissemination could yield similar benefits.

Effective scan programs supplement and make use of a variety of mechanisms for information exchange—such as trade and professional journals, conferences, and peer-to-peer forums. The core of a scan program, however, is the face-to-face discussion of current experience, providing opportunities for a unique exchange of information that is difficult or impossible to replicate through written materials, telephone conversations, and e-mails. The informal discussions yield useful, practical information drawing on the participants' observations and experience.

Program Design

A scan program recruits knowledgeable people who complete four key tasks:

1. Identify novel practices in their field;
2. Assess the likelihood that these new ideas might yield benefits in other settings;
3. Select the new practices that offer the most promise, arrange field visits to observe the practices, identify any issues relating to development and application, and assess appropriate opportunities and methods for technology transfer; and
4. Document the results for use and application.

The domestic scan program covers a range of topics, including any innovative practices of high-performing transportation agencies that can be adopted to benefit other interested agencies. The program includes regular cycles of topic selection, scans, and documentation. AASHTO committees solicit ideas for scan topics, and an NCHRP project panel selects the topics.

Working with AASHTO and NCHRP staff, the project panel appoints two cochairs for each scan. Each scan tour includes 8 to 16 participants from state DOTs, FHWA, and sometimes other agencies. AASHTO committees and FHWA program staff solicit nominations and select the participants—usually senior and midlevel staff who have

- Sufficient experience in the topic area to ask probing and insightful questions;
- A track record of working to implement innovations within their own agency and of communicating with peers at other agencies through participation in professional activities;
- Enough time remaining in their careers to communicate the innovations and knowledge gained from the tour within their professional communities; and
- Contributions to make to the mix of the group, in terms of state or agency context (e.g., geographic location, urban or rural, small or large); professional

PHOTO: MINNESOTA DOT

The scan team viewed implementation of the Minnesota DOT's ROW and utilities relocation procedures for Phase 2 reconstruction on I-494, west of Minneapolis.

background; non-DOT or DOT perspectives; and racial, ethnic, or gender diversity.

A subject matter expert guides each scan, researching the potential agencies and sites to visit, leading discussions with the host agencies, and completing a report on the scan findings. A consultant hired by NCHRP assists the subject matter expert by managing the program, taking care of administrative and logistical details, and contributing to the documentation.

The scan tour is an intensive process. Each tour spans a one- to two-week period of visits to two to six geographically dispersed sites. The group typically spends one to three days at each site, visiting up to three sites in the course of a week. Meetings are held with host state DOT staff and sometimes with other local agencies. Field visits also may be scheduled. The tour participants hold daily debriefings, which are critical to capturing the lessons learned.

Documentation of the scan findings takes two principal forms:

- A report, including a formal summary and detailed description of the findings; and
- A PowerPoint presentation, for the participants to use at conferences, meetings, and internal briefings.

In addition, each participant prepares a personal implementation plan identifying specific initiatives to explore within his or her own agency, as well as upcoming opportunities for sharing the findings with larger audiences. These communication and implementation activities ensure that the scan program has a widespread impact on improving transportation practice.

Participants also complete evaluations of the scan and, six months after the tour, report on their implementation activities. This helps NCHRP gauge the impacts of the program and improve future scans.

Asset Management Scan

The pilot scan of transportation asset management set out to identify best-case applications of principles and practice. During two separate weeks, the scan team met with representatives of six state DOTs—Florida, Michigan, Minnesota, Ohio, Oregon, and Utah—as well as with staff at regional and local agencies and at asset management organizations in those states. The 11-person scan team included 5 state DOT officials, 4 FHWA officials, a university professor, and a consultant.

The agencies on the tours were at different stages in applying asset management to the transportation decision-making process. Michigan DOT and Ohio DOT, for example, displayed a comprehensive and sophisticated approach, integrated throughout their organizations. Other agencies, such as Oregon DOT and Utah DOT, have not yet reached a comparable level but have adopted innovative and successful approaches that will progress toward that goal in the next few years. The following observations derive from the experience of agencies at different stages of development in asset management.

The scan team at a briefing by Florida DOT staff: (*left to right*) Donald Jackson, FHWA Value Engineer and Utility Program Coordinator; and scan Cochairs John Campbell, Texas DOT, and Susan Lauffer, FHWA Office of Real Estate Services (now retired).

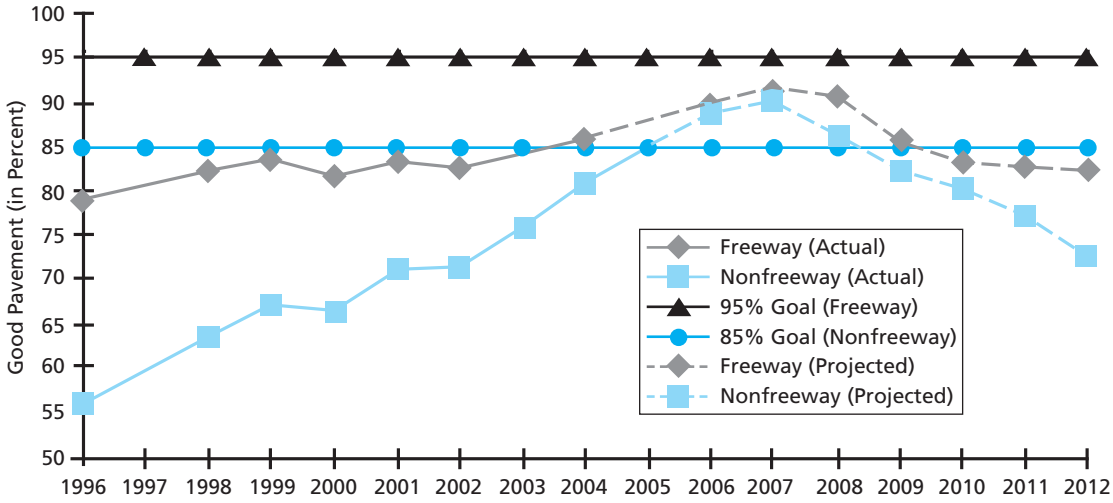
Investment Priorities

- **The agencies adopted a preservation-first strategy in determining priorities for investment**. In many cases, however, this strategy has raised concerns about reducing congestion and about creating new road capacity to handle population and employment growth.
- **In each case, the success of the asset management process was directly linked to the actions of an asset management champion or champions within the organization.** Until asset management became a standard operating procedure of the agency, the role of a champion was critical.
- **In several cases, the asset management process and the information that justified investment in the road system were instrumental in securing additional funds from the legislature.**
- **The most successful asset management has moved away from a worst-first investment strategy to adopt principles based on life-cycle costs that identify the most cost-effective preservation and maintenance strategies.** Although this concept can be difficult to explain to elected officials and to the general public, it provides a defensible and effective approach to infrastructure stewardship.

Performance Measures

- **The most successful asset management processes included performance measures that guided investment decisions throughout the organi-**

FIGURE 1 Pavement Condition in Michigan, 1996–2012



zation. Performance measures have become important in system monitoring; in one case, performance measures were used for annual personnel evaluations.

◆ **Scenario analyses that show the consequences in terms of performance measures were effective in convincing decision makers of the need to invest in the transportation system.** With the use of management systems, engineering analyses, and deterioration curves, agencies are able to show the expected conditions of pavements and bridges at different levels of investment.

Organizational Issues

◆ **No one organizational model defined asset management.** The scan found many different successful organizational models. Perhaps the most important organizational characteristic from the case studies was the team approach to defining and implementing asset management.

◆ **In almost all cases, the implementation of asset management fostered communication among different organizational units**. Many participants agreed that the cross-organizational coordination necessary for asset management has improved the effectiveness of the agency's planning and decision making.

◆ **Conducting an organizational self-assessment is a key starting point in implementing asset management**. Most of the DOT representatives identified AASHTO's *Asset Management Self-Assessment Guide* as a useful tool.

◆ **The application of risk analysis techniques to asset management was seldom observed.** Risk assessment allows transportation officials to determine the economic costs of infrastructure failure and to incorporate these costs into analyses. Other countries have adopted formal procedures for risk assessment. The approach will likely become part of U.S. asset management practice in the coming years.

Data Collection

◆ **In several cases, agencies viewed data as an asset and data collection as important for decision support.** The agencies that were visited valued high-quality data and cost-effective data collection, periodically verifying that the right data were being collected for the decisions that had to be made.

◆ **In several cases, the asset management process was customer-oriented.** Several agencies surveyed users of the road system to determine which aspects of infrastructure maintenance and condition were most important.

◆ **New technologies can make data collection for asset management more cost-effective and efficient**. Portable computer laptops combined with Global Positioning Systems, for example, can be used to collect condition data on the road network.

◆ **Agencies should document their performance measures and criteria, whether maintenance activities are performed in-house or through a private contract**. Some of the agencies used private contractors for long-term maintenance services—which they termed asset maintenance practice; others primarily relied on their own workforces.

The results of Michigan DOT's system preservation efforts since 1996 are shown in Figure 1. Although pavement conditions have improved significantly in the past 10 years, deterioration is expected unless investments can increase.

Right-of-Way and Utilities Scan

The second pilot scan sought to identify, document, and disseminate innovative state practices in acquiring ROWs and in relocating utilities to support the timely and cost-effective completion of projects.

ROW acquisition is the last step before construction and often is perceived as delaying a project's advertising and construction. Relocating and adjusting utilities also is critical to project development. In addition, rising real estate values, rapid property development in the planned project corridors, complications in relocating utilities, and concerns about private property rights have delayed transportation projects in many areas. Transportation agencies are realizing that ROW acquisition and utilities relocation can be expedited without compromising federal and state protections for property owners, tenants, and utilities.

The scan team consisted of 15 transportation professionals, including 9 state DOT officials from ROW and utilities offices, 4 FHWA officials, and 2 consultants who served as facilitators. The group visited three leading state agencies during one week:

- The Florida DOT District 5 Office in Central Florida;
- The Texas DOT Texas Turnpike Project Office in Austin; and
- Minnesota DOT in Minneapolis–St. Paul.

The scan team found that the states had improved their right-of-way acquisition and utilities relocation processes successfully, but no single "silver bullet" approach emerged that can be applied throughout the country. Instead, a range of tools and techniques may be adapted to different statutory, political, cultural, and geographic contexts.

Shared Traits

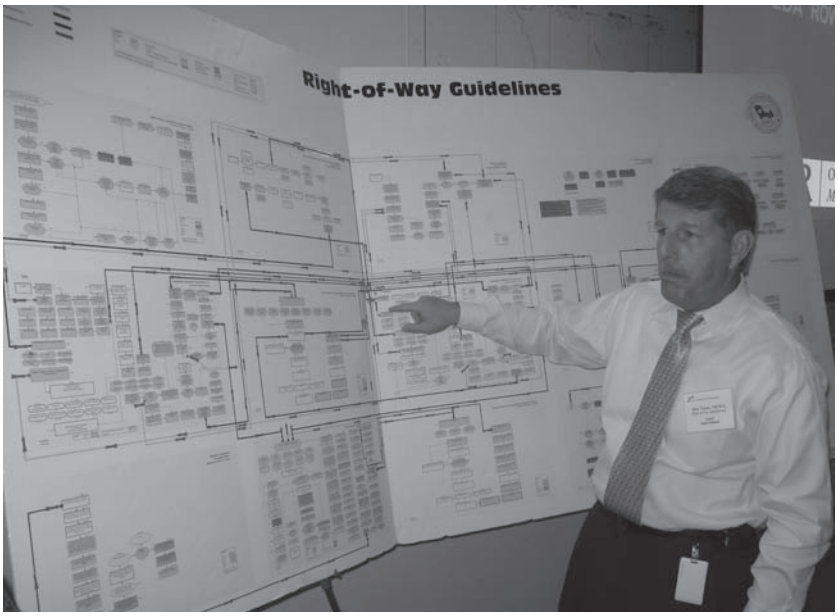
The team identified several traits that the three states shared:

- **A commitment to creating a supportive institutional environment.** ROW and utilities staff in all three states had the freedom to try new techniques and develop new processes, instead of having to adhere to established procedures and practices. In each case, upper management fostered a team approach.
- **A focus on process.** The experiences of Florida and Texas DOT demonstrated that explicit timelines and benchmarks, delegation of decision-making authority, colocation of major participants, and the use of conflict resolution techniques are effective in ensuring the timely performance of critical-path tasks, without delaying the process.

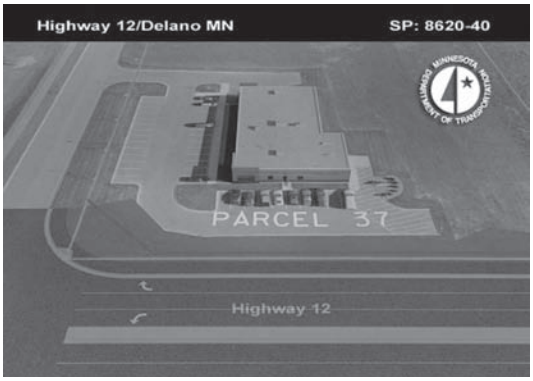
PHOTO: BILL LOHR, FHWA MINNESOTA DIVISION

The Right-of-Way and Utilities Scan tour group in front of the Minnesota state capitol. (*Front row, left to right:*) Jim Cheatham, FHWA Pennsylvania Division; Bimla Rinehart, Caltrans; Dan Mathis, FHWA Washington State Division; (*standing, left to right:*) Kevin Stout, Oklahoma DOT; Chris Porter, Cambridge Systematics; Jim Ware, Consultant; John Campbell, Texas DOT; Susan Lauffer, FHWA Office of Real Estate Services; J. D. Ewald, Texas DOT; Don Nelson, Washington State DOT; Rich Allen, Connecticut DOT; George Lovett, Florida DOT; John Sherman, Wyoming DOT; Ray Lorello, Ohio DOT; and Don Jackson, FHWA Office of Infrastructure.

- **Early and ongoing communication.** All three states made explicit efforts to have different disciplines working together from the earliest stage of project development, including design and engineering, ROW, utilities, environmental, and construction staff. Each agency also involved external stakeholders—such as property owners and utility



Toner explains a detailed flow chart of the Texas DOT ROW guidelines.



A visualization tool developed by the Minnesota Department of Transportation provides an animated fly-over of a three-dimensional representation of a project, showing ROW limits from the final design, as well as property lines.

company representatives—as early on as practicable, to identify and resolve potential conflicts.

◆ **Investment in technical tools.** Each state employed a comprehensive set of technical tools to support project management, property and utilities management, and public information efforts. Minnesota DOT has invested extensively in linked geographic information system databases, electronic data entry systems, and websites to track and communicate information about property status. Visualizations and animations have proved effective for explaining potential impacts to property owners and for resolving conflicts.

◆ **A willingness to make use of other incentives and techniques as appropriate.** Florida offers incentive acquisition and relocation payments to accelerate ROW clearance. Florida also makes utility reimbursements to expedite relocations in small and economically depressed communities. Minnesota assists local governments in acquiring property from willing sellers years in advance of a project. Creative design strategies often can mitigate or avoid the impacts of property takings and of utilities relocation. Subsurface utility engineering early in the design process can identify potential utility conflicts.

The scan team visited Texas State Highway 45, under construction, to gain insights into the application of the Texas DOT procedures.

Other Techniques and Benefits

Other techniques may vary, depending on a state's statutory requirements. Many states are expediting project development and delivery through design–build contracting. This requires attention to the structure of the contract, performance incentives, and risk sharing, to ensure that contractors conduct ROW acquisition and utilities relocation efficiently while complying with federal and state requirements.

The scan found that the most significant benefits of improved ROW acquisition and utilities relocation include shorter project delivery time and lower costs. Texas DOT, for example, has been able to move the large-scale and high-profile State Highway 130 project rapidly, in response to political pressures.

In some cases, the measures have produced direct cost savings, such as with Minnesota DOT's value engineering activities. In other cases, additional up-front costs—such as incentive payments—have led to lower long-run costs because of shortened schedules for project development and reduced expenses for litigation. Agencies anecdotally report other benefits—for example, all three states reported that the early involvement of stakeholders, especially of property owners and utilities representatives, has led to less animosity and better relationships with the stakeholders and with the public in general.

Evaluation of the Pilot Scans

An evaluation of the pilot scans was conducted to determine the benefits and impacts and to assist AASHTO in deciding whether to make the program permanent. The evaluations relied on three sources:

1. Feedback from participants on the value of the scan visits, from evaluation surveys completed immediately after the tour and again six months later. Feedback also was obtained informally from staff at the host agencies.
2. A review of the ways used for disseminating the scan findings, from reports by scan participants six months after the tour.
3. A review of actions taken to explore or implement practices within the participants' own agencies.

Feedback on the two pilot scans was positive. Participants indicated that the scans were valuable in advancing their professional knowledge. The host states also found the scan visits beneficial. In addi-

tion, the six-month evaluations confirmed that the lessons learned from the scans are being applied in practice. At least five states participating in the ROW and utilities scan and four states participating in the transportation asset management scan had implemented specific changes, and other states were considering changes.

The transportation asset management scan led to additional visits and to the creation of a quarterly webinar series that continued discussions about asset management practices and increased the availability of the scan products. In addition to making changes to their own agencies' practices, scan participants have presented findings at more than 16 regional and national conferences.

Future Directions

Because of these positive outcomes, AASHTO decided to continue the scan program under the general model outlined in the business plan. Minor adjustments to procedures were made to account for lessons learned from the two pilot scans.

In June 2007, NCHRP issued a request for proposals for a consultant to plan and manage domestic technology scans for an initial two-year period. NCHRP plans to request additional funds each year to continue the program. Work on the next round of scans started in December 2007 on the following topics:

- Project delivery management;
- Accelerated construction techniques;
- Winter maintenance;
- Regional, multiagency traffic signal operations management; and
- Bridge management decision making.

Utility poles are replaced as part of Texas DOT's accelerated State Highway 130 project.

The scan team viewed ROW and utilities relocation problems to be solved for the planned widening of US-50, west of Orlando, Florida.

The NCHRP domestic scan program represents an important new tool for spreading innovative practices throughout the U.S. transportation sector. The results should include improved mobility and safety for the traveling public, as well as responsible stewardship of fiscal and environmental resources.

Acknowledgments

Contributing to this article were Andrew Lemer, Senior Program Officer for the NCHRP domestic scan program; Michael D. Meyer, Georgia Institute of Technology, subject matter expert for the transportation asset management scan; James Ware, Consultant, subject matter expert for the ROW and utilities scan; and Joe Guerre and Lance Neumann of Cambridge Systematics, Inc.

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Changing the Culture of Construction Management

Applying Lessons from the International Technology Scanning Program

TED FERRAGUT AND KEITH MOLENAAR

Ferragut is President, TDC Partners, Ltd., Lewes, Delaware, and serves as implementation manager for the international scanning program. Molenaar is Associate Professor, Construction Engineering Management, Department of Civil, Environmental, and Architectural Engineering, University of Colorado, Boulder.

A team of U.S. transportation experts traveled to Europe in 2004 to review construction management practices, expecting to find new ways to manage projects after bids are opened. Instead, the team returned with a new perspective on managing construction projects to achieve customer-oriented goals through collaboration between the public and private sectors.

Team members now are applying what they have learned to change the culture of construction management practices in the United States. This is one example of how the U.S. highway community has benefited and changed the way it does business as a result of the International Technology Scanning Program.

"We knew that the European approach to construction management was going to be different," recalls scan team member John Smythe of the Iowa Department of Transportation. "The international highway community has developed complex construction management procedures incorporating alternative methods for procurement and contracting."

The scan experience has energized team members to develop and implement a long-term process of change in the United States. The results are beginning

Aerial view of the Stoke Pathfinder Project, Stoke on Trent, England, which used an innovative form of procurement and a teamwork model that involved the contractor early in the design process and speeded up delivery with cost-effective results. The construction management international scan team has adopted and adapted for U.S. application several concepts and approaches developed by the Highways Agency for the project.

to be seen in state agencies across the country.

"The new practices promote trust, create teamwork, and align all participants in the construction process with customer-focused goals of quality, safety, and dependable transportation facilities," observes scan team cochair Steve DeWitt of the North Carolina Turnpike Authority. "We're learning to analyze and allocate risk more effectively. The culture of construction management is changing to meet customer demands."

Program Goals

The scanning program started in 1991, when a team of executives from the Federal Highway Administration (FHWA), the American Association of State Highway and Transportation Officials (AASHTO), state departments of transportation (DOTs), and industry traveled to Europe to learn about asphalt paving technologies. The findings helped refocus the U.S. approach to asphalt paving, quality control, rolling operations, performance-based mix testing, and many other tasks. Since that first study, more than 75 scans have addressed such topics as innovative contracting strategies, roundabouts design, prefabricated bridges, asset management, and safety.[1]

The international scanning program is carried out by FHWA in cooperation with AASHTO and the Transportation Research Board's National Cooperative Highway Research Program (NCHRP) Project 20-36, Highway Research and Technology: International Information Sharing. This cooperative venture includes shared financing, the proposal and selection of topics for scans, and responsibility for implementing the scan results. Three to five topics are selected each year from suggestions submitted by the highway community. Teams of experts from state DOTs, FHWA, and industry come together under the guidance of a contract team that assists and supports FHWA in carrying out all phases of the scanning program.

Implementation of the scan findings is fundamental to the program's success. "Implementation starts on Day 1, when the scan team assembles," reports Hana Maier, FHWA's scanning program manager. "The first formal presentation emphasizes that the goal is to implement technologies and policies that could have a dramatic impact on U.S. practices and operations."

Potential Applications

The technologies and policies therefore always have potential applications in the United States. Some of the technologies observed overseas by scan teams and now undergoing U.S. evaluation and implementation include quiet pavements, prefabricated bridges, wildlife crossings, and intelligent compaction.

"Federal statutory and funding initiatives often can serve as a catalyst for states to evaluate new contracting and project delivery strategies—but states often are cautious about making such changes," notes Jerry Yakowenko, FHWA Contract Administration Group leader and scan team cochair. "Many times a combination of FHWA experimental project designations, federal legislation, and state statute and code changes are required to allow the implementation of innovative contracting methods, such as design–build and best value."

The most challenging type of scan implementation involves the combination of new techniques and policies to change the highway business culture. This is the task that the construction management scan team has undertaken. Implementing warranties, public–private partnerships, or innovative quality systems may require DOTs, FHWA, and contractors to make fundamental changes in the way they do business, think about jobs, and organize to get things done.

Members of the international scan team inspect the Stoke Pathfinder project site, gathering information.

Alternative Models

The traditional U.S. construction management processes—such as open bidding, unit price contracting, and agency inspection and quality control—served well during the construction of the Interstate Highway System. Today's projects, however, are more complex—aging highways must be rehabilitated while maintaining access for traffic, and more risk and responsibility are being transferred to contractors.

The team of U.S. experts who traveled to Canada and Europe in 2004 had planned to review and document construction management practices for effective project delivery, contract compliance, and quality assurance. The team met with representatives of government agencies, academia, and private-sector organizations involved in construction management and

[1] For more information about the International Scanning Program and to access scan reports online, please visit: www.international.fhwa.dot.gov.

PHOTO: CALIFORNIA DOT

Quiet pavement technology is one of many innovations evaluated by international scan teams for applications in the United States. The California Department of Transportation is conducting tests to measure sound levels from quiet pavements in traffic.

visited sites that demonstrated alternative technologies and practices.

The European and Canadian transportation communities face political and financial challenges and resource limits similar to those in the United States. The European and Canadian transportation systems have growing capital project needs, as well as a backlog of maintenance needs. The highway agencies must operate an aging infrastructure under tight funding constraints, increasing environmental challenges, and reduced staffs.

The agencies are addressing these challenges through a variety of innovative approaches—for example, developing construction management systems that promote the alignment of team goals, that integrate risk analysis techniques, and that support the strategic application of alternative delivery methods. These concepts are evident throughout a project's life cycle, from the procurement systems that define the framework to the contract payment systems that support alignment and trust.

The agencies also delegate traditional highway functions to the private sector to gain cost reductions and favorable schedules without sacrificing quality. These project delivery, procurement, and construction management techniques have resulted in closer partnerships between public and private entities and in increased customer awareness.

Changing a Culture

Back in the United States, the scan team formed a Construction Management Expert Task Group (ETG) to disseminate findings from the study and to promote a new culture of construction management. FHWA provided the ETG finances, and AASHTO provided the staff and committee support.

"To make the types of changes we were considering, it was essential for FHWA and AASHTO to help the scan team stay together," DeWitt explains. "We were champions of a cause but lacked an operating mechanism. We now have funding to work together for the next three to four years to make a difference."

The ETG set several goals for achieving change in U.S. construction management practices:

- Align customer, owner, and contractor goals and expectations to the construction effort.
- Select the best alternative delivery method to attain specific project goals.
- Identify and disseminate techniques to assess and allocate risk between the owner and the contractor.
- Allocate limited construction resources more efficiently to accomplish the work.
- Provide higher incentives to contractors for improving the quality of the final product.
- Continuously improve the construction management process by providing feedback within a systematic, closed-loop system.

Between twice-yearly meetings, ETG members write briefing papers, develop manuals and workshops, and manage conferences. These activities aim at implementing key concepts from the scan.

"We do not want to imitate the European system, but we want to think outside the box," Smythe reports. "We need to assess new ways of doing business and adapt these ideas to what will work in the United States."

Analyzing and Mitigating Risk

Risk analysis and mitigation is one of the concepts the team is promoting. Traditional construction management methods under design–bid–build arrangements ensure competition in bidding and minimize the transfer of risk to the private sector. The methods, however, can result in an adversarial—even litigious—relationship between the public and private sectors.

Some international agencies have turned to alternative construction management techniques as more efficient and more sustainable. The agencies believe that these techniques deliver better long-term value to customers by creating partnerships with industry that provide incentives for contractors to focus on customer-oriented goals.

"We understood the concept intuitively," recalls Brian Blanchard, Director of Construction for Florida DOT and a scan team member. "What eluded us was how it might work in the United States, where the low-bid system is entrenched. Although design–build is making inroads in the United States, our European counterparts are moving into yet more advanced aspects of construction management, with roles for the contractor that we had not imagined."

First-of-Its-Kind Manual

The Construction Management ETG therefore developed the *Guide to Risk Assessment and Allocation for Highway Construction Management*,[2] the first manual of its kind. The guide and a companion risk assessment workshop are designed to help state DOTs understand and organize for risk early in the project planning process.

The manual describes the risk assessment tools that the scan team learned about during the study. "The international community has an awareness of risk analysis and allocation techniques that is not present in all of our U.S. highway agencies," DeWitt observes. "We wanted to promote a similar awareness in FHWA and state DOTs."

In the United Kingdom, for example, England's Highways Agency developed the Highways Agency Risk Management (HARM) tool to help select delivery and contracting methods early in a project's life cycle. The Ministry of Transport, Public Works, and Water Management in the Netherlands developed the Public-Sector Comparator and the Public–Private Comparator to assist with the same kind of decisions. Both agencies have assigned staff to help the project teams identify and quantify risk through probabilistic techniques and then choose the delivery and contracting strategies that best mitigate the risks.

Take-Charge Workshops

To date, Colorado, Florida, and Texas DOTs have completed pilot workshops. The agencies plan to run risk assessments on projects in their states and determine how best to implement the concept.

"We have provided resources to help DOTs run their own risk workshops," Yakowenko notes. "Each DOT will take the lead and let us know how it worked and what the next organizational step is—Florida has train-the-trainer programs under way now."

Building Commitment

Cultural change requires a commitment from upper management and an understanding of the process by project-level staff. Florida DOT's approach to integrating risk assessment and allocation into its project management culture is both top-down and bottom-up.

The top-down policy under development is similar to the FHWA policy that requires a value engineering study for projects of a certain size. The Florida DOT policy would require qualitative risk management on projects with budgets of more than $20 million. Projects with total estimated costs exceeding $100 million would have to conduct a formal quantitative risk analysis workshop.

[2] FHWA-PL-06-032, http://international.fhwa.dot.gov/riskassess.

The bottom-up approach involves the training of project personnel in risk management. Florida has trained members of the value engineering staff in risk management, and they in turn are training the project staff. The training will be a key to the long-term integration of risk management into the project management culture.

"We want to develop new practices that promote trust, create teamwork, and align all participants with customer-focused objectives of quality, safety, and dependable transportation facilities," comments Brian Blanchard of Florida DOT. "We must learn to analyze risks more effectively and to allocate the risks to the party that can manage them best. These changes must occur to meet customer demands."

Contractor Involvement

All of the international agencies that the scan team met with rely on a balanced approach to project delivery. The agencies employ the entire range of traditional and alternative methods, including design–bid–build, design–build, design–build–operate, and a variety of public–private partnerships. The team also learned about several new methods—for example, one that allocates more risk to the private sector and another that motivates the private sector to develop total life-cycle maintenance and operation solutions.

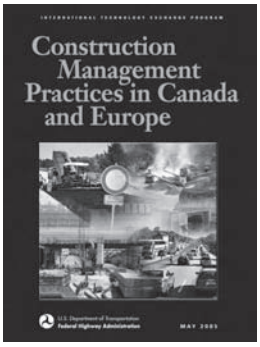
Of particular interest was the Early Contractor Involvement (ECI) approach pioneered by England's Highways Agency. Traditional methods create the project team late in the development process, but ECI chooses design and construction professionals early through a qualifications-based method.

The contractor and the Highways Agency then develop the project budget through an open-book target pricing system. The contractor pays penalties for exceeding the project budget and earns bonuses if the project finishes under budget. The Highways Agency participates in both the penalties and the bonuses.

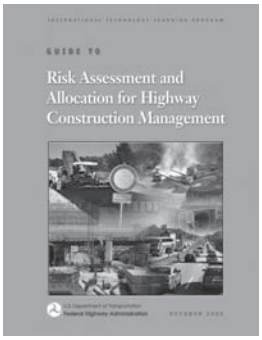
"The U.S. highway industry similarly must evolve from the traditional, one-size-fits-all project delivery method," observes Rich Wagman, Chairman of the Board and Chief Executive Officer, G.A. & F.C. Wagman, Inc., and a scan team member. "Continuous attention should be given to alternative delivery methods that promote early industry involvement and to life-cycle design solutions that maximize the project team's input to meet customer needs."

The scan team produced a comprehensive paper presenting the Highways Agency approach, *Early Contractor Involvement and Target Pricing in U.S. and U.K. Highways*.[3] According to DeWitt, the next step is to "solicit candidate DOTs to try out the concept—noth-

[3] http://pubsindex.trb.org/document/view/default.asp?lbid=802173.



The Expert Task Group is working to disseminate findings from the study, which will require far-reaching changes in construction management practices and approaches.



The *Guide to Risk Assessment and Allocation for Highway Construction Management* is one of the scan team's pioneering efforts.

ing works better than case studies."

Utah DOT already is employing a variation on ECI. To obtain more construction industry input early in the design stage, the agency has implemented a delivery system called Construction Manager/General Contractor, which is similar to the construction-manager-at-risk delivery method used in vertical building to obtain early constructability, schedule, and cost information.

Fostering Partnerships

Although the low-bid procurement system is in use abroad, most countries visited on the scan relied on a best-value procurement system as standard procedure. Procurements based solely on qualifications—that is, without a bid price—also are used.

Canada's Ministry of Transportation has developed the Registry Appraisal and Quality System (RAQS) to rate contractors on past performance and to adjust prequalification ratings for bidding. England's Highways Agency has produced the Capability Assessment Toolkit (CAT) to score company management practices; the scores are combined with records of past performance to make a qualifications-based selection of designers and contractors for major projects.

An overriding objective of these procurement systems is to foster trust and long-term partnerships between the highway agencies and industry. By evaluating proposals on factors such as quality or traffic management plans, agencies can align procurement with project and customer goals at the earliest stages.

"We say that this contractor is better than that contractor all the time, but we fall short of quantifying how much better," observes Smythe. "We say that past performance should be a criterion for future work, but we're not sure how to reward a good performer. Occasionally poor performers get into the system."

Rating Quality

To facilitate quality-based selection in the United States, the Construction Management ETG is developing and implementing consistent quality rating processes. Several states have begun collecting and tracking rating information for contractor qualifications. The processes in Canada and Europe took years to develop, and a concerted, long-term effort is necessary for the process to succeed in the United States.

Also under way is the development of a rating system for contractors that reflects the quality at the completion of a rapid renewal project. Under a performance specification contract with TRB's Strategic Highway Research Program 2 (SHRP 2), the scan team will look at ways to quantify a contractor's performance.[4]

"We try to rate contractors before a project award by looking at their history and program for quality and the promises they've made about managing the work," DeWitt notes. "We want to adapt that approach to determine how well they have performed."

Creating Incentives

Procurement systems start the project team toward success, but payment methods create incentives to meet customer needs. Unit price contracts in the United States appropriately allocate the risk for variations in quantity but do not provide incentives for completing project milestones early or for minimizing the impact on the traveling public. The Construction Management ETG is encouraging agencies to look at techniques used by their European and Canadian counterparts.

The Scottish Government, for example, does not use unit prices for contractor payment but sets a series of completion milestones for which it makes lump-sum payments. The government has found that this minimizes the administrative burden and provides contract incentives to complete the milestones efficiently. Both the Highways Agency in England and the Ministry of Transport, Public Works, and Water Management in the Netherlands apply congestion pricing incentives and disincentives in paying for projects that affect the traveling public.

The Construction Management ETG has developed a white paper, *Alternative Payment and Progress Reporting Methods,* on contractor invoicing, milestone payments, and other alternative payment methods.[5] "Part of the challenge is informing DOTs that others have applied alternative payment methods successfully," reports white-paper author Sid Scott of Trauner Consultants. "The paper highlights successes and should convince others to apply some of these techniques."

Long-Term Partnerships

In Europe and Canada, the project delivery and construction management methods that the scan team reviewed have increased the collaboration between the public and private sectors. The agencies are aware that their procurement and construction management methods affect their design and construction professionals and the supply chain.

The strategic application of delivery methods that promote life-cycle solutions, the consideration of qualifications and past performance in procurement, and the delegation of traditional highway agency con-

[4] SHRP 2 Renewal Project R07: Performance Specifications for Rapid Renewal. For more information, http://onlinepubs.trb.org/onlinepubs/shrp2/RenewalBrief.pdf.

[5] www.fhwa.dot.gov/programadmin/contracts/etgpayment.cfm.

struction management functions to the private sector have contributed to a closer relationship between the public and private sectors. The scan team would like to see a similar development in the United States.

"Exploring these innovations in construction management and creating long-term partnerships with the public sector will prove valuable," says ETG member Rich Juliano of the American Road and Transportation Builders Association. "Scan participants are as energized today as they were four years ago to build these relationships, and we appreciate the opportunity to continue to work through the Construction Management ETG."

Network Management

Among the key benefits observed by the team are the increased awareness of customers' needs by the highway agencies and their industry partners and the development of a network management philosophy to improve performance to meet those needs. England's Highways Agency has stated its network management objectives in terms of key performance indicators (KPIs) measured for each project and each service provider:

- Client satisfaction with the product,
- Client satisfaction with the service,
- Predictability of time,
- Predictability of cost,
- Achievement of safety, and
- Minimization of defects.

"This is difficult to apply in our current way of doing business," observes Tim Aschenbrenner, Materials and Geotechnical Branch Manager, Colorado DOT, and a member of the ETG. "Projects sometimes take 10 to 15 years or more to move from concept to opening to traffic. Many decisions and commitments are made in the process—involving, for example, traffic management, business access, environmental improvements, and aesthetics. We want to ensure that construction managers understand these goals and select the right strategy to enable their team and the contractor to meet these expectations."

Defining New Roles

The Construction Management ETG's goal is for DOTs and industry to create teams that start early and focus on customer goals throughout the cycle of project development and construction. The process begins with decisions about risk assessment and strategic project delivery. Procurement and construction management techniques should support these early decisions by providing incentives to achieve customer goals. The ETG is working with AASHTO's Project Delivery Task Force and Design–Build Task Force to forge a partnership on ideas and practices that address this concept.

The international scan team on a site inspection in Europe. The team is continuing its post-scan work as an Expert Task Group supported by FHWA and AASHTO.

The ETG is organizing the First International Transportation Construction Management Conference, September 9–11, 2008, in Orlando, Florida, on the new role of construction managers in assuring project success.[6]

"We want a larger segment of the contracting community to focus on this new approach to construction management," DeWitt states. "We want this to become a continuing conference that lets everyone know that the culture is undergoing change."

Catalyst for Change

The experience of the construction management scan team is another in the International Technology Scanning Program's long history of successes in finding technologies and practices in other countries that can benefit the U.S. highway community and the traveling public. Although a long-term effort is required, the Construction Management ETG is committed to serving as the catalyst for change, eventually creating a new construction management culture in the United States.

"When it comes to fundamental changes in the way we do business, we have to be patient as well as aggressive, provide energy and focus on new ideas, and show how new ways of business benefit the United States," DeWitt comments. "This is not change for the sake of change, but change for the better—and that will keep us focused."

[6] For more information about the conference, see www.2008tcmconference.volpe.dot.gov.

Promoting Public Health Through Transportation Planning

Utah Region Adopts and Applies Guidelines

SHAUNNA K. BURBIDGE

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As the home of the 2002 Winter Olympics, Salt Lake City, Utah, became well known worldwide. Its newfound fame and its location at the heart of the Wasatch Front region—a long and narrow area bounded by the Wasatch Mountains in the east and Utah Lake and Salt Lake in the west—have led to rapid growth, and the population is predicted to double by 2040.

Public Health Problem

The state of public health in the United States has received much attention in recent years, particularly the problems of obesity and the lack of physical activity, which are thought to contribute in turn to many other prevalent health problems, such as diabetes and cardiovascular disease (*1, 2*). Many commentators note that modern conveniences—such as the automobile—are conducive to a sedentary lifestyle, replacing the physical activity that formerly was part of the daily routine.

Utah has not escaped this public health trend, and many analysts have questioned the potential impact of the transportation environment on physical activity in the Wasatch Front. With only two major freeways—Interstates 15 and 80—and a limited mass transit system,* traffic congestion has become a significant problem in the region. Coupled with the sprawling growth patterns in the Salt Lake Valley during the past

A portion of the Salt Lake City skyline with the Wasatch Mountains in the background.

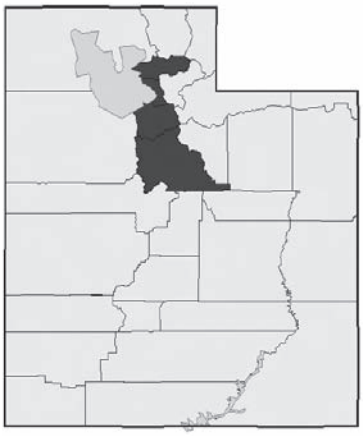

FIGURE 1 The Wasatch Front region encompasses Weber, Davis, Salt Lake, and Utah Counties (shown shaded from north to south).

three decades, the outcomes are long travel distances, reduced travel speeds, and an increased time sitting in automobiles.

In 2000, the average Utah resident spent 42 minutes per day commuting. According to the U.S. Census, more than 75 percent of local residents used automobiles as their sole mode of transportation, and approximately 3 percent regularly commuted by foot or bicycle (*3*). A study by the Utah Department of Health concluded that the physical inactivity of the region's residents generated nearly $400 million annually in direct medical costs, or approximately $265 per person (*4*).

With obesity on the rise and physical activity on the decline, transportation and planning researchers have begun to examine the built environment's influence on physical activity. A 2005 policy study by the Transportation Research Board and the Institute of Medicine for the Robert Wood Johnson Foundation and the Centers for Disease Control and Prevention noted that some environments can promote and encourage physical activity, but others can restrict physical activity or make it more difficult (*5*). In particular, the study recommended that transportation planning should give more consideration to physically active modes of transportation, such as walking and bicycling.

Search for Solutions

In 2005 the Wasatch Front Regional Council—the metropolitan planning organization (MPO) for most of the Wasatch Front—updated the region's transportation plan and determined to promote active modes of transportation. Working with Active Planning, a consulting firm, the council produced a technical report examining the state of active transportation modes in the Wasatch Front (*6*).

The report summarized research on topics related to active mode choice, including local transportation financing, travel behavior, the natural and built environments, and regional climate and topography. The research findings were instrumental in developing recommendations for updating the regional transportation plan.

Policy Approaches

The report recommended nine policy approaches for inclusion in the Wasatch Front Regional Transportation Plan:

- When building or reconstructing streets, require complete street designs that provide for all modes of transportation.
- Require active links to new transit stops and improve access to current transit, including safe, convenient bicycle paths and lanes and pedestrian routes.
- Incorporate bicycle parking and storage in key transit-oriented locations.

Planners are seeking to stimulate the use of active transportation modes—such as walking and bicycling—to counteract the effects of sprawling growth in the Salt Lake Valley area.

* Although the mass transportation system in Utah historically has been limited, a high-speed rail line began operation in April 2008, and many new projects are planned, including extensions of a light rail line.

New sidewalk offers enough room for pedestrians to travel comfortably; a buffer of trees maintains separation from adjacent traffic.

PHOTO: SHAUNNA K. BURBIDGE

◆ Require a 4-foot (1.25-meter) paved shoulder along new shared or repaired roadways to improve safety and convenience for bicyclists and motorists.

◆ Designate connected bicycle routes that are distinct from the automobile right-of-way and that can serve as arterials for active modes throughout the region. Make every effort to designate routes on streets with low traffic volumes.

◆ Mandate that new sidewalks provide a 3-foot (1-meter) buffer at minimum in all urban areas, to separate pedestrians from faster-moving vehicles such as bicycles and automobiles (see photograph, above).

◆ Identify appropriate locations for incorporating shared-use paths—along rivers, canals, utility right-of-ways, or railroad or freeway corridors; within college campuses; within or between parks and cul-de-sacs; and adjacent to any other natural barrier.

◆ Incorporate proper signage, as well as specific surface treatments, to define the active infrastructure as separate from the right-of-way for vehicle travel (see photograph below, left).

◆ Encourage local communities that are applying the Wasatch Choices 2040 Growth Principles to adopt activity-friendly land uses and to plan for active transportation choices in their general plans (7).

The Wasatch Front Regional Transportation Plan calls for on-street bicycle lanes to keep cyclists apart from pedestrians and separated from automobile traffic.

PHOTO: SHAUNNA K. BURBIDGE

Local Implementation

The MPO adopted the nine recommendations in fall 2006 as a new public health component of the regional transportation plan. The updated plan was approved in May 2007, and many municipalities are now applying the new recommendations.

Cities that were automobile-oriented are seeking out ways to incorporate active modes into their transportation systems. In addition, municipalities within the region are coordinating to ensure that new active infrastructure projects maintain continuity across boundaries, creating a regional network for active modes of transportation.

Broader Benefits

Transportation planners and officials are in a position to influence public health by incorporating more active mode choices into transportation system plans. Research on active mode choice and travel behavior is available and ready to be incorporated into the planning process. The research implementation in Utah serves as an example of how MPOs nationwide can begin to incorporate the goal of increased physical activity for public health into transportation plans.

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POINT OF VIEW

The Market Reach of Transit Stations

Recasting Effective Historical Measures

ROBERT R. PIPER

The author is a transportation consultant who has worked as Director of Marketing for the British Columbia Bureau of Transit Services and as Director of Transportation for the City of Berkeley, California.

Transportation planning newsletters recently have reported on new research suggesting that pedestrians walk considerably farther to light rail stations than commonly assumed. The source paper relied on surveys of home-based passengers at five different stations (*1*). Raw walking distance data from all stations were aggregated. The median distance was 0.47 mile—or almost one-half mile. If this finding accurately reflects passenger behavior, it invalidates the old rule of thumb that the catchment area of a rail station only extends up to one-half mile, or a 10-minute walk.

Sample Bias

An examination of the land use at the stations in the study, however, indicates that sample bias accounts for the anomalously long walking distances. The results are skewed toward long distances because much of the land close to the stations contains no residences from which respondents could walk. This special land use characteristic is not sufficient reason to reject historical findings about walking behavior.

Two stations yielded 60 percent of the study responses. Nonresidential uses such as surface parking and commercial buildings occupy 40 to 45 percent of the land within a quarter-mile walk at one station and 75 to 80 percent at the other.[1] The tracks at the second station run alongside a multilane Inter-

[1] The issue is actual walking distance, not defined by circles on a map. Pedestrians are limited to available walkways, such as the sidewalks of a rectilinear street network. A circle of a certain radius contains 60 percent more area than is actually walkable at that distance. The difference is greater when obstacles such as highways, railroads, or streams intervene.

Transit riders walk to their Southeast Washington, D.C., neighborhood Metrorail and bus stop.

Arlington, Virginia, residents walk to East Falls Church Metro station for their morning commute via bus or Metrorail.

state highway. The only residences within a quarter mile are located on the opposite side of the highway, and passengers must cross a pedestrian bridge to reach the station.

Data from a third station—representing 27 percent of respondents—also highlight the influence of land use. Residential development surrounds the station right up to the street along which the tracks run. The self-reported walking distances to this station are substantially shorter than those for the other two stations—the 50th percentile, for example, is 0.28 mile, compared with 0.50 mile. The contrast is readily explained by the differences in land development close to the station.

Transit agencies often perform or sponsor studies of walking distance. Sometimes the studies suppress the influence of land use by normalizing results (2). They divide the number of passengers walking from each increment of area by the number of residential units in that increment. The process is tedious, but it eliminates land use as a source of bias.

Propensity to Walk

Studies of walking distance agree that more passengers walk short distances than long distances. The distribution falls off farther away from the station and graphs as a long tail. The tail includes the outliers who walk farther than the majority of passengers; the majority defines the catchment area. From a planning perspective, however, this is only part of the story.

As a passenger leaves a station, the area enclosed by equal increments of distance grows with the square of that distance. For example, the area between a quarter mile and half a mile from a station is three times that within the first quarter mile. Not only do fewer passengers walk the greater distances, but they are spread over larger areas. Even if the population were uniformly distributed, aggregated data from all directions would not reflect walking behavior—that is, people's propensity to walk. The propensity to walk is better shown by a plot of passengers per acre by distance from the station. The plot falls off with distance more steeply than the curve for raw walking distance. This may be thought of as a proxy for transit modal share.

The propensity-to-walk curve shows the distance at which the share of passengers arriving by foot becomes inconsequential. The distance encompasses an area substantially smaller than the catchment area and serves as a guide for route planning—for example, determining what constitutes adequate coverage—as well as for transit-oriented development—for example, how far out does appreciable station influence extend?

Data from many sources tell us that this distance lies closer to a quarter mile than a half mile. Developments farther away will be automobile-dependent, not transit-oriented. They will have little impact on transit and vice versa. Investors seeking to capitalize on proximity to transit and environmentalists seeking to reduce vehicle miles traveled should take heed. The success or failure of a project depends on the share of all travelers who ride transit, not on the outliers who make up the tail of the walking distance distribution.

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POINT OF VIEW presents opinions of contributing authors on transportation issues. The views expressed are not necessarily those of TRB or TR News. *Readers are encouraged to comment in a letter to the editor on the issues and opinions presented.*

TRB SPECIAL REPORT

Potential Impacts of Climate Change on U.S. Transportation

NANCY HUMPHREY

The author is Senior Program Officer, TRB Division of Studies and Special Programs, and served as Study Director for this project. Amanda C. Staudt, Senior Program Officer, Division on Earth and Life Studies, National Research Council, assisted in staffing the study committee through February 28, 2007.

Transportation professionals should acknowledge the challenges that will result from climate change and should incorporate current scientific knowledge about climate change into the planning, design, construction, operation, and maintenance of transportation systems. Climate change will affect every mode of transportation and every region in the United States, and the challenges to infrastructure providers will be new and often unfamiliar.

TRB Special Report 290: Potential Impacts of Climate Change on U.S. Transportation presents the findings and recommendations of a study conducted by a committee of experts under the auspices of the Transportation Research Board and the Division on Earth and Life Studies of the National Research Council (see box, page 24). According to the study committee's report, focusing on the problem now should help avoid future costly infrastructure investments and disruptions to transportation operations.

Challenges of Climate Change

Climate change will affect transportation primarily through increases in several types of weather and climate extremes, such as very hot days and heat waves; warming Arctic temperatures; rising sea levels coupled with storm surges and land subsidence; intense precipitation events; and intense hurricanes. The impacts will vary by mode of transportation and by region of the country but will be widespread and costly in human and economic terms and will require significant changes in the way that transportation professionals do business.

The historical regional climate patterns of the past several decades, commonly used by transportation planners to guide operations and investments, may no longer be a reliable guide. In particular, the future climate will include new classes of weather and will reach extremes in terms of magnitude and frequency—for example, with record rainfalls and record heat waves—as human-induced environmen-

A Joplin, Missouri, police car travels through a flooded intersection.

Focusing on the Consequences for Transportation

Although many studies have examined the potential impacts of climate change on broad sectors of the economy, such as agriculture and forestry, few have studied the impacts on transportation. The primary focus of this study is on the consequences of climate change for U.S. transportation infrastructure and operations.

The report provides transportation professionals with an overview of the scientific consensus on the current and future climate changes relevant to U.S. transportation, including the limits of scientific understanding about the timing, magnitude, and geographic location; identifies the potential impacts on U.S. transportation and the options for adaptation; and offers recommendations for research and for actions to prepare for climate change. The report also summarizes research and work on strategies for reducing transportation-related emissions of carbon dioxide (CO_2), the primary greenhouse gas and a contributor to climate change.

The study was funded by the Transportation Research Board, the National Cooperative Highway Research Program, the U.S. Department of Transportation, the Transit Cooperative Research Program, the U.S. Environmental Protection Agency, and the U.S. Army Corps of Engineers.

tal changes are superimposed on the natural variability of the climate.

The decisions that transportation professionals make today—particularly for the redesign and retrofitting of transportation infrastructure or for the location and design of new infrastructure—will affect how well the system will adapt to climate change.

Addressing the Impacts

◆ **Inventory critical infrastructure.**

The flooding of coastal roads, railways, transit systems, and runways will be a likely result of a projected global rise in sea level coupled with storm surges and exacerbated by land subsidence in some locations. This flooding represents the greatest potential impact of climate change on North America's transportation system.

The vulnerability of transportation infrastructure to climate change, however, will extend beyond coastal areas. Federal, state, and local governments, in collaboration with owners and operators of infrastructure—such as ports, airports, and private railroads and pipelines—should inventory critical transportation infrastructure, identifying whether, when, and where the projected climate changes may be consequential.

In a possible preview of coastal area transportation problems that may become routine with projected climate changes, torrential rainwater rushes down the commuter steps onto the platform and tunnel at New York City's Times Square station, August 8, 2007.

◆ **Incorporate climate change into investment decisions.**

Every day, public officials at various levels of government and executives of private companies make short- and long-term investment decisions that have implications for how the transportation system will respond to climate change. Transportation decision makers, therefore, should be preparing now for the projected climate changes.

State and local governments and private infrastructure providers should incorporate adjustments for climate change into long-term capital improvement plans, facility designs, maintenance practices, operations, and emergency response plans. A six-step approach for determining appropriate investment priorities is presented in the box on page 23.

◆ **Adopt strategic, risk-based approaches to decision making.**

The costs of redesigning and retrofitting transportation infrastructure to adapt to the potential impacts of climate change are likely to be significant. More strategic, risk-based approaches to investment decisions are needed.

Transportation planners and engineers should incorporate more probabilistic investment analyses and design approaches that trade off the costs of making the infrastructure more robust against the economic costs of failure. Moreover, they should communicate these trade-offs to the policy makers who are responsible for investment decisions and for the authorization of funds.

The California Seismic Retrofit Program offers a model. The program uses a risk-based approach to analyze a highway bridge's vulnerability to earthquakes and its criticality to the road network, to determine priorities for retrofitting and replacement.

◆ **Improve communication.**

For transportation decision makers, one of the most difficult aspects of addressing climate change is obtaining the relevant information in the form they need for planning and design. Transportation professionals often lack sufficient information about the details and timing of expected climate changes to take appropriate action. The National Oceanic and Atmospheric Administration, the U.S. Department of Transportation (DOT), the U.S. Geological Survey, and other agencies should work together to institute a process to improve communication among transportation professionals,

climate scientists, and those in other relevant scientific disciplines, and to establish a clearinghouse for climate change information related to transportation.

In addition, better decision support tools are needed to assist transportation decision makers. Ongoing and planned research at federal and state agencies and universities that provide climate data and decision support tools should include the needs of transportation decision makers.

◆ **Integrate evacuation planning and emergency response into transportation operations.**

Projected increases in weather and climate extremes underscore the importance of emergency response plans for vulnerable locations. Transportation providers must work more closely with weather forecasters and emergency planners and assume a greater role in evacuation planning and emergency response.

Climate extremes—such as more intense storms and more intense precipitation—will require near-term operational responses from transportation providers and greater attention to emergency response in transportation operations and budgets. Transportation agencies and service providers should build on the experience of jurisdictions that have integrated transportation into emergency response and evacuation plans.

◆ **Develop and implement monitoring technologies.**

Monitoring the condition of the transportation infrastructure, particularly the impacts of weather and climate extremes, offers an alternative to the preventive retrofitting or reconstruction of some facilities in advance of climate change. Greater use of sensors and other "smart" technologies would enable infrastructure providers to receive advance warnings of potential failure caused by water levels and currents, wave action, winds, and temperatures exceeding what the infrastructure was designed to withstand. Federal and academic research programs should encourage the development and implementation of these technologies.

◆ **Share best practices.**

As the climate changes, many areas of the United States will experience new weather patterns. The geographic extent of the United States—from Alaska to Florida and from Maine to Hawaii—and its diversity of weather and climate conditions can provide a laboratory for best practices and information sharing as the climate changes. Drawing on technology transfer mechanisms, transportation professional and research organizations should develop a mechanism to encourage the sharing of best practices to address the potential impacts of climate change.

◆ **Reevaluate design standards.**

Environmental factors are integral to transportation infrastructure design. Engineers have not addressed the sufficiency of current design standards, however, for accommodating climate change. Climate change projections, for example, indicate that today's 100-year precipitation event is likely to occur every 50 years or perhaps even every 20 years by the end of this century.

Reevaluating, developing, and regularly updating design standards for transportation infrastructure to withstand the impacts of climate change will require a broad-based research and testing program and a substantial implementation effort. U.S. DOT should take the lead, working with professional organizations in the forefront of civil engineering practice, to initiate immediately a federally funded, multiagency research program for all modes. The program should reevaluate design standards and develop new standards as progress is made in understanding future climate conditions and the options for addressing them.

A research plan and cost proposal should be developed and submitted to Congress for authorization and funding. Until new standards are developed, infrastructure rehabilitation projects in highly vulnerable locations should be rebuilt to higher standards.

The development of appropriate design standards to accommodate climate change is only one of several possible adaptation strategies that may require federal leadership, research, and funding. Federal agencies have not focused on adaptation in addressing climate change. Better collaboration could direct attention to

TRB Special Report 290, Potential Impacts of Climate Change on U.S. Transportation*, is available from the TRB online bookstore, www.trb.org/bookstore; to view the book online, go to http://onlinepubs.trb.org/onlinepubs/sr/sr290.pdf. The background papers commissioned by the study committee are also available online at www.trb.org/news/blurb_detail.asp?id=8808.*

Decision Framework for Addressing the Impacts of Climate Change on U.S. Transportation Infrastructure

1. Assess how climate changes are likely to affect various regions of the country and modes of transportation.
2. Inventory transportation infrastructure essential to maintaining network performance in light of climate change projections to determine whether, when, and where their impacts could be consequential.
3. Analyze adaptation options to assess the trade-offs between making the infrastructure more robust and the costs involved. Consider monitoring as an option.
4. Determine investment priorities, taking into consideration criticality of the infrastructure components as well as opportunities for multiple benefits (for example, congestion relief or the removal of evacuation route bottlenecks).
5. Develop and implement a program of adaptation strategies for the near and long terms.
6. Periodically assess the effectiveness of adaptation strategies, and repeat Steps 1 through 5.

PHOTO: WASHINGTON STATE DOT

Floods from the surging Chehalis River in southwestern Washington State overwhelm Interstate 5, December 4, 2007. Climate change may trigger more intense storms and extend the scope of special flood hazard areas.

these issues and shape research programs. U.S. DOT should take the lead in developing an interagency working group focused on adaptation.

◆ **Include climate change in transportation and land use planning.**

One of the most effective strategies for reducing the risks of climate change is to avoid placing people and infrastructure in vulnerable locations. Transportation planners are not currently required to consider climate change and its effects on infrastructure investments. Land use decisions are made primarily by local governments, which have too limited a perspective to account for the broadly shared risks of climate change. Integration between transportation and land use planning is uncommon.

Federal planning regulations should require that public-sector, long-range transportation plans include the consideration of climate change. In addition, regulations should eliminate any perception that such plans only need to address the next 20 to 30 years. The regulations also should require collaboration in plan development among the agencies responsible for land use, environmental protection, and natural resources management, to foster more integrated transportation–land use decision making.

◆ **Evaluate the National Flood Insurance Program and flood insurance rate maps.**

The federal government is the insurer of last resort for homeowners in specially designated flood hazard areas. The National Flood Insurance Program, administered by the Federal Emergency Management Agency (FEMA), and the flood insurance rate maps (FIRMs), which determine program eligibility, do not take climate change into account.

FEMA should reevaluate the effectiveness of the National Flood Insurance Program and the FIRMs in risk reduction, particularly because climate change may trigger more intense storms and because the rise in sea level will extend the scope of flood damage in some special flood hazard areas. At a minimum, updated FIRMs that account for sea level rise—as well as for land subsidence—should be a priority in coastal areas.

◆ **Develop new organizational arrangements.**

The impacts of climate change do not follow the modal, corporate, or jurisdictional boundaries that define decision making in the transportation sector. The institutional arrangements for transportation planning and operations were not organized to address climate change and may not be adequate to the task.

Models of cross-jurisdictional cooperation include regional authorities for specific facilities, such as Southern California's Alameda Corridor; regional and multistate emergency response agreements; and state-mandated regional authorities responsible for air quality improvement. Similar arrangements could emerge to address the effects of sea level rise on coastal real estate and infrastructure, of drought on shipping along inland waterways, and of hurricanes in the Gulf Coast. State or federal incentives, however, may be necessary to ensure the development of such organizational arrangements at the regional or multistate level.

Leadership and Commitment

Actions to prepare for climate change can be taken immediately. Local governments and private infrastructure providers can undertake some steps, but others depend on federal and state action. In all cases, leadership and continuing commitment are essential.

Committee on Climate Change and U.S. Transportation

Henry G. Schwartz, Jr., NAE, Sverdrup/Jacobs Civil, Inc. (retired), St. Louis, Missouri, *Chair*
Alan C. Clark, Houston–Galveston Area Council, Texas
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Willliam J. Gutowski, Jr., Iowa State University, Ames
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Klaus H. Jacob, Columbia University, Palisades, New York
Thomas R. Karl, National Oceanic and Atmospheric Administration, Asheville, North Carolina
Robert J. Lempert, RAND Corporation, Santa Monica, California
Luisa M. Paiewonsky, Massachusetts Highway Department, Boston
S. George H. Philander, NAS, Princeton University, Princeton, New Jersey (through December 2006)
Christopher R. Zeppie, Port Authority of New York and New Jersey, New York City

TRB Meetings 2008

July

6–9 47th Annual Workshop on Transportation Law
San Diego, California

7–10 Southern African Transport Conference*
Pretoria, South Africa
Martine Micozzi

8–10 The Greenshields Fundamental Diagram: 75 Years Later
Woods Hole, Massachusetts

13–16 8th National Conference on Access Management*
Baltimore, Maryland

13–17 4th International Conference on Bridge Maintenance, Safety, and Management*
Seoul, South Korea

20–22 TRB Traffic Signals Committee Midyear Meeting
Detroit, Michigan

21–22 Bus Rapid Transit Workshop
Cleveland, Ohio

27–30 6th National Seismic Conference on Bridges and Highways*
Charleston, South Carolina

27–30 TRB Highway Capacity and Quality of Service Committee Summer Meeting
Irvine, California

28–29 Young Driver Subcommittee Midyear Meeting and Workshop
Woods Hole, Massachusetts
Richard Pain

August

6–8 North American Travel Monitoring Conference and Exposition (NATMEC)
Washington, D.C.

11–16 6th International Conference on Case Histories in Geotechnical Engineering*
Washington, D.C.

17–21 9th International Conference on Concrete Pavements*
San Francisco, California

September

TBD Workshop on Identifying Traveler Information Research Needs to Achieve All Roads, All Modes, All the Time
Irvine, California
Richard Cunard

3–5 Best Practices in Meeting SAFETEA-LU Requirements in the Statewide Transportation Planning Process
Atlanta, Georgia

7–10 13th International Conference on High-Occupancy Vehicle Systems, Pricing, and Managed Lanes*
Minneapolis, Minnesota
Richard Cunard

8–11 International Conference on Construction Management*
Orlando, Florida

17–19 11th National Conference on Transportation Planning for Small and Medium-Sized Communities: Tools of the Trade
Portland, Oregon

22–23 North American Freight Transportation Data Conference
Irvine, California

24–26 National Workshop on Highway Asset Inventory and Data Collection*
Durham, North Carolina

October

TBD U.S.–U.K. Promising Geophysical Technologies for Best Practices for Designating, Locating, and Characterizing Subsurface Utilities
Clearwater, Florida
Stephen Maher

1–3 3rd International Conference on Accelerated Pavement Testing*
Madrid, Spain

6–7 Northeast Traffic Monitoring Workshop
Woods Hole, Massachusetts

6–8 European Transport Conference*
Leiden, The Netherlands
Martine Micozzi

19–22 18th National Rural Public and Intercity Bus Transportation Conference
Omaha, Nebraska

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 lkarson@nas.edu. Meetings listed without a TRB staff contact have direct links from the TRB calendar web page.

*TRB is cosponsor of the meeting.

Extending the Use of Supplementary Cementitious Materials in Concrete Pavement During the Late Fall

Indiana Revises Specifications

TOMMY E. NANTUNG

The author is Section Manager, Office of Research and Development, Indiana Department of Transportation, West Lafayette.

The performance of new concrete pavement constructed with supplementary cementitious materials during the late fall has been a major concern in Indiana. A survey of 12 neighboring states indicated that 9 allowed the use of fly ash or ground granulated blast furnace slag (GGBFS) throughout the year without any major detrimental effects in pavement performance; 3 states, however, expressed serious concern about the long-term performance of pavement that would be exposed to cold weather before reaching a certain maturity level.

Problem

The Indiana Department of Transportation (DOT) specification had limited the use of fly ash or GGBFS in concrete pavement mix to a replacement ratio of 20 percent to 25 percent and had permitted placement between April 1 and October 15. The specification reflected concern that a concrete pavement mix with a low content of portland cement and a high content of fly ash or GGBFS may not reach the necessary level of maturity if exposed to cold temperatures during construction. Along with a reduction in strength and in freeze–thaw resistance, the concrete would be prone to scaling—a roughening of the pavement surface—which would compromise long-term performance.

Extending the construction season into late fall, however, would produce substantial cost savings. Nonetheless, ensuring that the concrete, as it matures, would not be adversely affected by cold temperatures and salt during the late fall and winter months is a necessity.

Solution

Indiana DOT initiated a joint study with the concrete pavement industry in the state to evaluate concrete pavement made during late fall from local materials, under standard construction practices, and containing fly ash or GGBFS. The study examined the pavement's freeze–thaw durability, resistance to salt scaling, and long-term performance.

Phase 1

In Phase 1, researchers obtained mill certificates of cements (28 sources), Class C fly ash (9 sources), Class F fly ash (4 sources), and GGBFS (1 source). Using the certificate information, they developed models for predicting the strength of the cements and for the strength activity index of the fly ashes.

A sensitivity analysis of the models evaluated the way that the chemical composition and fineness of the cements and fly ashes influenced variability in the rate of strength development. To apply the results of the sensitivity analysis to a range of mixtures, a subset of materials was selected for tests on mortars and concretes, including two Type I cements, one Type I/II cement, one Type III cement, three Class C fly ashes, one Class F fly ash, and one slag.

A screening program administered compressive strength tests on mortar cubes at 1, 3, 7, 28, and 90 days and at curing temperatures of 23°C, 10°C, and 1°C. Maturity tests were applied to mortars at different ages, and determinations were made of the nonevaporable water content of companion pastes. Strength and maturity relationships were developed for 24 different mixtures, allowing strength prediction at any age and temperature.

Six binder systems with potential for slow strength gain under low temperature conditions were used to produce concrete specimens. The specimens were evaluated for mechanical properties—such as maturity-based rate of strength gain and flexural and compressive strengths—and for durability, including resistance to freeze–thaw and to scaling.

The sorptivity and the air-void system characteristics of the hardened concrete were studied, along

with the weight loss after drying. Specimens for the scaling tests were moist-cured, followed by air drying. Finally, the resistance to freeze–thaw and to scaling was related to the strength, the air-void spacing, the rate of water ingress, the rate of moisture loss at drying, and the slump.

Phase 2

In Phase 2, the cement–fly ash binder identified as the worst-performing in the laboratory underwent an in-depth investigation of scaling resistance under conditions that simulated an Indiana highway environment. Although the worst-performing mix had shown significant scaling in the laboratory, scaling was not observed under the simulated field conditions. This finding confirmed the observations in nine other states with climates similar to Indiana's; those states had approved the use of supplementary cementitious materials in pavements in late fall.

Strength, air content, and air-void spacing requirements were developed from the study's findings. In addition, a risk analysis indicated that the probability of scaling on a typical Indiana concrete pavement was less than 0.5%. All seven combinations of cementitious materials in the study either satisfied or exceeded the scaling resistance requirement in the ASTM C-672 test.

Application

The study provided a tool for contractors and Indiana DOT to minimize the risk of placing inappropriate mixes of concrete in the late fall. To foster implementation, mathematical models were developed to indicate maturity parameters to minimize the risk in the field. These included the ultimate compressive strength and the rate of reaction of mortar mixture in relation to the amount, chemical composition, and physical characteristics of supplementary cementitious materials. Contractors are effectively using the maturity method to predict the age required to attain a given strength level with curing at any temperature.

With the study's findings, Indiana DOT revised and implemented the standard specification for concrete pavement during the 2006 and 2007 construction seasons to allow the use of fly ash or slag up to November 15. The contractor, however, must understand the risk to freeze–thaw resistance if the target strength of 3,500 psi is not achieved.

Benefits

The responses from industry and Indiana DOT construction engineers have been positive. The findings of the public–private joint study contributed to a new specification that has lowered the cost of concrete pavement projects, extended the construction season, and addressed the occasional issue of cement shortage in the state by encouraging the use of waste cementitious materials for pavement construction.

The Super-70 pavement replacement project in downtown Indianapolis was completed in November 2007 under a revised specification allowing the use of fly ash or slag in concrete mixes through late fall.

The cost savings from an extended construction season with the use of fly ash or GGBFS were documented in 2006 and 2007. The savings per cubic yard of concrete with fly ash or GGBFS is $2.59 for a typical Indiana DOT mix with 564 pounds of cement per cubic yard. In a typical late fall pavement construction season, therefore, a potential savings in the range of $52,000 to $78,000 is possible for a project that requires 20,000 to 30,000 cubic yards of concrete. In the recent reconstruction of Interstate 70 in downtown Indianapolis, 58,300 cubic yards of concrete were placed between October 15 and November 15, producing a cost savings of $151,000 for the project.

For more information, contact Tommy E. Nantung, Section Manager, Indiana Department of Transportation, Office of Research and Development, 1205 Montgomery Street, West Lafayette, IN 47906, telephone 765-463-1521, ext. 248, e-mail tnantung@indot.in.gov

EDITOR'S NOTE: Appreciation is expressed to Inam Jawed, Transportation Research Board, for his efforts in developing this article.

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

John P. Broomfield

Broomfield Consultants

Independent consultant and materials engineer John Broomfield specializes in preventing the corrosion of steel in concrete and in steel-framed structures. In his 29-year career in transportation, he has gained comprehensive knowledge in technical areas that include electrochemical rehabilitation techniques for concrete and steel-reinforced structures, corrosion rate measurement and inhibitors, and residual life modeling, as well as experience in the preparation of specifications, repair design, supervision and commissioning, research, product development, and training.

Broomfield has served as a technical contract manager with the first Strategic Highway Research Program (SHRP), Washington, D.C.; as a research engineer with Taywood Engineering, Southall, Middlesex, United Kingdom; and as a corrosion scientist at the Central Electricity Research Laboratory, Leatherhead, United Kingdom.

"It is crucial that there is adequate investigation and analysis before design and construction on a project begin."

Broomfield considers his time with SHRP to be a highlight of his career. He participated in state-of-the-art projects on highway materials, worked to develop investigation and repair techniques, and went on to author *Corrosion of Steel in Concrete: Understanding, Investigation, and Repair*—a guidebook now in its second edition—for transportation personnel involved in designing, constructing, and maintaining buildings, bridges, and other reinforced concrete structures.

A significant personal and professional achievement is Broomfield's ongoing work since 2003 on the Teaching Wall at the University of East Anglia, Norfolk, England. The wall consists of a group of reinforced concrete buildings containing offices, labs, and lecture rooms, with water tanks above lift towers that are set at intervals. As a corrosion specialist with Jacobs Babtie Consultants, Broomfield was tasked with applying forensic structural engineering to all of the reinforced concrete structures that had exposed facades on the East Anglia campus, including elevated walkways and bridges, which had been subjected to more than 40 years of deicing salts.

"We surveyed the site and developed a model for the time-to-corrosion for each element or group of elements of concrete structures, to figure out what was corroding," Broomfield recalls. "Our findings enabled us to select the most cost-effective repair for each element or structure. Our investigations revealed that a wide range of required repair techniques was necessary, and the project is continuing as the university's budget allows. Our work demonstrated the capabilities of life-cycle modeling of corrosion in concrete, and that the modeling could provide practical assistance to practitioners in selecting optimal repair techniques with minimal disturbance to historic structures and, in this case, to the campus environment."

As a consulting engineer, Broomfield places a high value on transportation research, as well as on keeping up-to-date with the latest in highway research developments. He maintains that "it is crucial that there is adequate investigation and analysis before design and construction on a project begin. Unexpected problems lead to delays, which lead to higher costs. Judicious application of trials can show the potential snags for a new or innovative practical approach."

He advises students of transportation, as well as young transportation professionals, to focus on understanding the materials, design, and maintenance requirements of the current highway infrastructure, and to work with departments of transportation that are willing to support transportation research for finding cost-effective solutions to extending the life of highway infrastructure.

Broomfield has participated in TRB activities—including Annual Meetings—since 1988. He has chaired and is an emeritus member of the Corrosion Committee; served as a liaison representative on the National Cooperative Highway Research Program Project Panel on the Performance of Epoxy-Coated Reinforcing Steel in Highway Bridges; and is a past member of the Maintenance Section.

Other professional organizations to which Broomfield has contributed include the Institute of Materials, Institute of Corrosion, Concrete Society, American Concrete Institute, American Society for Testing and Materials, Institute of Civil Engineers, National Association of Corrosion Engineers (NACE), and the International Concrete Repair Institute. He is a registered European engineer, a chartered engineer, and a NACE International–certified corrosion specialist.

Broomfield holds a patent for technology in the corrosion of steel in concrete and has authored more than 100 published papers and articles, one book, and three book chapters. He earned a bachelor's degree in chemical physics from the University of Sussex, Brighton, England, in 1976, and a doctorate in metallurgy and materials science from the University of Oxford, England, in 1980.

Jo Strang

Federal Railroad Administration

With a leadership style grounded in vision, reality, ethics, and courage, Jo Strang has worked to change rail industry culture and to achieve meaningful and sustained improvements in rail safety. Appointed Federal Railroad Administration (FRA) Associate Administrator for Safety in 2006, Strang also has served as FRA's Acting Associate Administrator, Deputy Associate Administrator for Railroad Development, and Region 4 Deputy Regional Administrator.

Under Strang's leadership, the FRA Office of Safety is successfully implementing provisions of the National Rail Safety Action Plan—a 2005 plan to reduce accidents resulting from human error on U.S. railroads, minimize the dangers of crew fatigue, deploy state-of-the-art technologies to detect track defects, and concentrate inspection on safety trouble spots.

"FRA has worked to focus safety inspection activities and resources by developing new applications to facilitate uniform comparison of information across all rail safety disciplines."

"FRA has worked to focus safety inspection activities and resources by developing new applications to facilitate uniform comparison of information across all rail safety disciplines," Strang comments. "I am overseeing FRA's effort to encourage the railroad industry to deploy safe and proven electronically-controlled pneumatic (ECP) brake technology. To support this new technology we have published a report that details the business benefits of ECP brakes, and we are working to revise federal regulations."

In addition to her work on the National Rail Safety Action Plan, Strang is establishing risk reduction programs to supplement traditional rail safety enforcement models, including the Close Call Reporting System project. Now in its second year, the project focuses on the identification and correction of systemic rail safety issues by allowing rail employees to report confidentially any incidents that have accident potential but that do not cause accidents.

Other projects to which Strang has contributed include the first Intelligent Transportation Systems Joint Program Office–funded, shared-use study, as well as an FRA Office of Research and Development effort to advance positive train control (PTC) technology, which was designed to prevent train collisions and high-speed derailments.

"As a result of our efforts, PTC technology is being pursued by the four major Class I railroads and is starting to be deployed; our next challenge is to help make the technology more affordable," Strang reports. "Track inspection technology for detecting internal rail defects, cracks in joint bars, and changes in track geometry already is leading to reductions in train derailments. Additionally, railroads are embracing the systematic collection of information, performing trend analysis, and linking defects to geographic locations."

A proponent of workplace diversity, Strang has developed initiatives that include restructuring the FRA Inspector Trainee Program and many positions to recruit from a wide range of grade levels; fostering the Upward Mobility Program; training managers and employees on the necessity of deploying a workforce that reflects the diversity of the United States; and stressing the significance of telecommuting as a quality-of-life benefit.

An active affiliate of TRB, Strang has provided significant substantive assistance to the National Research Council–appointed TRB Committee for Review of the FRA Research, Development, and Demonstration Programs, as well as for the planning and conduct of the 2006 Workshop on Research to Enhance Rail Network Performance. She is a past member of the Rail Group and has attended TRB Annual Meetings since 1995.

Strang has received many awards for her contributions to transportation, including the FRA Diversity Achievement Award and the Federal Laboratories Excellence in Technology Transfer Award in 2007; the National Transportation Safety Board's Managing Director's Award and Outstanding Performance Award in 2001 and 2002, respectively; the Vice President's Hammer Award in 1999; the Secretary of Transportation's Gold Medal Award for Outstanding Achievement in 1998; the FRA Administrator's Superior Achievement Award in 1996 and in 1998; and the U.S. Army Corps of Engineers' Civilian Achievement Medal in 1994.

Mass Transit published a paper by Strang in 2007 on trends in current FRA passenger rail safety research crashworthiness, interior occupant protection, emergency egress and response, and the use of an FRA-developed rollover rig for training emergency responders. She holds a master's degree in public policy economics, econometrics, and statistics from Marquette University, Milwaukee, Wisconsin.

Phoenix, Arizona, has developed rapidly from the nation's 99th largest city in 1950 to the 7th largest today, spreading from 17.1 square miles of area to 470 square miles.

Gauging Urban Growth and Traffic

A recent survey by the Urban Land Institute examining the 23 largest and fastest-growing metropolitan areas in the United States has led to predictions of an average population increase of 39 percent and an average traffic growth of 51 percent in the next 25 to 30 years. Growing transportation system demands are cited as a significant problem for regions struggling with development and traffic congestion.

The fastest-growing regions are Phoenix, Arizona; Houston, Texas; and Orlando, Florida—where population growth is expected to increase by 53 percent to 87 percent, with congestion projected to double for Phoenix and Houston. Many regions are instituting alternative scenarios to direct growth into established areas that offer options for transportation, with less dependence on the automobile.

Per capita transportation spending is expected to increase by 24 percent, regional highway plans by 9 percent, and transit plans by 52 percent. Twelve large regions are planning on long-term transit, including Washington, D.C.; Los Angeles, San Diego, and San Francisco, California; Dallas, Texas; Atlanta, Georgia; Phoenix, Arizona; Minneapolis–St. Paul, Minnesota; St. Louis, Missouri; and Milwaukee, Wisconsin.

For more information, visit www.uli.org.

Rail Plan Lowers Accident Rates

The number of train accidents in the United States decreased by 23.3 percent from 2004 to 2007. According to the U.S. Department of Transportation's *National Rail Safety Action Plan Final Report*, keys to the reduction were the *Rail Safety Action Plan*, the Federal Railroad Administration's comprehensive freight and passenger rail safety programs, and the work of railroads and rail employees.

Accidents attributed to track flaws and human factors—the most common causes of rail accidents—fell by 27.2 percent and 13.8 percent, respectively. Additionally, grade-crossing collisions declined by 10.9 percent; grade-crossing fatalities by 8.9 percent; and the train accident rate by 25 percent. The train accident rate reached a 10-year low in 2007 of 3.3 accidents per million train miles.

Launched in May 2005, the *Rail Safety Action Plan* focuses on eliminating high-risk causes of train accidents; accelerating research to strengthen rail tank cars carrying hazardous materials; addressing the effects of fatigue on train crews; enhancing highway–rail grade crossing safety; and using data in new ways to direct federal inspection resources to the places that need the most attention.

For more information and to view a copy of the National Rail Safety Action Plan Final Report, *visit http://fastlane.dot.gov.*

ECO POWER—On May 27, CSX Transportation, the Michigan Department of Transportation, and the Southeast Michigan Council of Governments inaugurated state-of-the-art GenSet locomotives at the CSX Rougemere railyard in Dearborn, Michigan. Powered by ultra-low-emission diesel engines that meet U.S. Environmental Protection Agency Tier 3 emissions standards, the locomotives feature six traction monitors, an engine-idle monitoring technology, and an engine sleep mode, which can reduce nitrous oxide and particulate matter emissions by 80 percent and carbon dioxide emissions by 50 percent.

Northwestern Adds to TRIS Database

The Northwestern University Transportation Library has provided TRB with more than 19,100 environmental impact statement (EIS) bibliographic records for the Transportation Information Services (TRIS) bibliographic database. The addition of the impact statements makes the TRIS database—which contains more than 660,000 records of technical reports, journal articles, conference papers and monographs—one of the largest publicly accessible EIS collections.

The Northwestern collection contains approximately 80 percent of all EIS documents issued by U.S. federal agencies since 1969 and is considered one of the largest paper-based EIS collections in the country. The documents include final and supplementary reports, drafts, related environmental assessments, records of decisions, and maps.

For more information, visit http://tris.trb.org/about/ or www.library.northwestern.edu/transportation.

SPRING CAUCUS—In April, the Technical Coordinating Committee for Reliability Research of the Strategic Highway Research Program 2 hosted a working group of the joint Organization for Economic Cooperation and Development–International Transport Forum. The group presented research findings on ways to improve travel time reliability and levels of service on surface transportation networks in Europe. Participants included (*left to right*) Mark Bush, American Association of State Highway and Transportation Officials; Sarath Joshua, Maricopa Association of Governments; Lily Elefteriadou, University of Florida Transportation Research Center; Lap Thong Hoang, Florida Department of Transportation; Raj Ghaman, Federal Highway Administration (FHWA); and Regina McElroy, FHWA.

COOPERATIVE RESEARCH PROGRAMS NEWS

Determining Highway Maintenance Costs

Because of increased demand for highway maintenance, despite resource limitations, state departments of transportation (DOTs) and other highway agencies are considering nontraditional methods for the financing and contracting of highway maintenance services. State DOTs currently have no widely accepted process for determining the costs associated with highway maintenance performed by transportation agency employees. A process is needed for generating realistic estimates of maintenance service costs for highway agencies.

Cambridge Systematics, Inc., Cambridge, Massachusetts, has been awarded a $299,970, 24-month contract [National Cooperative Highway Research Program (NCHRP) Project 14-18, FY 2008] to develop a process for determining the highway agency costs associated with highway maintenance activities and to provide guidance for estimating data that are not readily available. The proposed process will be considered for adoption by the American Association of State Highway and Transportation Officials.

For more information, contact Amir N. Hanna, TRB, 202-334-1892, ahanna@nas.edu.

Establishing Procedures for Pavement Selection

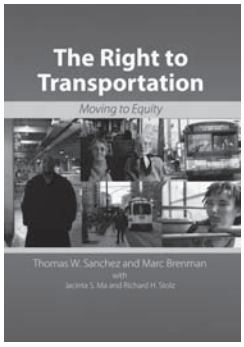
The *Mechanistic–Empirical Pavement Design Guide*, developed under NCHRP, describes engineering, traffic, construction, and economic considerations involved in the selection of pavement type and strategy, but does not identify procedures for comparing alternatives and making a pavement selection. Additionally, recent developments in construction practices, contracting approaches, and materials utilization may influence the pavement-type selection process.

The process traditionally uses life-cycle cost analysis to model the cost of pavement alternatives during a performance period. Some state DOTs are developing processes for the selection of pavement type or other highway materials through the bidding process. Some pavement selection processes have not been well documented, raising concerns about their effectiveness and impartiality. Current practices should be identified to develop rational processes that provide a realistic means for pavement-type selection.

Applied Pavement Associates, Inc., Champaign, Illinois, has been awarded a $299,911, 24-month contract (NCHRP Project 10-75, FY 2008) to develop a guide for pavement-type selection, incorporating agency-based and contractor-based processes.

For more information, contact Amir N. Hanna, TRB, 202-334-1892, ahanna@nas.edu.

The Right to Transportation: Moving to Equity



Thomas Sanchez, Marc Brenman, Jacinta Ma, and Richard Stolz. American Planning Association (APA), 2008; 241 pp.; APA member, $35.95; nonmember, $47.95; 978-1932364293.

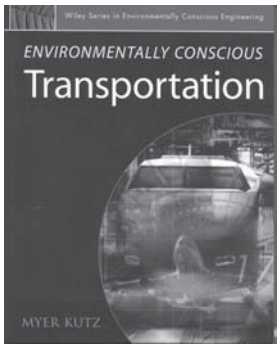
With a premise that transportation directly affects the lives of minority, low-income, elderly, and physically disabled citizens, the authors maintain that transportation policies can limit access to education, jobs, and services, as well as undermine the economy and the social cohesion of communities.

Presented are strategies and policies to address inequalities in the U.S. transportation and transportation planning systems by extending the benefits and burdens of the systems equally to all communities. Transportation policies and their effects on individuals are examined; demographic trends, historical events, and current policies shaping transportation in the United States are explained; and recommendations for creating policies that ensure equity are offered. Coauthor Thomas Sanchez chairs the TRB Social and Economic Factors of Transportation Committee.

Environmentally Conscious Transportation

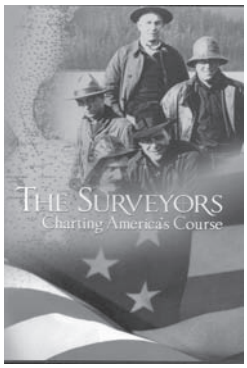
Myer Kutz. Wiley, 2008; 350 pp.; $120; 0471793698.

The 5th volume in the Wiley series on environmentally conscious engineering presents a foundation for understanding and implementing methods for reducing the environmental impacts of transportation modes—public transportation, passenger cars, heavy trucks and buses, rail, and aircraft.



Each of the 12 chapters covers practical and analytic techniques for improving the reliability of vehicles and of the infrastructure, as well as for measuring and reducing pollution produced by the transportation system. Specific topic areas include economic and environmental footprints of transportation; public transportation and the environment; transportation and air quality; electric and hybrid vehicle design and performance; and biofuels. The text examines the social costs of transportation in a broad sense and should be of use to environmental, civil, transportation, mechanical, and industrial engineers, as well as to public policy planners and officials.

The Surveyors: Charting America's Course (DVD)



National Oceanic and Atmospheric Administration, 2008; 26 min., 40 sec.

A historical overview of the National Oceanic and Atmospheric Administration (NOAA), this DVD guides viewers through the work of the earliest U.S. surveyors, including Thomas Jefferson's establishment of the Survey of the Coast in 1807, up to the modern-day NOAA.

To download or view a streaming version of this video, visit the NOAA website at http://celebrating200years.noaa.gov/surveyors.html.

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

TRB PUBLICATIONS

Management and Maintenance of the Infrastructure

Transportation Research Record 1991

Procedures for estimating annualized life-cycle costs of road infrastructure for road classes and geographic regions of Canada; a ranking procedure that employs statistical hypothesis testing to address highway sections in need of repair; a new index for concrete bridge deck management in Utah; best practices for rehabilitation and relocation of historic, metal truss bridges; and a modified direct tensile test method to predict low-temperature properties of hot-poured, bituminous crack sealants are among the topics examined in this volume.

2007; 132 pp.; TRB affiliates, $41.25; nonaffiliates, $55. Subscriber category: maintenance (IIIC).

Transit: Management, Technology, and Planning

Transportation Research Record 1992

Research findings are reported on the market effects of automobile gas prices on domestic and international transit demand; system planning for developing successful large-scale transportation projects; the state and regional transportation agencies in the United States adopting smart-card technology; the long-term impacts of the City Car Share program in San Francisco, California; the Federal Transit Administration's

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sampling plans to estimate the use of fixed-route bus services in the United States; and more.

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Data, Survey Methods, Traffic Monitoring, and Asset Management
Transportation Research Record 1993
Topics include an operational-performance-measure-based system for transportation agency executives; an evaluation of wireless, probe-monitoring systems for traffic monitoring; the impact of traffic flow on the travel time variability of freeway corridors, using data from China and the Netherlands; nonresponse errors in a Swedish travel survey; and a real-time system for detection and tracking of automobile base fronts for measuring traffic counts and speeds on highways.

2007; 174 pp.; TRB affiliates, $46.50; nonaffiliates, $62. Subscriber category: planning and administration (IA).

Crosscutting Techniques for Planning and Analysis 2007
Transportation Research Record 1994
Researchers explore a decision support system for use in transportation projects that require new utility construction; the safety impacts of access management techniques on arterial roads in Utah; factors that affect mode choice at worksites; the influence of knowledge accessibility on innovation in northern Taiwan; a tour-based, fleet allocator model for Calgary, Canada; a geographic information system used as a supply-side component in a comprehensive land use modeling framework; and more.

2007; 158 pp.; TRB affiliates, $43.50; nonaffiliates, $58. Subscriber category: planning and administration (IA).

Railways 2007
Transportation Research Record 1995
Presented are findings on the application of low-cost airline industry pricing strategies to European railway networks; characteristics of potential high-speed rail corridors in the United States; the development and testing of a crew-resource-management training course for the U.S. rail industry; a probabilistic model for predicting rail breaks and reducing the risk of train derailment; and more.

2007; 83 pp.; TRB affiliates, $35.25; nonaffiliates, $47. Subscriber category: rail (VII).

Finance, Congestion Pricing, Economics, and Economic Development 2007
Transportation Research Record 1996
Authors present research on a new public support mechanism for toll road concession contracts in Spain; public–private concessions for toll road projects; financing obstacles for transit-oriented development; methods for increasing the probability of success in road-pricing projects; behavioral impacts of a high-occupancy toll rate on automobile drivers in Minnesota; and a methodology to evaluate air-travel service and its impact on economic development in the state of Alaska.

2007; 105 pp.; TRB affiliates, $36.75; nonaffiliates, $49. Subscriber category: planning and administration (IA).

Innovative Planning Approaches 2007
Transportation Research Record 1997
The organizational structures of independent metropolitan planning organizations in Florida; transportation planning and infrastructure delivery for major cities and megacities; a manual travel allocation spreadsheet for cost-effective transportation development in small towns; public transportation ridership models for transportation demand forecasting in three Washington State counties; and innovative consulting practices applied by tribes, states, and metropolitan planning organizations for transportation planning are some of the topics presented in this volume.

2007; 55 pp.; TRB affiliates, $31.50; nonaffiliates, $42. Subscriber category: planning and administration (IA).

Bituminous and Nonbituminous Materials of Bituminous Paving Mixtures 2007
Transportation Research Record 1998
Included is research on the effects of aggregate surface and water on the rheology of asphalt films; the effects of moisture, polymer modification, and long-term aging on asphalt binder bond strength; a dynamic creep test for the evaluation of asphalt binder elastic response; the effect of aggregate degradation on the volumetric properties of hot-mix asphalt during mixing and compaction; and the effect of calcareous fillers on the aging process of bituminous asphalt mix.

2007; 148 pp.; TRB affiliates, $43.50; nonaffiliates, $58. Subscriber category: materials and construction (IIIB).

Traffic Flow Theory 2007
Transportation Research Record 1999
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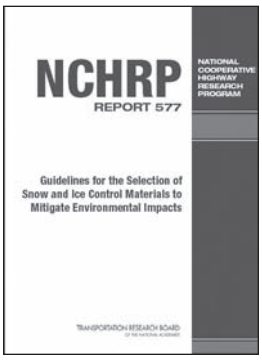

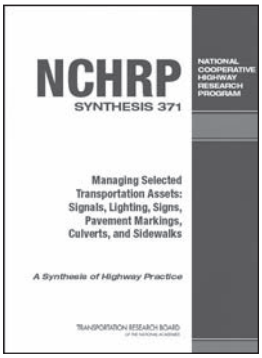

ings on an extended speed gradient model for studying the mixed traffic flow of two vehicle types with differing velocities and lengths; speed-limit control at freeway bottlenecks using the Kerner–Klenov microscopic stochastic traffic flow model in the context of the Kerner three-phase traffic theory; traffic incidents and reductions in freeway capacity in microscopic simulation models; characteristics of speed dispersion in urban freeway traffic; a mathematical framework and solution approach for the calibration of microscopic traffic simulation models; and more.

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Intelligent Transportation Systems and Vehicle–Highway Automation 2007
Transportation Research Record 2000
Topics examined include the limitations of variable message signs in an urban road network; an adaptive automobile cruise control strategy for varied traffic situations and driving styles; an online dynamic traffic control strategy for an urban expressway–arterial corridor system; a methodology for assessing benefits of an incident management program in an advanced transportation management system; and an adaptive route choice model for personalized route guidance.

2007; 127 pp.; TRB affiliates, $41.25; nonaffiliates, $55. Subscriber category: highway operations, capacity, and traffic control (IVA).

Bituminous Paving Mixtures 2007
Transportation Research Record 2001
Research presented in this volume includes a Fred Burggraf Award-winning paper on methods for measuring the specific gravity of hot-mix asphalt; an analytical method for calculating an asphalt pavement resilient modulus from a dynamic modulus; a method for predicting an asphalt pavement resilient modulus from a dynamic modulus; predictive models for the viscosity and complex shear modulus of asphalt binders; approaches for predicting fatigue cracking of asphalt pavements; and more.

2007; 168 pp.; TRB affiliates, $43.50; nonaffiliates, $58. Subscriber category: materials and construction (IIIB).

Pedestrians 2007
Transportation Research Record 2002
This volume gathers papers on topics such as a cost–benefit analysis for nonmotorized transport in Montreal, Quebec, Canada; a model for estimating the mode share of nonmotorized trips using data from multiple sources; deficiencies in Florida state-maintained pedestrian crash data; methods for identifying high-risk pedestrian crash locations; placement of and motorist adherence to in-roadway, yield-to-pedestrian signs; a comparison between pedestrian average walking speed and walking speed at signalized crosswalks; and more.

2007; 130 pp.; TRB affiliates, $41.25; nonaffiliates, $55. Subscriber category: safety and human performance (IVB).

Travel Demand 2007
Transportation Research Record 2003
Research papers include a dynamic activity choice model of urban commercial activity patterns for vehicles and people; an event-driven, queue-based, traffic flow microsimulation for large-scale scenarios; incorporation of a destination–choice model for detour time with an activity-based model of travel demand for modeling choice of location in daily activity sequences; the effects and relevance of choice set composition in route choice modeling; and an examination of the Land Use Scenario Developer model.

2007; 138 pp.; TRB affiliates, $41.25; nonaffiliates, $55. Subscriber category: planning and administration (IA).

Soil Mechanics 2007
Transportation Research Record 2004
Part 1: Geotechnical Engineering Aspects of Foundations contains papers on a neural network model to predict pile setup and on the development and calibration of a new pile-driving formula. Part 2: Geotechnical Instrumentation includes research on an instrumenting pencel pressuremeter control unit to simplify data collection, reduction, and analysis, and on a wireless, shape–acceleration array system for local identification of soil and soil structure systems. Part 3: Use of Smart Equipment in Earthwork Construction presents findings on lightweight deflectometer use for field assessment of pavement material stiffness and on alternative water sources for earthwork construction. Part 4: Pavements, Reflective Cracking, Geosynthetic Reinforcement and Subsurface Drainage addresses the use of geogrids to minimize reflective, longitudinal cracking on pavements over shrinking subgrades and offers guidelines for using geosynthetics with hot-mix asphalt overlays to reduce reflective cracking in pavements.

2007; 172 pp.; TRB affiliates, $46.50; nonaffiliates, $62. Subscriber category: soils, geology, and foundations (IIIA).

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Guidelines for the Selection of Snow and Ice Control Materials to Mitigate Environmental Impacts
NCHRP Report 577
The cost and impacts of snow and ice control materials on infrastructure and the environment are evaluated. Examined are tools for the selection of materials to suit the specific needs of highway agencies, a purchase specification, and a quality assurance monitoring program that includes procedures and standard tests to characterize snow and ice control products before purchase or use.

2007; 194 pp.; TRB affiliates, $37.50; nonaffiliates, $50. Subscriber categories: energy and environment (IB); maintenance (IIIC).

Evaluating Air-Entraining Admixtures for Highway Concrete
NCHRP Report 578
A procedure is presented for evaluating air-entraining admixtures in highway concrete, and criteria are proposed for acceptance of admixtures for highway pavements and structures. The recommended procedure and acceptance criteria will guide materials engineers in evaluating and selecting air-entraining admixtures that contribute to freeze–thaw durability, good performance, and long service life.

2007; 49 pp.; TRB affiliates, $27; nonaffiliates, $36. Subscriber category: materials and construction (IIIB).

Application of LRFD Bridge Design Specifications to High-Strength Structural Concrete: Shear Provisions
NCHRP Report 579
Presented is research on extending the applicability of shear design provisions in the *AASHTO LRFD Bridge Design Specifications* manual for reinforced and prestressed concrete structures to compressive strengths greater than 10 ksi. Recommended revisions to the specifications are included.

2007; 198 pp.; TRB affiliates, $39.75; nonaffiliates, $53. Subscriber category: bridges, other structures, and hydraulics and hydrology (IIC).

Design of Construction Work Zones on High-Speed Highways
NCHRP Report 581
Included is an approach for selecting appropriate types of construction work zones; guidance for the design of geometric features, including horizontal and vertical alignment, cross-sectional features, and barrier placement; and an examination of ancillary features, such as drainage systems, lighting, and surface types.

2007; 65 pp.; TRB affiliates, $28.50; nonaffiliates, $38. Subscriber category: highway and facility design (IIA).

Managing Selected Transportation Assets: Signals, Lighting, Signs, Pavement Markings, Culverts, and Sidewalks
NCHRP Synthesis 371
This synthesis explores the state of the practice for managing transportation infrastructure assets other than pavements and bridges, documents gaps in knowledge, and identifies areas that need further study.

2007; 190 pp.; TRB affiliates, $38.25; nonaffiliates, $51. Subscriber categories: bridges, other structures, and hydraulics and hydrology (IIC); maintenance (IIIC); safety and human performance (IVB).

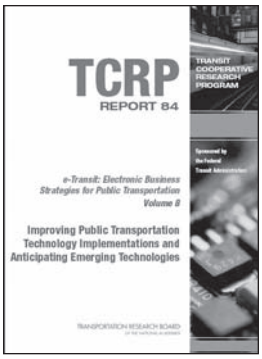
Emerging Technologies for Construction Delivery
NCHRP Synthesis 372
Examined are five emerging technologies for transportation construction: Global Positioning Systems for layout, machine guidance, and quantity tracking; handheld computers for construction records; automated temperature tracking for concrete maturity monitoring; four-dimensional computer-aided drafting for constructability analysis and improved communications; and web-based video cameras for remote project monitoring.

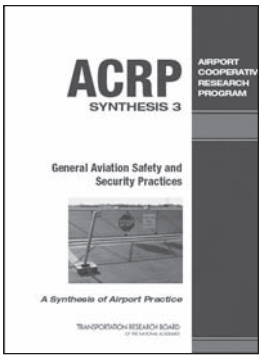
2007; 111 pp.; TRB affiliates, $35.25; nonaffiliates, $47. Subscriber category: materials and construction (IIIB).

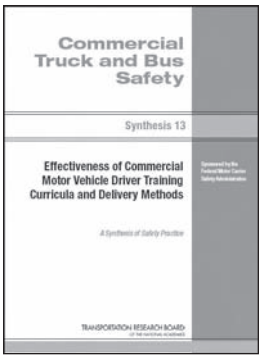
Multidisciplinary Teams in Context-Sensitive Solutions
NCHRP Synthesis 373
This synthesis explores multiple perspectives and disciplines in the decision-making process for developing transportation solutions that improve quality of life for communities served by transportation agencies.

2007; 83 pp.; TRB affiliates, $32.25; nonaffiliates, $43. Subscriber categories: planning and administration (IA); energy and environment (IB); and highway and facility design (IIA).

e-Transit: Electronic Business Strategies for Public Transportation, Volume 8: Improving Public Transportation Technology Implementations and Anticipating Emerging Technologies
TCRP Report 84, Volume 8
The value of current technologies used in public transportation is explored, and methods for improving the success of technology implementation are examined.







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Five promising emerging technologies for transit agencies are reviewed.

2008; 76 pp.; TRB affiliates, $35.25; nonaffiliates, $47. Subscriber category: public transit (VI).

Guidebook for Evaluating, Selecting, and Implementing Suburban Transit Services

TCRP Report 116

Examined are the current status and interrelationship of suburban transit services and land use environments. Characteristics are identified to help policy boards and transit agencies better understand service options, attributes, and other issues involved in suburban transit services.

2006; 33 pp.; TRB affiliates, $22.50; nonaffiliates, $30. Subscriber category: public transit (VI).

Design, Operation, and Safety of At-Grade Crossings of Exclusive Busways

TCRP Report 117

This report examines the planning, design, and operation of various at-grade intersections, as well as busways within arterial street medians; physically separated, side-aligned busways; busways on separate rights-of-way; and bus-only ramps. Guidance is provided for enhancing safety at crossings, maintaining efficient transit and highway operations, and minimizing pedestrian delay.

2007; 39 pp.; TRB affiliates, $25.50; nonaffiliates, $34. Subscriber categories: planning and administration (IA); public transit (VI).

Bus Rapid Transit Practitioner's Guide

TCRP Report 118

Provided is information on planning and decision making for implementing components of bus rapid transit (BRT) systems. Included are updates to information presented in *TCRP Report 90: Bus Rapid Transit*, as well as highlights of the costs and impacts of implementing BRT components and their effectiveness.

2007; 242 pp.; TRB affiliates, $41.25; nonaffiliates, $55. Subscriber category: public transit (VI).

Bus Transit Service in Land Development Planning

TCRP Synthesis 67

The relationship between bus transit service and land development planning is described and the strategies for—and challenges of—incorporating bus transit service into land development are identified. Also provided is information on the use of transit agency development guidelines and their components.

2006; 62 pp.; TRB affiliates, $24; nonaffiliates, $32. Subscriber category: public transit (VI).

Methods of Rider Communication

TCRP Synthesis 68

This synthesis documents effective methods of communicating with transit customers in various situations. The state of the practice in transit agency communications with customers is discussed, and criteria are presented for determining successful communication. Other pointers cover the agency's target audience and its location; the content, form, and accessibility of the communication; the timing and frequency; the dissemination media; and the associated capital and operating costs.

2006; 91 pp.; TRB affiliates, $26.25; nonaffiliates, $35. Subscriber category: public transit (VI).

Web-Based Survey Techniques

TCRP Synthesis 69

Described is the state of the practice for web-based surveys. Resources are provided for successful application, along with information on the technologies necessary for conducting web-based surveys and case studies of transit agency use of web-based surveys.

2006; 104 pp.; TRB affiliates, $23.25; nonaffiliates, $35. Subscriber category: public transit (VI).

General Aviation Safety and Security Practices

ACRP Synthesis 3

Current practices in safety and security at general aviation airports are identified, and aviation community resources used in the development of safety and security programs are reviewed. The synthesis also presents sources of funding and budget issues that determine safety and security.

2007; 44 pp.; TRB affiliates, $25.50; nonaffiliates, $34. Subscriber category: aviation (V).

Effectiveness of Commercial Motor Vehicle Driver Training Curricula and Delivery Methods

CTBSSP Synthesis 13

The state of commercial motor vehicle (CMV) operator training in the trucking and motor coach industries, as well as CMV training programs that combine simulators and computer-based instruction, are explored. Included are measures of training effectiveness used in the CMV community.

2007; 33 pp.; TRB affiliates, $25.50; nonaffiliates, $34. Subscriber categories: operations and safety (IV); freight transportation (VIII).

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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, 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, geology, law, environmental concerns, energy, etc.). Manuscripts should be no longer than 3,000 to 4,000 words (12 to 16 double-spaced, typed pages). Authors also should provide appropriate and professionally drawn line drawings, charts, or tables, and glossy, black-and-white, high-quality photographs with corresponding captions. 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.

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- All manuscripts should be supplied in 12-point type, double-spaced, in Microsoft Word 6.0 or WordPerfect 6.1 or higher versions, on a diskette 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 or greater. 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.

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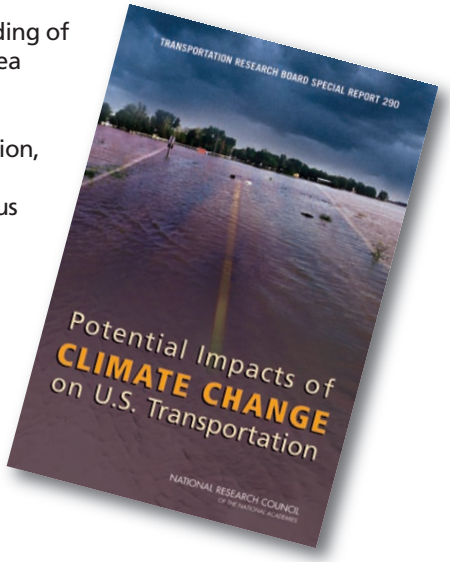
Potential Impacts of Climate Change on U.S. Transportation

New Release!

Every mode of transportation in the United States will be affected as the climate changes. Potentially the greatest impact on transportation systems will be the flooding of roads, railways, transit systems, and airport runways in coastal areas because of rising sea levels and surges brought on by more intense storms. Although the impacts of climate change will vary by region, they will be widespread and costly in human and economic terms and will require significant changes in the planning, design, construction, operation, and maintenance of transportation systems.

This National Research Council report presents an overview of the scientific consensus about the current and future climate changes affecting U.S. transportation, including the limits of scientific understanding of the timing, magnitude, and location of the effects; identifies the potential impacts on U.S. transportation and the options for adaptation; and recommends research and actions to prepare for climate change. The report also summarizes previous work on strategies for reducing the transportation-related emissions of carbon dioxide—the primary greenhouse gas—which contribute to climate change.



TRB Special Report 290, ISBN 978-0-309-11306-9, 280 pages, 6 x 9, paperback, $37.00

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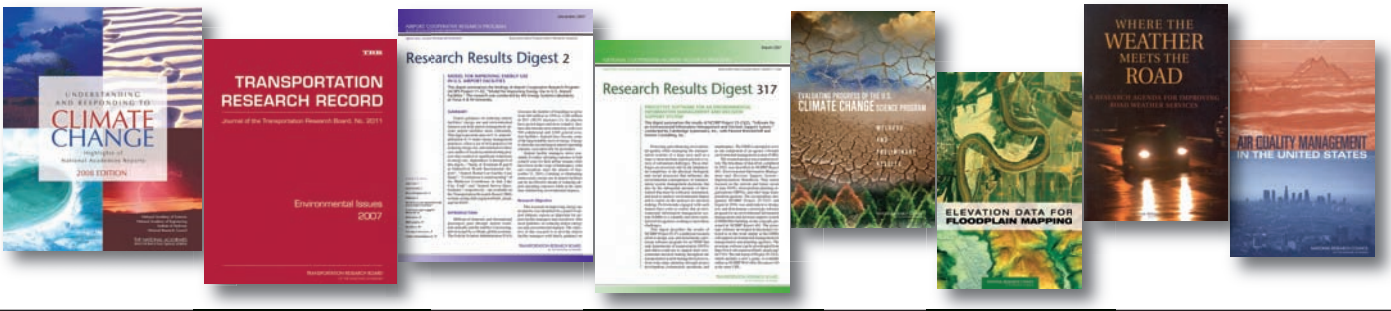
NRC, ISBN 0-309-08932-8, 426 pages, 6 x 9, paperback, 2004, $58.50



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