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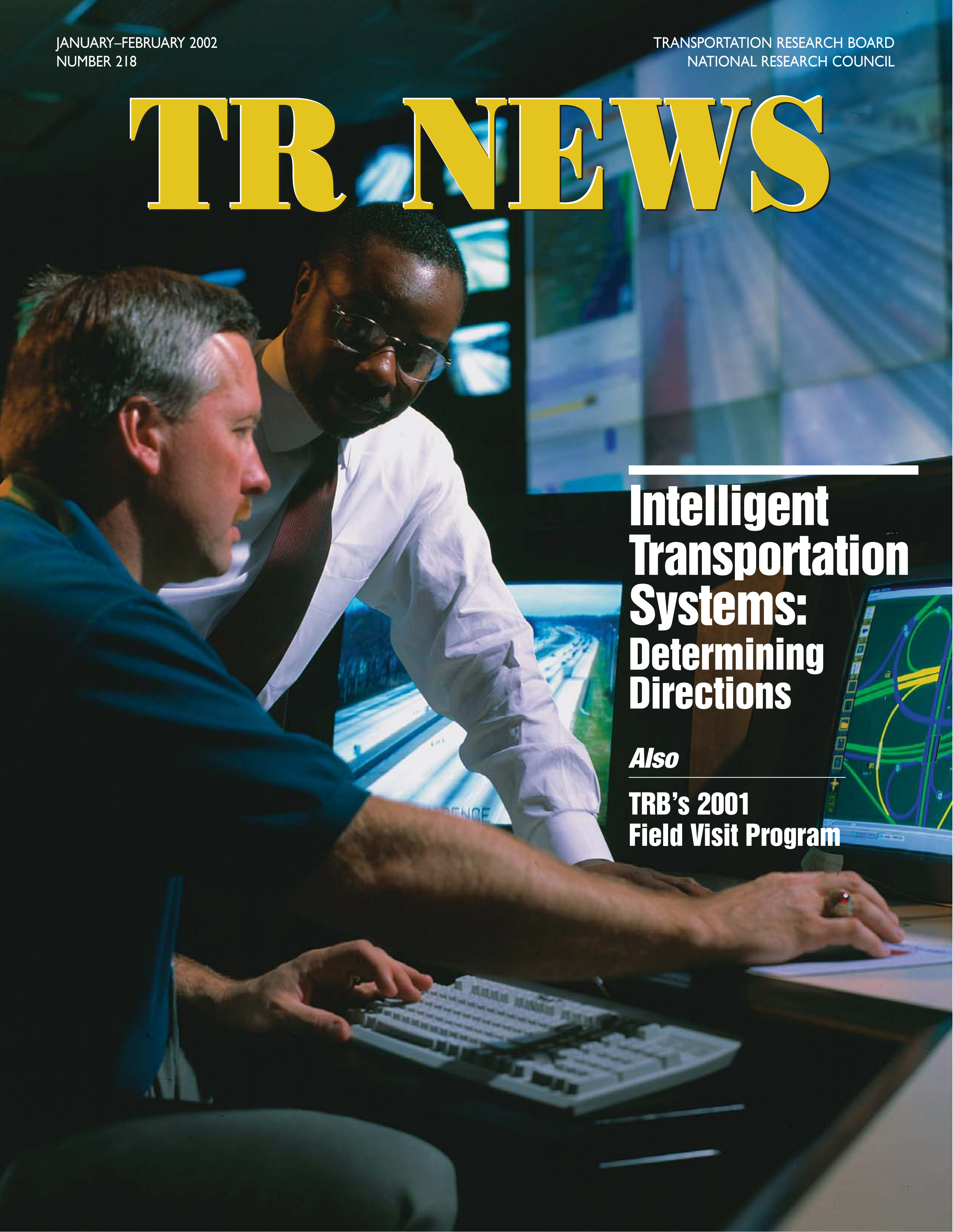
TR NEWS



Intelligent Transportation Systems: Determining Directions

Also

TRB's 2001 Field Visit Program

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TR NEWS

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Intelligent Transportation Systems: Determining Directions

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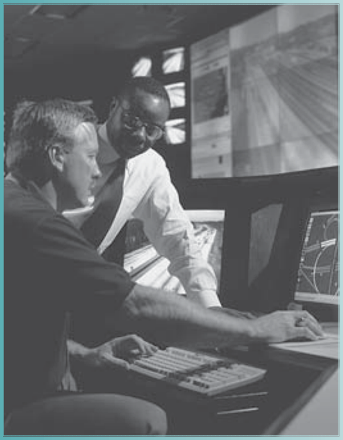

Cover: Michael Corwin (*left*), URS Corporation, and Stephany Hanshaw, Virginia Department of Transportation (VDOT), use the Smart Traffic Center of Hampton Roads in Virginia Beach (*photo by Tom Saunders, courtesy of VDOT*).

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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The upcoming March–April *TR News* features reports and highlights, including a section on transportation security, from the TRB 81st Annual Meeting, held January 13–17, 2002 in Washington, D.C.

U.S. Secretary of Transportation Norman Y. Mineta delivers remarks on the new Transportation Security Administration and the status of transportation since September 11.

Introduction

Intelligent Transportation Systems

Making Inroads

The technology of the age determines its transportation systems and the systems' performance. In the pre-industrial world, human and animal power were fundamental to transportation on land, and the forces of wind and moving water were harnessed for travel over water. The industrial world of the 19th century introduced motorized transport across water and along steel rails over land. The 20th century, with advances in propulsion and materials technologies, produced advances in road and air transportation.

Many have called the new century the Information Age; information technology can stimulate advances in transportation comparable in significance to any previous advances. However, realizing these advances requires thinking about transportation in more than traditional terms. The seeds of new thinking have been planted in the past 15 years with the development of intelligent transportation systems (ITS) but have yet to take root.

Nonetheless, deployment of ITS technology has begun; the articles in this special issue illustrate the breadth of the influence that ITS is having on transportation.

- The opening feature provides an overview of the opportunities that ITS technologies and applications present to integrate the transportation system and outlines the most pressing research needs.
- Joseph M. Sussman reviews the principal lessons from many of the ITS services since the federal program began nearly one decade ago.
- Pravin Varaiya shows how data collection and processing capabilities with ITS technologies have improved understanding of some basic issues in traffic engineering. Real-world data show that several assumptions that have prevailed for generations are not necessarily valid on today's freeways.
- Jon Bottom, Masroor Hasan, and Jane Lappin review the importance of information in travel decision making and point out the benefits that could become available through ITS.
- Thomas A. Horan shows how ITS can empower transportation system users with more choices and can encourage new ways of thinking about the market for transportation services.
- Andrew C. Lemer highlights findings of a TRB study examining the U.S. Department of Transportation's efforts to set national standards for ITS infrastructure.

With the assistance of colleague William Johnson, several of the authors developed the articles for this issue working as a task force of the TRB Committee on Intelligent Transportation Systems, which is chaired by Richard Weiland.

Steven E. Shladover

Deputy Director, Partners for Advanced Transit and Highways,
University of California, Berkeley

Editor's Note: Appreciation is expressed to Richard Cunard, Engineer of Traffic and Operations, TRB, for his efforts in coordinating this issue of *TR News*. B. Ray Derr, Senior Program Officer, National Cooperative Highway Research Program, also served as an adviser.

ITS

Introducing Intelligent Transportation Systems

Paradigm for 21st Century Transportation

STEVEN E. SHLADOVER

The author is Deputy Director of the Partners for Advanced Transit and Highways (PATH) Program administered by the Institute of Transportation Studies, University of California, Berkeley, and is a member of the TRB Committee on Intelligent Transportation Systems (ITS), the Committee on Vehicle–Highway Automation, and the Committee for the Review of the U.S. Department of Transportation's ITS Standards Program.

The term "intelligent transportation system" (ITS) means different things to different people. Some define ITS with an "alphabet soup" of "user service" acronyms; others define ITS as a U.S. Department of Transportation (DOT) program; and yet others see it as technological gadgetry with limited significance. But these are narrow perspectives that miss the fundamental importance of ITS.

The term has inherent ambiguity—"intelligent transportation system" can mean "intelligent system of transportation" as well as "system of intelligent transportation." The ambiguity can help to broaden support, but also can lead to confusion about focus. A simple, straightforward definition might be

> *ITS is the application of information technology to improve transportation system operations.*

Information technology includes computer hardware and software, as well as sensing, telecommunications, and control technologies. The improvements in transportation system operations can include improvements in efficiency, capacity, safety, and environmental impacts, and can extend to planning and maintenance.

Information technology has revolutionized major sectors of the world economy. For example, consider the changes in financial services in the past two decades. Round-the-clock trading of securities worldwide and the ability to withdraw funds in a foreign currency instantly from a personal bank account on the opposite side of the world were once unthinkable. Similarly, the ability to access a vast collection of worldwide information instantly via the World Wide Web and sophisticated search engines, or to contact an individual via a wireless phone almost anywhere in the industrialized world would have seemed like science fiction 20 years ago. But considering the pace of change these examples demonstrate, transportation systems today seem to differ little from those of two decades ago.

Not the Technology, the System

Yet the significance of ITS is not in the impact of a new gadget or technology—ITS offers the opportunity to integrate the transportation system. System thinking has progressed in air, rail, and marine transportation, as well as public transit, but road transportation has lagged behind.

The transportation system as a whole includes infrastructure, vehicles, and the people and goods being moved (Figure 1). Each of these elements has experts, organizations, advocates, and sometimes a dedicated government agency; information technology can bind these elements into an integrated system.

If information flows easily and inexpensively via modern technology, the system is more likely to be optimized and to operate as a system. Conversely, if information is unavailable or impeded, it is impossible for the system to operate as it should. The flow of information is fundamental to the effectiveness of the transportation system of the future.

The information-oriented paradigm of transportation, as depicted in Figure 1, can help to dissolve the traditional—and increasingly artificial—barriers between transportation and communications. People, goods, and information can be moved from one place to another, and in many cases one

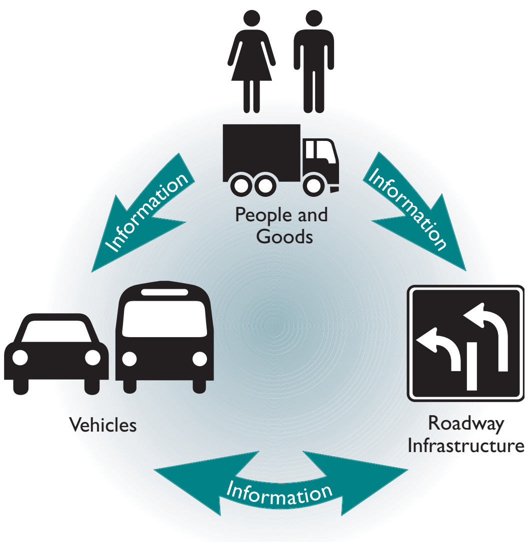


FIGURE 1 Integrated transportation system.

can be substituted for another to achieve the ends more efficiently. Why mail a letter if e-mail can reach the recipient faster, more inexpensively, and possibly more reliably? Why travel across the country for a meeting if a video conference is possible instead? Advances in information technology can help in considering the fully integrated infrastructure needed for the new century.

Institutional Impediments

Today's institutional structures, however, are not positioned to capitalize on the opportunity that ITS presents to address transportation as an integrated system, particularly in regard to surface transportation. Transportation industry meetings focus on roadway infrastructure and are not well attended by representatives of the vehicle or information technology industries. Similarly, meetings of the vehicle industry have negligible participation from representatives of the transportation infrastructure or information technology sectors.

The transit and railroad industries have linked vehicles and infrastructure more closely; however, in transit, the infrastructure interests concentrate heavily on rail transit; the bus interests are almost entirely vehicle-related. At the state level, the focus has been on infrastructure, and frequently the only connection with vehicles occurs when the rubber meets the road.

These impediments are rooted in the historic separation of vehicle and infrastructure concerns; yet the potential benefits of ITS are incentives to overcome the barriers. Educating vehicle and infrastructure interests about the benefits of interacting in a larger system should make both groups more willing to interact. Interactions are primarily exchanges of information; each must perceive that the value of the information received is greater than the cost and risk of providing information.

ITS User Services

Since the development of the national architecture for ITS in the early 1990s, the most common taxonomy has been the list of user services. The groups of user services traditionally are defined in parallel; however, it is valuable to arrange the groups in a matrix, with one dimension associated with technological capabilities and the other focused on application environments (Table 1). The technological capabilities listed in the rows of Table 1 can apply to the environments specified in the columns or to any other environment within the transportation system—for example, to passenger cars operating on urban and suburban roadways.

Technological Capabilities

ITS can be built on three technological capabilities:

◆ Advanced traffic management systems (ATMS) collect data about the real-time operation of the transportation system, manage traffic flows, and handle incidents. Although normally viewed as

TABLE 1 ITS Taxonomy of Primary User Services

	Special Application Environments		
Technological Capabilities	Advanced Public Transportation Systems (APTS)	Advanced Rural Transportation Systems (ARTS)	Commercial Vehicle Operations (CVO)
Advanced Traffic Management Systems (ATMS)			
Advanced Traveler Information Systems (ATIS)			
Advanced Vehicle Control and Safety Systems (AVCSS)			

GERALD STONE, CALIFORNIA PATH PROGRAM

California's Bay Area Rapid Transit carsharing program is an example of advanced public transportation systems services used by transit operations.

infrastructure-centered, an ATMS receives much incident information from citizens with wireless phones, and the most dramatic new opportunities to enhance data collection involve probe vehicles and communications.

◆ Advanced traveler information systems (ATIS) disseminate information about travel conditions to travelers before or during trips. Although normally considered vehicle-centered, an ATIS receives sizable amounts of raw data from infrastructure-based sensing. ATIS will not attain full value until fully integrated with ATMS, allowing system managers to incorporate ATIS data into operations decision making.

◆ Advanced vehicle control and safety systems (AVCSS) provide safety warnings, control assistance, or fully automated driving (see sidebar, page 13). Often considered entirely vehicle-centered, AVCSS sometimes is ignored within the more traditional infrastructure-centered parts of the ITS community. However, these systems can benefit from infrastructure cooperation, particularly in addressing such challenges as intersection collision warnings, lane-departure warnings, low-friction road surfaces, and automated driving. In recent years, the vague and misleading term "intelligent vehicle" sometimes has been applied as a synonym for AVCSS.

Special Applications

A variety of special operating conditions and niche problems has led to the creation of another set of user services for special applications:

◆ Advanced public transportation systems cut across the three classes of technological capabilities and also include services specific to transit operations, such as fleet management and fare collection.

TABLE 2 ITS Stakeholder Community of Interests

Public Providers	Private Providers	Users
Federal (Congress, Department of Transportation)	Automotive Original Equipment Manufacturers and Suppliers	Emergency Services
Local (cities, counties)	Communication Service Providers	General Public (including nonusers)
Regional (metropolitan planning organizations)	Electronics Industry	Law Enforcement
State DOTs	Insurance	Private Motorists
	Software	Transit Operators and Users
		Trucking Operators and Shippers

◆ Advanced rural transportation systems apply ITS technologies in rural areas under operating conditions and system design trade-offs significantly different from those of urban or suburban areas.

◆ Commercial vehicle operations are information services for heavy truck operators, complementing the three basic classes of technological capabilities and addressing such issues as regulatory processes at border crossings (see sidebar, page 8) and shipping documentation.

These user service clusters are diverse; each category comprises multiple services, which can be implemented at a variety of levels of performance and sophistication. This makes it difficult to generalize about the state of development or deployment of ITS as a whole. The diversity also means that a wide range of stakeholders must be engaged for ITS to reach full potential (Table 2).

ITS Funding

ITS is not a federal government program. The investment decisions for the deployment and operation of ITS elements in the public infrastructure are not made in Washington, D.C., but by many state and local government agencies.

The larger decisions about investing in ITS elements for private vehicles, computer systems, and handheld devices such as wireless phones are made by companies and individuals throughout the country. The investments that the private sector has made in developing ITS technologies, products, and services substantially exceed those of the U.S. DOT in its ITS program. The diversity of the decision makers in all sectors increases the challenges that must be overcome to achieve a fully integrated ITS.

Benefits of Integrated ITS

Stakeholder investments in ITS are motivated by the expected benefits. The vehicle and infrastructure industry stakeholders are looking to gain benefits from using information technology within their domains; however, few have sought to exploit the benefits of integrating their information with the information available in other domains. Significant improvements in the effectiveness of the transportation system as a whole would include the following:

◆ Accurate and timely information about travel conditions available in real time at home, in the office, in the vehicle, and on handheld devices, incorporating data derived from infrastructure and from vehicle-based sources;

Gerald Stone, California PATH Program

As part of a Forward Collision Warning System, two light-emitting diode displays mounted on the left and right of the front window of a bus in Dale City, California, flash red lights when the bus is on a collision course with another object.

◆ Real-time optimization of transportation operations, integrating freeways, arterials, transit, and freight systems, using comprehensive real-time and historical data derived from infrastructure and from vehicle-based sources;

◆ Incident management with communication of information to individual travelers and transportation system managers, enabling decisions that benefit individuals and society;

◆ Inexpensive but effective collision warning and avoidance systems that optimize sensing and communication functions between vehicles and roadway infrastructure;

◆ Inexpensive sensors for traffic management and safety applications through cooperative marking and communication devices installed on vehicles and roadway infrastructure;

◆ Detection of traffic conditions, road surface conditions, and safety hazards by roving vehicles that relay information to transportation system operators and individual vehicles;

◆ Bus rapid transit systems that can approach the line-haul capacity and service quality of more expensive rail transit systems, but retain the flexibility of buses for passenger collection and distribution; and

◆ Cooperative vehicle–highway automation systems that can relieve drivers from some driving tasks, smooth traffic flow, significantly increase highway capacity, and reduce energy use and pollutant emissions.

ITS Research Needs

A frequent refrain in ITS meetings and documents is that the research stage of ITS is complete and now is the time to deploy. There is a kernel of truth to this, but the claim oversimplifies the issue.

When first defined as a transportation program, ITS emphasized research because the technologies were immature and the operating concepts ill-defined. Now that some ITS technologies and concepts have matured and are ready to be deployed, more resources should be spent on deployment.

However, other ITS technologies and concepts still require development and even those ready to deploy today need continuing research to assess their effectiveness. These systems need ongoing enhancements and refinements based on use, continuing the cycles of research and development in tandem with deployment and operations, as in other aspects of transportation.

The key research questions in ITS fall into the following categories: enabling technologies, system capabilities and concepts, understanding human interactions with the systems, and crosscutting questions.

Enabling Technologies

◆ What combination of vehicle- and infrastructure-based sensing technologies can provide vehicle posi-

New Frontier at the Border

The International Border Clearance (IBC) program tests the feasibility of intelligent transportation system (ITS) technologies at U.S. border crossings to facilitate trade and transportation safety and to expedite the processing of commercial vehicles at ports of entry. Initiated under the Intermodal Surface Transportation Efficiency Act of 1991, the IBC program expanded to help the U.S. Treasury address requirements for improved trade statistics and more effective import and export processing.

The IBC program deploys ITS technologies to facilitate trade and enhance commercial vehicle safety at international borders. The program uses information technology and vehicle identification to enable federal and state agencies to make informed decisions quickly and effectively about cargo, vehicles, and drivers crossing the border while also reducing congestion and environmental impacts.

Seven border crossing sites have deployed and tested ITS technologies—two on the United States–Canada border and five on the border with Mexico. Working closely with other federal, state, and local agencies; systems developers; and private shippers and motor carriers; the Federal Highway Administration (FHWA) has sponsored and cofunded the installation of dedicated short-range communications systems, local processing systems and networks, and connections to other federal and state systems.

Work continues to expand the utility and value of IBC implementations through interfaces with state commercial vehicle information systems developed and deployed under FHWA's Commercial Vehicle Operations program. The IBC program comprises (1) technology deployments at border crossing sites; (2) interfaces with current and planned federal and state safety and trade processing systems; (3) partnerships with the transportation, customs, and immigration agencies of Canada and Mexico; and (4) liaison with private-sector stakeholders involved with international border crossing facilities and activities.

During Fiscal Year 2000–2001, Laredo, Texas, and Detroit, Michigan, tested technologies to support a freight and trade processing system (FTPS) that directly interfaces with customs. The FTPS or its equivalent will allow verification of a commercial motor vehicle's registration and safety status before the vehicle crosses the border.

EDITOR'S NOTE: This information preceded the events of September 11. The program currently is undergoing changes.

SOURCE: ITS at International Borders—A Cross-Cutting Study, Facilitating Trade and Enhancing Transportation Safety, U.S. Department of Transportation Report, April 2001.

tion and collect traffic data most effectively in terms of costs, reliability, and operating conditions?

◆ What sensor technologies, combined with what kinds of special markings on vehicles and roadway elements, can provide the most effective situation awareness for safety warning and vehicle control systems, considering costs, reliability, and operating conditions?

◆ What wireless technologies and protocols work best for vehicle–roadway and vehicle–vehicle data communications?

◆ How can safety-critical vehicle systems incorporate fault detection and fault management at an affordable price?

System Capabilities and Concepts

◆ How can freeway–arterial corridor traffic and areawide urban traffic be managed effectively and efficiently, balancing the needs of users and operators?

◆ How can information systems be used to implement cost-effective, high-quality transit services in low-density suburban environments?

◆ How can vehicle automation be introduced progressively into road transportation so that benefits exceed costs for key stakeholders at each deployment stage?

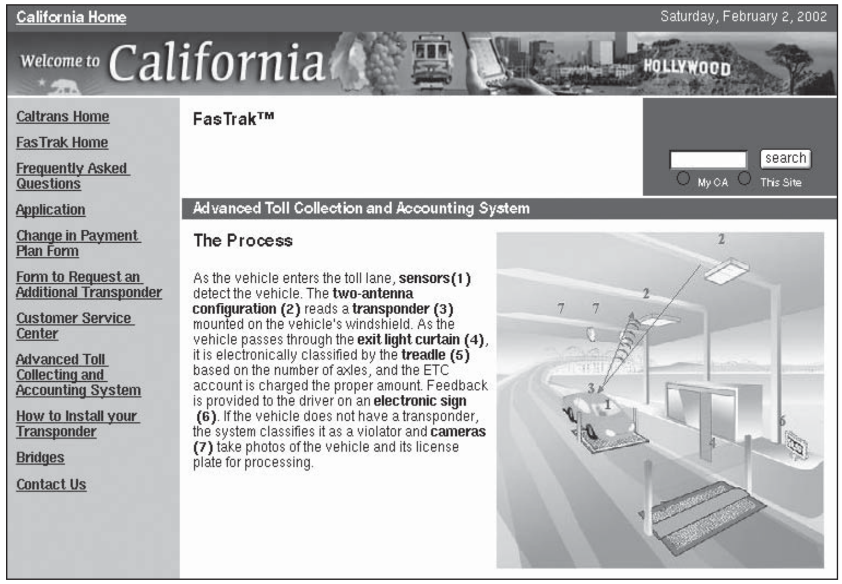
Human Interactions

◆ How will the availability of different kinds of information about travel conditions influence travel and shipping choices, and how can transportation planning models be updated to reflect the diversity of information and decisions?

◆ How do drivers drive? How can a comprehensive understanding of microscopic and macroscopic aspects of driving behavior be developed to create a "science of driving" that will explain the phenomena behind traffic flow, congestion, and safety problems?

◆ How will driving behavior change with in-vehicle safety warning, control assistance, and automation systems? How interested will drivers be in buying and using these systems, and to what extent will drivers offset the safety benefits by adopting riskier behaviors? How will they respond to false or nuisance alerts?

◆ How will in-vehicle information systems affect driving safety, considering that improvements to the quality of the driving experience may distract drivers from safety-critical responsibilities?



California's FasTrak™ website (www.dot.ca.gov/fastrak/atas.htm) details the process of advanced toll collection.

◆ How well will drivers and passengers accept automated driving under different conditions?

Crosscutting Questions

◆ How can data from infrastructure- and vehicle-based sources be fused to produce the most accurate and comprehensive description of current travel conditions on freeways, arterials, and transit systems?

◆ How can we best apply real-time data and understanding of traffic dynamics to predict traffic conditions and provide the best possible advice to travelers and system operators?

◆ What are the costs and benefits of the ITS approaches that can be considered along with the traditional facility construction alternatives in a Major Investment Study? How can the experiences of these costs and benefits in one location be applied in others?

◆ What will be the safety impacts of deploying the full array of ITS systems—not only those aimed at improving safety, but also those aimed at relieving congestion and improving the quality of travel?

The answers to these research questions are key to developing and deploying the most effective transportation system; yet the answers may change as the technologies advance. Challenging opportunities await the transportation research community; if the challenges are unanswered, the opportunities will become impediments to improving the transportation system.

ITS

Intelligent Transportation Systems at the Turning Point

Preparing for Integrated, Regional, and Market-Driven Deployment

JOSEPH M. SUSSMAN

The author is JR East Professor and Professor of Civil and Environmental Engineering and Engineering Systems, Massachusetts Institute of Technology, Cambridge; past Chairman of the TRB Executive Committee; and 2002 recipient of TRB's Roy W. Crum Distinguished Service Award.

Intelligent transportation systems (ITS) apply technologies in communications, control, electronics, and computer hardware and software to improve surface transportation system performance.

This simple definition points to a substantial change in surface transportation. The increased social, political, and economic difficulty of expanding transportation capacity through conventional infrastructure-building has motivated the development of ITS. ITS represents an effort to harness the capabilities of advanced technologies to improve transportation on many levels—to reduce congestion, enhance safety, mitigate the environmental impacts of transportation systems, enhance energy performance, and increase productivity.

The U.S. National ITS Program is more than a decade old. In December 1999, the ITS Joint Program Office of the U.S. Department of Transportation initiated a project, What Have We Learned About ITS?, with a series of presentations in Washington, D.C. Industry experts responded to the following questions about ITS technologies and applications:

- What ITS technology applications have been successful and why?
- What ITS technology applications have not been successful and why?
- For which ITS technologies is "the jury still out"?
- What institutional issues arose in ITS deployments and how were they overcome?
- What next steps are needed?

In April 2000, in conjunction with the Institute of Transportation Engineers 2000 International Conference in Irvine, California, the initial results were presented to a broader community to validate or debunk—and, if possible, to document a national consensus. The following summarizes some of the key concepts presented in papers by experts in the seven ITS areas studied (*1*).

Freeway, Incident, and Emergency Management, and Electronic Toll Collection (ETC)[1]

This area comprises several different, but related, technologies: transportation management centers, ramp metering, dynamic message signs, roadside infrastructure, and dynamic lane and speed control. ETC is one of the fundamental and earliest-deployed ITS technologies—it is the most common example of the electronic link between vehicle and infrastructure that characterizes ITS.

Freeways, or limited-access highways, are another major and early ITS application area. Incident management is important in reducing nonrecurring congestion on freeways. Emergency management predates ITS, but is enhanced through ITS technologies.

Several systems have gained deployment; however, more remains to be accomplished. An important technical advance would upgrade the systems to predict congestion from current traffic patterns and expectations, replacing responsive systems. Institutions need to establish operations budgets

[1] Paper by Vincent Pearce, Booz-Allen & Hamilton (now with FHWA) (*1*, Ch. 2).

for these systems and to attract high-quality technical staff for deployment and operations support.

Arterial Management[2]

The management of arterials—high-capacity roadways controlled by traffic signals, with access via cross-streets and often from abutting driveways—predates ITS, with early deployments in the 1960s. Nonetheless, adaptive control strategies for arterials, making real-time adjustments to traffic signals based on conditions such as queues, are not in widespread use.

The reasons for this lag include costs as well as concerns that adaptive traffic control algorithms do not perform well. When traffic volumes are heavy, state-of-the-art algorithms appear to break down—although vendors claim otherwise. The complexity of the system also requires additional training for personnel.

Traveler information systems for arterials are not yet widely deployed, although studies suggest safety benefits and reductions in delays. Cellular phones, traffic probes with cellular phone geolocation, and implementation of the national three-digit traveler information number (511) may stimulate deployment. Integrating traffic management technologies—such as emergency vehicle management, transit management, and freeway management—with arterial management may be an important next step.

Traveler Information Systems[3]

Traveler information is one of the core concepts of ITS. Travelers value easy and timely accessibility to high-quality information, high-quality user interfaces, and low prices—preferably free. Consumer demand for traveler information is a function of

- The amount of congestion on the regional transportation network,
- The network's characteristics,
- The quality of the information and the user interface,
- The characteristics of individual trips, and
- The characteristics of drivers and transit users.

Many kinds of traveler information systems are in use. Although people value high-quality travel information, they are not necessarily willing to pay for it, since free information is available, such as radio reports. Whether traveler information systems can be viable as a stand-alone commercial enterprise is unclear; transportation information probably will be packaged with other information services via the Internet.

Traveler information systems make clear that ITS operates within the environment of people's expectations for information. Timeliness and quality of information are continually increasing for many non-ITS applications, such as the Internet, and providers of traveler information need to be aware of changing expectations.

The integration of traveler information with network management or transportation management systems, such as freeway and arterial management, has not occurred for the most part. Network management and traveler information systems would benefit from substantial integration, as would the customers—travelers and freight carriers.

Advanced Public Transportation Systems[4]

Transit has difficulty attracting market share for the following reasons:

- Land-use patterns incompatible with transit use;
- Lack of high-quality service, with long and unreliable travel times;
- Lack of comfort;
- Security concerns; and
- Incompatibility with the way people currently travel—for example, by trip-chaining.

ITS transit technologies—including automatic vehicle location, passenger information systems, traffic signal priority, and electronic fare payment—can improve transit productivity, quality of service, and real-time information. However, deployment of ITS to upgrade transit has been modest, stymied by

- A lack of funding for ITS equipment,
- Difficulties in integrating ITS technologies into conventional transit operations, and
- The lack of human resources to support and deploy the technologies.

As people with ITS expertise join transit agencies, there will be a steady but slow increase in the use of ITS technologies for transit management. But training is needed, and a chronically capital-poor industry must overcome inertia to deploy these technologies.

[2] Paper by Brandy Hicks and Mark Carter, SAIC (*1*, Ch. 3).
[3] Paper by Jane Lappin, EG&G Technical Services/John A. Volpe National Transportation Systems Center (*1*, Ch. 4).
[4] Paper by Robert Casey, John A. Volpe National Transportation Systems Center (*1*, Ch. 5).

Integrating transit services with other ITS services promises major intermodal benefits; the integration of highway and transit, multiprovider services, and intermodal transfers may be feasible in the near term. But the transit industry should provide critical, high-quality service in urban areas and can support environmentally-related programs—ITS may be the mechanism to boost and reinvent the industry.

Commercial Vehicle Operations[5]

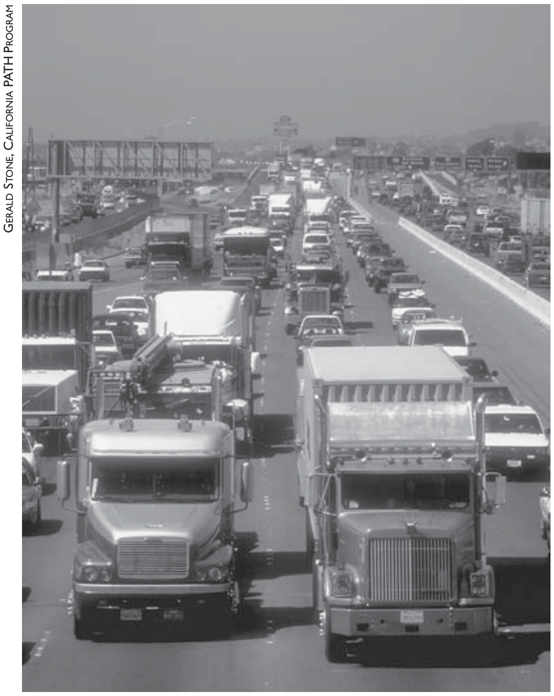
Through commercial vehicle operations (CVO), states ensure safety and enforce regulations related to truck operations on highways; the public-sector components of CVO are the main focus. Commercial vehicle information systems and networks (CVISN) deal with roadway operations, including safety information exchange and electronic screening, as well as back-office applications like electronic credentialing.

CVISN has experienced some successes. In most programs, participation by carriers is voluntary; requiring truckers to use transponders may be difficult—universal deployment is a challenging task. Another problem for deployment is consistency from state to state. Because trucking is a regional or even national business, the interface between the trucking industry and the states must be consistent for widespread deployment. Although each state has its own requirements based on the operating environment, interstate interoperability is necessary through expanded partnerships among states and between the federal government and states.

The CVISN program has raised some public- and private-sector tensions. For example, truckers endorse the technology that allows weigh-station bypasses for previously checked vehicles—the information is relayed from the adjoining station or even from another state. Yet because of competition, truckers are concerned about another application of the same system—for tax collection—questioning its equitability and the privacy of origin–destination data. Public–private partnerships need to develop both applications to capture the benefits effectively.

Crosscutting Technical and Programmatic Issues[6]

Advanced technology is at the heart of ITS, which means dealing with changing technologies while relating to the need for standards. Rapid obsolescence is a problem, but technology issues are not a substantial barrier to ITS deployment; costs, however, can be a barrier. Most technologies perform—but are they are priced within the budget of the deploying organizations, and are the prices consistent with the benefits?



Gerald Stone, California PATH Program

Commercial vehicles can benefit from advanced information systems and networks that address safety and screening.

Surveillance and communication are two core ITS technologies. Surveillance technologies have experienced successes with cellular phones for reporting and videos for verifying incidents, but cellular phone geolocation for traffic probes is still a question. The lack of traffic-flow sensors in many areas and on some roadway types inhibits the growth of traveler information and the improvement of transportation management systems.

Communications technologies have experienced success with the Internet for pretrip traveler information and credentials administration in CVO. The growth rate in the use of the Internet and also emerging technologies like the wireless Internet and automated information exchange may portend increased use of ITS applications.[7]

[5] Paper by John Orban, Battelle (*1*, Ch. 6).

[6] Paper by Michael McGurrin, Mitretek Systems (*1*, Ch. 7).

[7] A Survey of Government on Internet: The Next Revolution, *The Economist* (June 14, 2000).

Crosscutting Institutional Issues[8]

The key barriers to ITS deployment are institutional, involving issues such as the awareness and perception of ITS, long-range operations and management, regional deployment, human resources, partnering, ownership and use of resources, procurement, intellectual property, privacy, and liability.

Public awareness and political appreciation that ITS can help deal with issues such as safety and quality of life are central to successful deployment. Building a regional perspective on deployment through public–private partnerships is important. Planning for sustained funding for long-term operations also is critical. Procurement is an institutional concern, and public-sector agencies are not accustomed to procuring high-technology components that may involve questions of intellectual property.

ITS deployment requires a cultural change for transportation organizations that traditionally have focused on conventional infrastructure, not on operations. This cultural change is a continuing, ongoing, arduous process that must be undertaken if ITS is to be deployed successfully.

Assessing ITS

An assessment of ITS should consider the three dimensions that characterize transportation: technology, systems, and institutions (2):

- Technology includes infrastructure, vehicles, and the hardware and software that make them function.
- Systems deal with the performance of holistic sets of components—for example, a regional transportation network.
- Institutions refer to organizations and interorganizational relationships that support the development and deployment of transportation programs.

Technology

Four technologies are central to most ITS applications:

- Sensing—registering the position and velocity of vehicles on the infrastructure;
- Communicating—from vehicle to vehicle, between vehicle and infrastructure, and between infrastructure and centralized transportation operations and management centers;

[8] Paper by Allan J. DeBlasio, John A. Volpe National Transportation Systems Center (*1*, Ch. 8).

Advanced Vehicle Control and Safety Systems: The Other Parts of ITS

STEVEN E. SHLADOVER

Infrastructure-oriented public agencies often overlook advanced vehicle control and safety systems (AVCSS) when considering intelligent transportation systems (ITS), but AVCSS can interact closely with the operation of a roadway infrastructure.

AVCSS includes a diverse collection of user services ranging from in-vehicle collision warning systems to control assistance systems—such as adaptive cruise control—to the fully automated driving of buses, trucks, and passenger cars. Most of these systems will appear in the private marketplace as options offered by vehicle manufacturers to private vehicle purchasers.

The initial systems have been autonomous, relying entirely on information collected with onboard sensors. However, significant improvements in performance are possible through cooperative implementations that share information via wireless data communications from vehicle to vehicle, as well as between vehicles and the roadway infrastructure.

Forward and side collision warning systems have been available for commercial trucks since 1993, and the buyers and sellers have claimed that the introduction of these systems into truck fleets has reduced the frequency and severity of crashes dramatically; however, scientific studies have not yet verified these claims.

Adaptive cruise control—adding forward sensing and automatic deceleration so that a vehicle can maintain a gap behind a preceding vehicle—recently appeared on the market for trucks and high-end passenger cars. Lane departure warning systems also are becoming available for trucks.

Fully automated driving of road vehicles, demonstrated on test tracks and also on public roadways under limited conditions, is not yet commercially available. However, fully automated, driverless transit vehicles carry millions of passengers safely every day on special rights-of-way at major airports and in several urban transit systems.

AVCSS differs from other ITS elements in many particulars. For one, private industry—particularly the automotive manufacturing and supply industries—has made the majority of the investments in developing AVCSS.

The primary impediments to deployment are technological and economic, not institutional. A significant technical challenge is the development of sensor and signal processing systems that can detect all relevant hazards without sounding frequent false alarms. User interfaces must be designed to be readily and safely understandable by a diverse driving population without additional training. Finally, the sophisticated systems must be affordable for the average car buyer.

Studies have predicted extensive safety benefits from collision warning systems and significant highway capacity benefits from fully automated driving. The effects of control assistance systems—such as adaptive cruise control—are subtle, and implementation details will determine whether the impacts on traffic flow capacity and dynamics are favorable or not. However, implementation of the systems has not yet occurred at a sufficient scale to prove the effects.

◆ Computing—processing the data collected and communicated during transportation operations; and

◆ Algorithms—computerized methods for operating transportation systems.

In most cases, off-the-shelf technology can support ITS functions. The important questions about technology quality concern algorithms—for example, the efficacy of software to perform adaptive traffic signal control. Also, the quality of the information collected may be a technical issue in some applications.

Public agencies may see the technology as too costly for deployment, operations, and maintenance, particularly if the benefits to be gained are not commensurate. In some cases, technology falters because it is not easy to use—intuitive user interfaces are essential.

Systems

The integration of ITS components is the critical need at the systems level. Many ITS deployments are stand-alone applications, such as ETC. It is often cost-effective in the short run to deploy an application without worrying about the interfaces and platforms required for an integrated system. Decision makers often have opted for stand-alone applications—a reasonable approach for the first generation of ITS deployment.

However, the next steps require system integration for efficiency and effectiveness—for example, integrating services for arterials, freeways, and public transit, then integrating incident management, emergency management, traveler information, and intermodal services. Integration adds complexity, but also provides economies of scale in system deployment and improvements in overall system effectiveness, resulting in better freight and traveler services.

Another aspect of system integration is interoperability—ensuring that ITS components can function together. Possibly the best example is the interoperability of ETC hardware and software in vehicles and on the infrastructure. To achieve interoperability, the design of electronic linkages among vehicles and infrastructure must employ system architecture principles and open standards.

The public wants transponders that will work with ETC systems across the country or even regionally. The technology should operate not only on a broad geographic scale, but also locally for public transportation and parking applications.

Systems that should work on a national scale, such as CVO, must achieve interoperability among components. There are institutional barriers to interoperability—for example, the differences among jurisdictions—although widespread deployment is ultimately in the interest of all.[9]

Integration is needed between advanced transportation management systems (ATMS) and advanced traveler information systems (ATIS); the two technologies have developed largely independently. ATMS provides for operations of networks and ATIS for pretrip and in-vehicle information for individual travelers. ATMS can collect and process a variety of network status data and can estimate future demand to provide travelers with dynamic route guidance via ATIS services. With integration, ATMS-derived operating strategies for the network—which account for customer response to ATIS-provided advice—can lead to better network performance and better individual routes.

Institutions

Technical integration is vital, but institutional integration will be equally important for the future of ITS, including the integration of public- and private-sector perspectives on ITS, as well as the integrated operations of various public-sector organizations.

The major barriers to ITS deployment are institutional. Looking at transportation from an intermodal, systemic point of view requires a shift in institutional focus. Dealing with intra- and interjurisdictional questions, budgets, and regional perspectives on transportation systems; shifting institutional attention to operations instead of construction and maintenance; and training, retaining, and compensating qualified staff are institutional barriers to deployment. Developing strategies to overcome these institutional barriers is the single most important activity to ensure successful ITS deployment and implementation.

ITS and Operations

In recent years, transportation operations—as opposed to construction and maintenance of infrastructure—have become a primary focus. ITS deals with the technology-enhanced operations of complex transportation systems. The ITS community has argued that focusing on operations through advanced technology is cost-effective, considering the social, political, and economic barriers to conventional infrastructure,

[9] Orban (*1*, Ch. 6) contrasts technical interoperability, operations interoperability, and business model interoperability in the context of CVO and CVISN.

particularly in urban areas. ITS can avoid the high up-front costs of conventional infrastructure through more modest investments in electronic infrastructure, followed by a focus on effectively operating the infrastructure and the transportation network at large.

Although ITS can provide less expensive solutions, there are up-front infrastructure costs and additional expenses for operating and maintaining hardware and software. Training staff to support operations requires resources. Spending for ITS differs from spending for conventional infrastructure, requiring less up front but more investment in the following "out" years. Therefore, planning for operations requires a long-term perspective by transportation agencies and politicians.

Operations should be institutionalized within transportation agencies. To maintain system effectiveness and efficiency, budgets for operations must be stable and cannot be subject to yearly fluctuation and negotiation. Human resources needs also must be considered.

To justify ITS capital as well as continuing costs, it is helpful to consider life-cycle costs—the costs and benefits that accrue over the long term are the important metric. But organizations must recognize that a lack of follow-through will cause out-year benefits to disappear if unmaintained ITS infrastructure deteriorates and if the algorithms for traffic management are not recalibrated.

Mainstreaming

Mainstreaming has several definitions in the ITS context. To some, mainstreaming means integrating ITS components into conventional projects. Two examples of projects that include conventional infrastructure and ITS technologies and applications are the Central Artery–Ted Williams Tunnel project in Boston, Massachusetts, and the redesign of the Woodrow Wilson Bridge on I-95, connecting Maryland and Virginia. In such projects, the ITS component typically is a fraction of the total project cost.

Nonetheless, ITS technologies and applications can come under close political scrutiny disproportionate to their financial impact. For example, in the Woodrow Wilson Bridge project several ITS elements were considered for elimination (3).[10]

Another approach to mainstreaming suggests that ITS projects should not be protected by specially allocated funds, but should compete for funds with all other transportation projects. The advantage is that ITS would compete for a larger pool of money; the disadvantage is that ITS might not compete successfully. Those responsible for spending public monies have favored conventional projects for transportation infrastructure. Convincing decision makers that the funds are better spent on ITS applications may be difficult.

This issue is also linked to human resource development. Professionals cannot be expected to select ITS unless they are knowledgeable about it; education of the professional transportation cadre is essential for mainstreaming. The National ITS Program also must demonstrate that the benefits of ITS deployments are consistent with the costs.

Protected funds that can be spent only on ITS applications may be a good transitional strategy as professional education continues and the benefits become more clear; but in the long run, mainstreaming ITS via competitive proposals will be advantageous.

Human Resources

The deployment of the new ITS technologies and applications requires personnel—skilled, knowledgeable specialists, as well as generalists with policy and management skills who can incorporate advanced thinking about transportation technologies and services into systems (4).

Several organizations have established programs for human resource development—for example, the Federal Highway Administration's (FHWA's) Professional Capacity Building program and CITE (Consortium for Intelligent Transportation Education),

GERALD STONE, CALIFORNIA PATH PROGRAM

Caltrans' magnetically guided advanced snowplow clearing Interstate 80 near Lake Tahoe, California.

[10] John Collins, then president of ITS America, likened the decommitting of ITS technologies from the Woodrow Wilson Bridge to "constructing a house and deciding to save money by not buying light bulbs."

housed at the University of Maryland. These programs, along with graduate transportation programs incorporating ITS-related changes, can prepare talented and skilled people for the industry.

However, institutional changes in transportation organizations are needed to engage and retain personnel with high-technology skills, who often can demand higher salaries than public-sector transportation organizations can provide. Cultural change, along with appropriate rewards for operations staff, will be necessary in organizations that have favored conventional infrastructure construction and maintenance.

Public-sector organizations may have to contract for outside staff to perform some high-technology functions. Contracting with private-sector organizations to handle various ITS functions is another option. In the short run, these options may be helpful; in the long run, however, developing technical and policy skills within the public agency has advantages for strategic decision making.

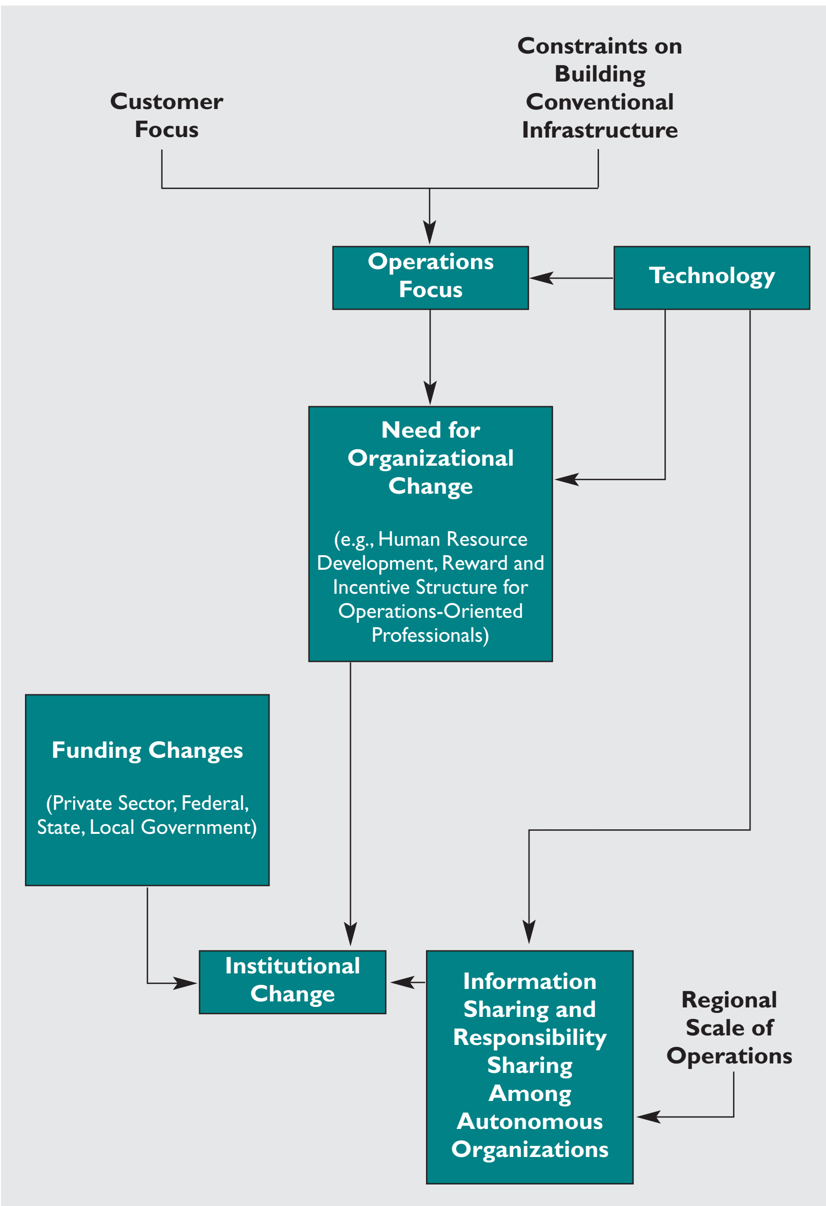


FIGURE 1 Changes in a regional intelligent transportation systems (ITS) environment.

ITS Opportunities

Regional Approaches

ITS provides an opportunity to manage transportation at the scale of the metropolitan-based region. Along with state or multistate geographic areas, metropolitan-based regions—the basic geographic unit for economic competition and growth (*5*) and for environmental issues—can manage transportation effectively through ITS.

A few regions have made progress, although none yet has translated ITS technologies into a complete, regionally scaled capability. Thinking through the organizational changes to allow some autonomy for subregional units, but also system management at the regional scale, is a priority (*6*). The strategic vision is for ITS to integrate transportation, communications, and intermodalism on a regional scale (*7*). Multistate regions with traffic coordination over large geographic areas, such as the mountain states—and also corridors, such as I-95—present ITS opportunities.

Surface Transportation Markets

Surface transportation should be thought of as a market of individual customers with ever-rising and differing expectations. Modern markets provide choices. People demand choices in level of service and often are willing to pay for superior service; surface transportation customers increasingly will demand this service differentiation. Although a market framework for publicly provided services is not without controversy, surface transportation operators can no longer think in terms of "one size fits all."

An early example of this market concept in highway transportation is the high-occupancy toll lane, which uses ITS technologies to allow single-occupant vehicles on a high-occupancy vehicle lane for a toll. Other market opportunities building on ITS will emerge, as researchers and policy makers consider how surface transportation should operate in rela-

tion to markets—philosophically and conceptually—in an ITS environment.

A market or customer focus plus the constraints on building conventional infrastructure require an emphasis on operations enabled by ITS technology. Technological change and an emphasis on operations, in turn, entail changes in transportation organizations. The institutional changes for operations involve different funding arrangements as well as sharing information and responsibility on a regional scale (Figure 1).

Introducing Change

ITS presents a turning point in surface transportation, similar to the introduction of air traffic control systems into air transportation. In scale, ITS resembles the Federal-Aid Highway Program, which forged a new relationship between the federal and state governments as the idea of a national highway system took shape during the second decade of the 20th century.

The electronic linkage between vehicle and infrastructure via ITS has profound implications for surface transportation. But so far the changes have been incremental; the real impact has yet to be felt. Integrated, regional systems are examples of the changes to come.

The functional change that ITS introduces must go beyond institutional changes in transportation organizations to cultural changes—reflecting the importance of operations, new technology, and market-based forces, especially in the highway sector. Achieving these cultural changes will take leadership, education, and training.

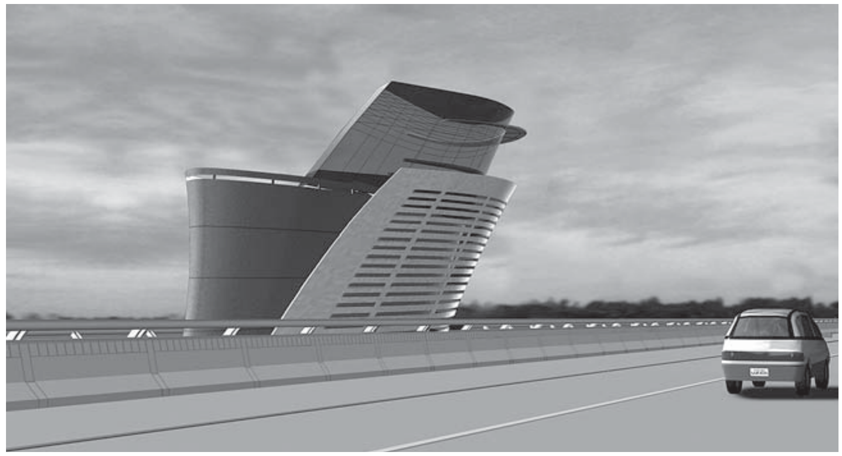
ITS offers an opportunity for the transportation profession to evolve to a more sophisticated level. Advanced technologies, system-thinking about transportation services, and expanded possibilities for policy initiatives in technology-enabled transportation create vital professional opportunities—which the educational sector must recognize and develop.

Great Expectations

What have we learned about ITS? Much has been achieved by choosing clear-cut, sure winners—an appropriate strategy for the first generation of any technology. However, successful deployment requires focusing on integrated, regional, and market-driven systems.

ITS can be a critical component of surface transportation. The public's expectations are changing in the age of the Internet. People are using sophisticated information technology and telecommunications equipment every day—the expectation is for accessible information from multiple sources at the click of a mouse or television switch.

ITS is the transportation community's opportunity to be part of this revolution and to advance transportation and the profession. Success will be predicated on extensive deployment and on integrated, regional systems. For now, ITS is on the right track, but more must be achieved, as more will be expected.



The bird's eye view from the tower of the future Woodrow Wilson Bridge, in metropolitan Washington, D.C., is ideal for various ITS functions. By remotely opening barriers between local and express lanes, the tower can enable traffic to bypass major traffic incidents. In addition, the tower can post bridge closings on electronic message signs and use cameras to ensure the bike path is clear before the drawbridge is opened.

References

1. What Have We Learned About Intelligent Transportation Systems? U.S. Department of Transportation, Washington, D.C., 2000. www.itsdocs.fhwa.dot.gov//JPODOCS/REPTS_TE/@9W01!.PDF.
2. Sussman, J. M. *Introduction to Transportation Systems*. Artech House, Boston, Mass., and London, 2000.
3. *The Washington Post,* June 29, 2000, page A-15.
4. Sussman, J. M. Educating the "New Transportation Professional," *ITS Quarterly,* Vol. 1, No. 3, Summer 1995, pp. 3–10.
5. Porter, M. *On Competition*. Harvard Business School Press, Boston, Mass., 1998.
6. Hardy, C. Are We All Federalists Now? In *Beyond Certainty: The Changing Worlds of Organizations,* Harvard Business School Press, Boston, Mass., 1996.
7. Sussman, J. M. ITS Deployment and the "Competitive Region," *ITS Quarterly,* Vol. 4, No. 2, Spring 1996, pp. 3–5.

California's Performance Measurement System

Improving Freeway Efficiency Through Transportation Intelligence

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Information technology (IT) provides the means to store, manipulate, and disseminate massive amounts of data. The integration of IT at all levels of the transportation system creates the intelligence in intelligent transportation systems (ITS). But this integration is a long and difficult process of searching for and exploiting opportunities in the interconnected operations, planning, and funding of today's transportation systems.

The Performance Measurement System (PeMS) was developed more than three years ago to enhance freeway systems productivity.[1] PeMS collects and stores data from California loop detectors—which record the occupancy and flow of vehicles on a freeway section—and converts the data into useful information. Examples from Los Angeles illustrate how this information can improve system management, assist travelers, and challenge current understanding of freeway traffic behavior.

PeMS provides information that previously was unavailable or too costly to gather for freeway operations and planning. The system can generate routine reports—like California's congestion monitoring report, which requires appreciable resources to produce—at minimal cost. Engineers and planners can isolate problem areas quickly and focus on potential solutions—for example, identifying bottlenecks or locating congested freeway segments that could benefit from intelligent ramp-metering.

Travelers face large variations in travel time dur-

[1] PeMS website, transact.eecs.Berkeley.EDU.

Gerald Stone, California PATH Program

Performance Management System (PeMS) collects and stores data from loop detectors operated by Caltrans, like these in Irvine, California.

ing peak hours. However, knowledge of the current state of traffic can reduce this variation, allowing accurate predictions of travel times. PeMS not only makes these predictions but suggests optimal routes.

Models of traffic behavior inform professional training and decision making; yet many of these models are insufficiently validated. Using PeMS data to test these models has produced two surprising findings. First, maximum throughput occurs at a free-flow speed of 60 mph, not between 35 and 50 mph, the range used by California. Second, a large portion of freeway congestion delay is due to inefficient operation, not to excessive demand.

ITS often is associated with a set of technologies deployed one at a time for incremental benefits—for example, automatic vehicle location or electronic toll collection. But a freeway system guided by the kinds of information that PeMS provides can realize productivity gains affecting the operations, planning, and investment processes.

System Overview

PeMS collects and stores data from loop detectors operated by the California Department of Transportation (Caltrans). PeMS applications convert these data into information accessible through the Internet by Caltrans personnel, value-added resellers, the public, and the research community.

PeMS is a functioning prototype that will be deployed statewide in July 2002. A low-cost system built from commercial, off-the-shelf components, PeMS can be deployed incrementally without disrupting current procedures (*1*). The software is open, so that PeMS can incorporate other data sources that become available—for example, electronic data for transit. Located at the University of California, Berkeley, the PeMS database computer has 4 gigabytes of main memory and 4 terabytes of disk space, capable of storing several years of data.

The software is organized into three layers. The bottom layer performs database administration—the standard but highly specialized functions of disk management, crash recovery, and table configuration. The middle-layer software works on real-time data:

- ◆ Aggregating 30-second values for flow and occupancy into lane-by-lane, 5-minute values;
- ◆ Calculating the speed for each lane (*2*);
- ◆ Aggregating lane-by-lane values of flow, occupancy, and speed; and
- ◆ Computing basic performance measures such as congestion delay, vehicle-miles traveled, vehicle-hours traveled, and travel times.

Applications in the top software layer include reports for decision makers, identification of bottlenecks, determination of travel times and optimal routes, and more.

Routine Reports

Caltrans policy makers depend on monthly and annual reports and programs that provide high-level information, such as the Traffic Operations Strategies report, the Highway Congestion Monitoring Program (HICOMP), and the System Performance Measures Initiative. PeMS can assist in each of these reports and programs.

For example, the HICOMP report presents the location, magnitude, and duration of congestion on California freeways, enabling Caltrans to identify problems and to establish priorities for operations and air quality improvement projects. Cars driven through 5- to 7-mile freeway sections twice a year during congested periods obtain the data. Figure 1 shows a PeMS average plot giving the maximum, average, and minimum vehicle-hours of congestion delay—the time spent driving below 35 mph—on US-101N for each day of the week, averaged over a 16-week period beginning February 4, 2001.

For 16 Wednesdays (Day 4 in Figure 1), the delay ranged from 10,000 to 60,000 vehicle-hours. This 600 percent variation implies that the twice-a-year HICOMP samples are unreliable. PeMS can track congestion to determine trends and variations to pro-

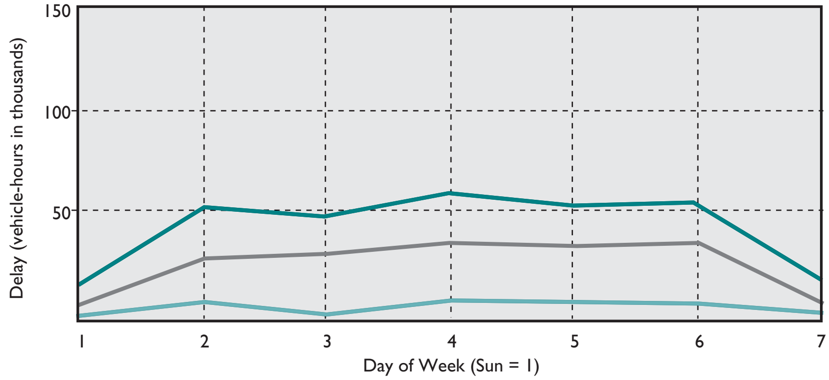


FIGURE 1 Maximum, minimum, and average delay on California's US-101N by day of week over 16 weeks.

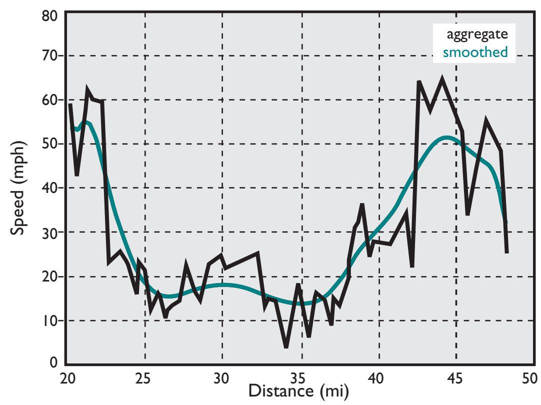


FIGURE 2 Speed on 30-mile stretch of I-10W, 7:30 a.m., September 14, 2000.

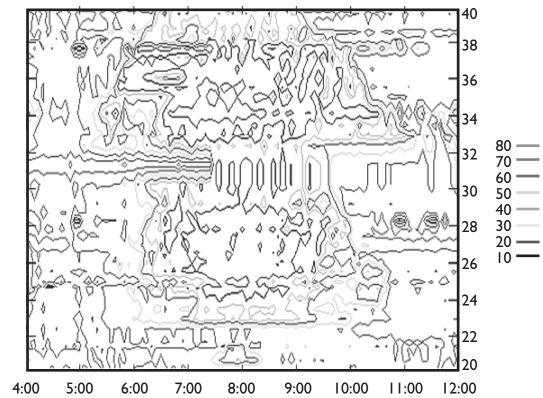


FIGURE 3 Contour plot of speed on I-10W, 4:00 a.m. to noon, September 14, 2000.

duce a report with meaningful statistical measures. Because congestion delay is a random quantity, PeMS measurements and reports account for statistical fluctuations.

The same applies to other reports based on one-shot samples of randomly fluctuating quantities. Travel time, an important component in mobility measures, fluctuates widely from day to day; a meaningful summary of travel times should reflect the fluctuations. PeMS computes the travel time for each freeway segment every 5 minutes.

PeMS also collects statewide incident data reported by the California Highway Patrol and coordinates the incidents with loop detector data. In this way, hypotheses relating incidents to such traffic variables as vehicle-miles traveled or congestion delay, or to freeway geometry, can be formulated and tested.

Finding Bottlenecks

The PeMS application, “plots across space,” can assist in identifying bottlenecks for detailed investigation. An engineer selects a freeway section, a time, and a performance variable such as speed, flow, or delay. PeMS produces a plot of the variable across space. Figure 2, for example, displays speed averaged across all lanes for a 30-mile stretch of I-10W, beginning at Milepost 20, at 7:30 a.m., September 14, 2000. PeMS also can provide lane-specific plots.

The precipitous drop in speed from 60 to 20 mph near Milepost 23 indicates a potential bottleneck; another potential bottleneck appears near Milepost 32. The PeMS contour plot in Figure 3 confirms both bottlenecks, as does an examination of the same plots for other days. Without PeMS, the analysis would be time-consuming. Quickly determining the bottlenecks, the engineer then can determine the cause—for example, the location of interchanges, the highway geometry, or large flows at ramps—and propose solutions.

In addition, any scheme to relieve a bottleneck can be evaluated in a before-and-after comparison; the implementations of different schemes can be compared. As statewide experience accumulates, the most effective and appropriate schemes can be implemented.

Testing Maximum Flow

The speed-flow relationship is fundamental to traffic theory. The *Highway Capacity Manual,* 2000 ed., charts this relation as curves that yield a maximum flow at speeds between 50 and 55 mph; California uses the range of 35 to 50 mph, based on earlier versions of the manual. PeMS was used to test these ranges against cross-sectional data from 3,363 loop detectors at 1,324 locations in Los Angeles, for a 12-hour period beginning midnight, September 1, 2000, bracketing the morning commute.

The 5-minute interval during which the flow reached its maximum value was determined for each detector, and the average speed during a 25-minute interval surrounding the maximum-flow interval was calculated, to measure the sustained speed during maximum flow. Figure 4 displays the per-lane distribution of this speed: in Lane 1, the innermost lane, the speed was between 60 and 70 mph; in Lane 2, it was between 55 and 60 mph; in Lanes 3 and 4, it was between 50 and 60 mph. The PeMS test therefore contradicts the hypothesis that maximum flow occurs between 35 and 50 mph, as well as the hypothesis that it occurs between 50 and 55 mph.

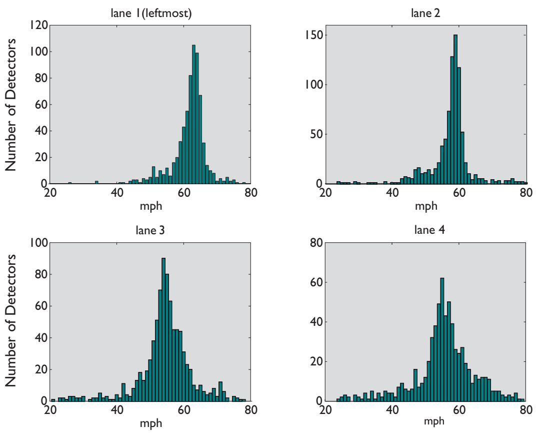


FIGURE 4 Distribution of speed by lane at time of maximum flow.

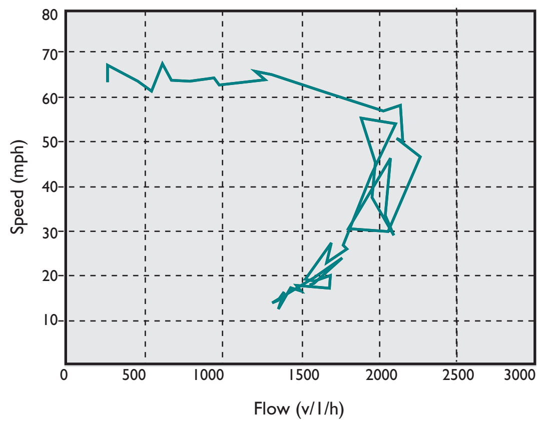


FIGURE 5 Speed-flow relationship, I-10W, 4:00 a.m. to 8:00 a.m., September 14, 2000.

The finding has significance. First, it indicates that 60 mph is the most efficient speed—drivers at slower speeds experience congestion—implying that congestion delay should be measured as the time spent driving below 60 mph. Caltrans, however, measures congestion as the time spent driving under 35 mph continuously for 15 minutes.

The second implication is that a ramp-metering strategy will be effective only if it maintains free-flow speed. Lower speeds—for example, 45 mph—are not sustainable, as shown in Figure 5, a PeMS *x-y* plot comparing 5-minute averages of any two variables at a detector. The speed-flow relationship on Lane 1 is from 4:00 to 8:00 a.m. on September 14, 2000, at Milepost 32.87 on I-10W, near the second bottleneck in Figure 2. As soon as occupancy causes the speed to drop below 60 mph, at 5:10 a.m., the flow becomes unstable, dropping to 30 mph by 5:30 a.m., and 15 mph by 7:00 a.m. It is unlikely that traffic flow can be sustained at speeds below 55 mph. Examining hundreds of similar plots confirms this conclusion.

Ramp Metering

A complex PeMS application calculates the potential reduction in congestion from an ideal ramp-metering policy (IMP) on a freeway section that experiences recurrent congestion during the morning rush hour, from 6:00 a.m. to 10:00 a.m. Data were gathered at a 16-mile segment of I-210W, starting at Milepost 22, on January 11, 2001. The time period, 4:00 a.m. to noon, spanned the rush hour; traffic was free-flowing at the beginning and end of the study period.

The freeway section comprises several PeMS segments, some with on-ramps, some with off-ramps, and some with neither. For each 30-second interval, PeMS gives the inflows of vehicles into the study section from each on-ramp and from upstream, as well as the outflows at each off-ramp and downstream. PeMS does not have origin–destination data, so the application calculates a ratio for the total inflow and outflow in each segment.

The application next calculates the maximum throughput in each segment—the maximum flow observed in the segment during the study period. The maximum flow is an empirical quantity, which varies slightly from day to day and from segment to segment (*4*).

The hypothesis is that if the flow on each segment stays below the maximum—for example, by 3 percent—then vehicles will travel at 60 mph. Although

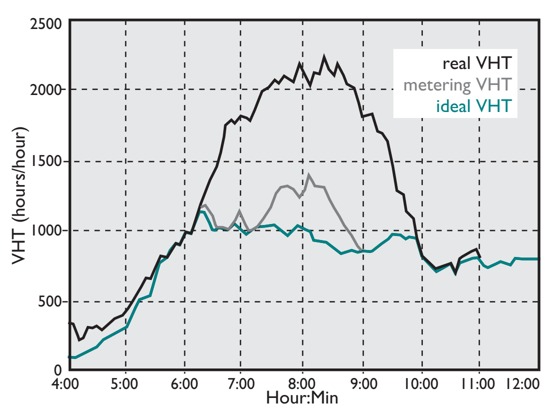


FIGURE 6 Potential reduction in congestion delay from ramp metering.

the conclusions about free-flow speed support this hypothesis, a true test requires field experiments.

IMP admits vehicles at each on-ramp—and upstream of the study section—as long as the flow in every section does not exceed the maximum flow minus 3 percent. Hypothetically, a vehicle may be held back at an on-ramp, but when it enters the freeway it will travel at 60 mph.

The three plots in Figure 6 display the result of IMP. The top curve plots the actual vehicle-hours spent in the study section during each 5-minute slice from 4:00 a.m. to noon. The units are vehicle-hours per hour, calculated from the known flows and speeds.

The area under the top curve is the total vehicle-hours spent in the section during that period. The bottom curve gives the vehicle-hours that the vehicles would have spent without delays at the ramps and traveling at 60 mph. The area under the bottom curve, therefore, shows the free-flow vehicle-hours that would have been spent with the same traffic demand. The difference in the area under the top and bottom curves represents the vehicle-hours of delay caused by traveling less than 60 mph. The two curves coincide outside the 6:00 a.m. to 10:00 a.m. congestion period.

The middle curve plots the vehicle-hours that would have been spent under IMP. According to the hypothesis, a vehicle is either in queue at an on-ramp or traveling at 60 mph on the freeway. The area between the middle and bottom curves, then, depicts the vehicle-hours spent in queue at the on-ramps, and the area between the top and middle curves is the net reduction in congestion delay. The Figure 4 example shows approximately 3,000 vehicle-hours of total congestion delay; IMP could eliminate 2,400 hours, along with 600 vehicle-hours of queuing delay at on-ramps.

With this application, planners can locate sites that would benefit from ramp metering. Ramp metering is a contentious local public-policy issue in California, but PeMS can provide an empirical basis for estimating the cost and benefit of a proposed installation. The application also calculates the queue lengths that would form at the ramps and upstream of the study section—information that can be used to determine if the storage for ramp queues is sufficient. The queue at one on-ramp can be traded off against another. The application can stimulate a study of alternative coordinated ramp-metering strategies and coordinated arterial signaling.

Extrapolating data from five freeways in Los Angeles for the morning commute periods of the week of October 3–9, 2000, to all Los Angeles freeways produces an estimate that travelers spend 70 million vehicle-hours each year driving below 60 mph; IMP can eliminate 50 million of those vehicle-hours. If vehicle-hours are valued at $20 each, the potential annual savings would be $1 billion (*3*).

Freeway Efficiency

The freeway segment of Figure 5 can support a flow of 2,100 vehicles/lane/hour at 60 mph. But at 7:00 a.m., when congestion is heaviest, the segment serves only 1,300 vehicles/lane/hour at 15 mph. A measure of efficiency, η, is given by Formula 1:

$$\eta = \frac{Flow \times Speed}{Max\ Flow \times Speed\ at\ Max\ Flow} \qquad (1)$$

According to this formula, the efficiency of this segment at the time of heaviest congestion was

$$\eta = \frac{1300 \times 15}{2100 \times 60} = 13\ percent$$

The formula considers the freeway segment as a queuing system that provides a service to each customer, or vehicle. A vehicle's service time is

$$\frac{Segment\ Length}{Speed}$$

The throughput of this queuing system at any time is the number of vehicles served per hour:

$$\frac{Speed}{Segment\ Length} \times Flow$$

The maximum throughput is

$$\frac{Speed\ at\ Max\ Flow}{Segment\ Length} \times Max\ Flow$$

Formula 1 defines efficiency as the ratio of actual throughput to maximum throughput.

PeMS was used to estimate the efficiency of 291 segments of I-10W during the morning of October 1,

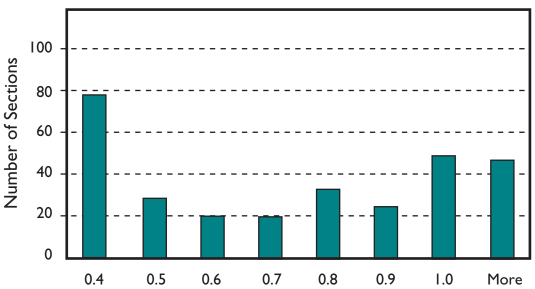


FIGURE 7 Efficiency during heaviest congestion along segments of I-10W, midnight to noon, October 1, 2000.

2000. For each segment, the 5-minute interval with maximum occupancy between midnight and noon was determined, along with the speed and flow, and the maximum flow during the 12-hour interval. The values were applied to determine the efficiency of the segment during the heaviest congestion.

Figure 7 shows the distribution of efficiency for the 291 segments at the time of heaviest congestion: 78 segments were under 40 percent, 65 between 40 and 80 percent, 71 between 80 and 100 percent, and 46 above 100 percent—recording speeds above 60 mph at the time of maximum occupancy.

The calculation shows that the capital stock operates at low efficiency at times of greatest demand. The gain from restored efficiency will exceed that from any increases in capacity through new construction. Any program to build intelligence into the transportation system must make its main objective the recovery of lost efficiency.

Travel Times

Figure 8 gives the travel times for a 48-mile trip on I-10E, beginning at Milepost 1.3 between 5:00 a.m. and 8:00 p.m., for 20 working days in October 2000; the data are from PeMS travel time calculations. A traveler leaving at 5:00 p.m. may require between 45 and 130 minutes, with a 70 percent chance the trip will take between 60 and 100 minutes and a 10 percent chance it will take more than 100 minutes. At a 90 percent confidence interval, the best travel time estimate would be between 55 and 110 minutes—a 200 percent variation that can be reduced if conditions are known.

There are 20 curves in the figure, one for each day, obtained from the travel times. If the current travel time for a particular trip is known, the travel time can be predicted for the immediate future. If at 4:00 p.m. the travel time is 90 minutes, then at a 90 percent confidence level the travel time at 5:00 p.m. will be between 85 and 110 minutes—a 25 percent variation.

A PeMS application makes estimates of future travel times for each freeway segment based on current and past travel times (*5*). Through an Internet browser, a user indicates a proposed trip by clicking on the origin and the destination, then selects a start or arrival time, and PeMS calculates 15 routes with travel time estimates for each, indicating the routes with the shortest travel times and the shortest distances.

Other Applications

Freeway lanes are often closed for maintenance. PeMS can compute the likely delay caused by a lane closure, comparing traffic demand for similar time intervals in the past with the reduction in throughput from the closure. Proposed lane closures then may be shifted to times that would minimize the impact.

PeMS also collects data on high-occupancy vehicle (HOV) lanes. These data can be used to determine the shift to carpooling as a function of the congestion in the mainline lanes. If ramp-metering can eliminate mainline congestion, HOV lanes would offer no advantage, and could be converted to mainline lanes, increasing capacity. However, HOV bypass lanes at on-ramps still can encourage carpooling.

General-purpose simulation models like CORSIM and Paramics typically answer if-then questions ranging from the effectiveness of ramp-metering schemes to the impact of traveler information. PeMS data may be used to calibrate the parameters for the models.

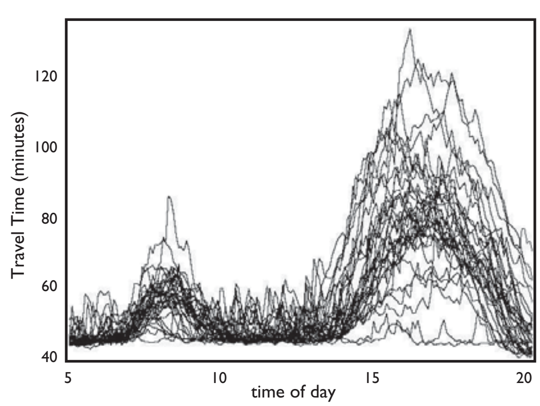
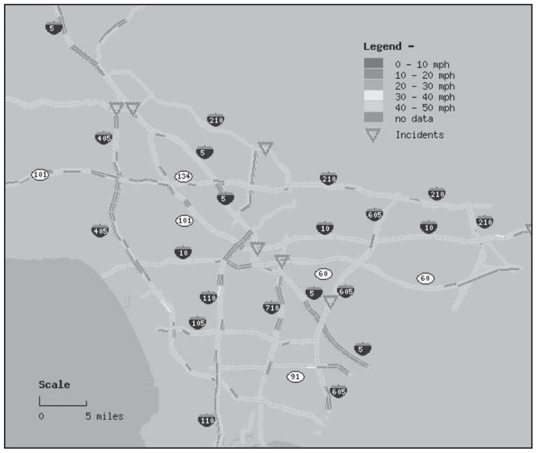


FIGURE 8 Travel time on I-10E between Mileposts 1.3 and 48.5 for 20 working days, at different start times from 5:00 a.m. to 8:00 p.m., October 2000.



Screen shot of a PeMS display of traffic conditions around Los Angeles, California, April 4, 2001.

Similarly, PeMS data may create special-purpose statistical models—for example, for the impact of lane closures, HOV effectiveness, and travel time prediction. Other models might estimate the impact of incidents, weather, and special events. Special-purpose statistical models are easier to calibrate and maintain, and can be more reliable than the general-purpose simulation models.

Improving System Performance

ITS technologies originally promised a quick path to productivity gains in transportation. Although a realistic assessment of the gains from the deployment of these technologies has not yet been made, an informed guess is that the gains have been marginal. The production of transportation services is highly complex, orchestrating many interdependent activities in the areas of operations, planning, and investment. Such complex systems are not affected by quick technological fixes.

A wise traffic engineer remarked 40 years ago, “If you don’t know how your system performed yesterday, you cannot expect to manage it today.” A prerequisite to ITS is intelligence—knowing what is happening to the system, understanding what decisions are effective, identifying opportunities for valuable services, and determining what technologies can help.

The consensus of drivers in California’s urban areas is that this productivity is declining. But the status quo can be changed. The first step is to equip system operators and customers with intelligence about the system—PeMS can do this. The next steps are difficult, requiring a careful examination of all the activities that affect system performance, finding the changes in the activities that can lead to the greatest improvement in performance, and implementing and monitoring those changes.

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References

1. C. Chen, K. Petty, A. Skabardonis, P. Varaiya, and Z. Jia, Freeway Performance Measurement System: Mining Loop Detector Data. In *Transportation Research Record: Journal of the Transportation Research Board, No. 1748*, TRB, National Research Council, Washington, D.C., 2001, pp. 96–102.
2. Z. Jia, C. Chen, B. Coifman, and P. Varaiya. The PeMS Algorithms for Accurate, Real-Time Estimates of g-Factors and Speeds from Single-Loop Detectors. IEEE 4th International ITS Conference, Oakland, Calif., Aug. 2001.
3. Z. Jia, P.Varaiya, C. Chen, K. Petty, and A. Skabardonis. Maximum Throughput in L.A. Freeways Occurs at 60 mph v.4. ransacct.EECS.Berkeley.EDU/info.phtml, Jan. 2001.
4. Z. Jia, P. Varaiya, C. Chen, K. Petty, and A. Skabardonis. Congestion, Excess Demand, and Effective Capacity in California Freeways. transacct.EECS.Berkeley.EDU/info.phtml, Dec. 2000.
5. J. Rice and E. van Zwet. A simple and Effective Method for Predicting Travel Times on Freeways. IEEE 4th International ITS Conference, Oakland, Calif., Aug. 2001.

Traveler Response to Information

Who Responds and How?

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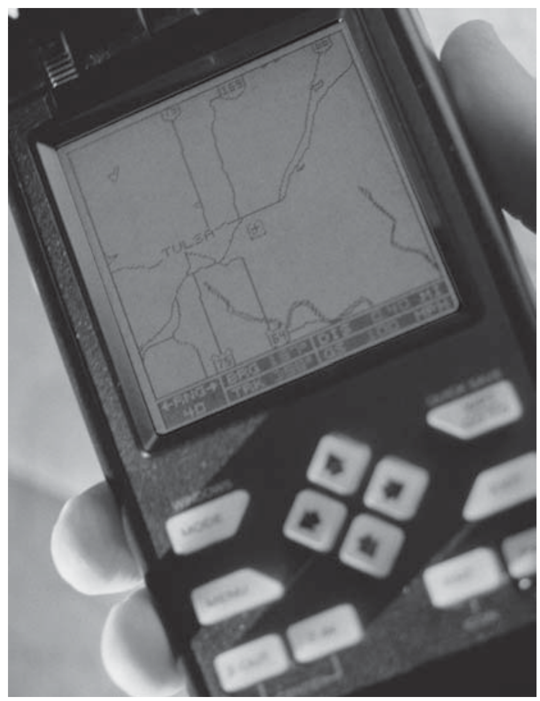
When the automobile first made it possible for large numbers of people to travel beyond their local areas, finding directions became a problem. The range for most travel had been limited previously to short distances from home, and people were familiar with the local network—signs were not necessary. However, as new drivers roamed into unfamiliar areas, the lack of signage made getting lost a common experience.

Technology found ways to deliver information to travelers (*1*). For example, an in-vehicle cylindrical or disc-shaped device with imprinted way-finding information turned at a rate synchronized with the vehicle's wheel rotation. When given the trip starting location, the device would display direction options at each major decision point. Advanced models provided information on road conditions, railroad crossings, and speed traps.

Major investments in signage and road maps made such devices less necessary, and by the mid-1900s research in traveler information systems was mostly limited to specialized or military applications. But as traffic congestion and the economic and environmental effects of automobile use became concerns, advanced traveler information systems (ATIS) regained interest. Technological progress in traffic monitoring, vehicle location, and data processing and communications has made many new traveler information applications possible.

Devices store data about large portions of the nation's road network, use Global Positioning Systems to determine vehicle location, and provide turn-by-turn directions to a chosen destination. Real-time information on travel conditions is available via television, radio, computer, telephone, and wireless devices. Systems soon may make travel recommendations based on forecast traffic conditions.



Global Positioning Systems can determine vehicle location and provide turn-by-turn directions.

Interest also has increased in understanding traveler reactions to trip-related information:

◆ Companies developing information products need to know what features travelers value and why, to make improvements and determine appropriate pricing.

◆ Agencies investing in travel information infrastructure need to know how travelers perceive and value the benefits.

◆ Agencies may use traveler information as a tool to improve operating conditions in the transportation system. This requires predicting the network-level impacts of information by aggregating the responses of individual travelers to ATIS messages and also accounting for traveler interactions.

◆ Finally, systems that provide information based on predicted travel conditions also must incorporate traveler response. For example, if an ATIS uses short-term traffic forecasts to predict congestion on one route, many drivers may divert to a different route; but this reaction may invalidate the forecast, leaving the original route relatively free-flowing, and creating congestion on the alternate. Generating messages based on traffic forecasts therefore requires the ability to predict and incorporate driver reactions.

Potential Users

A recent analysis of results from a survey of travelers in areas with Metropolitan Model Deployment Initiative ATIS prototypes identified several distinct groups of users, including (2)

◆ Control seekers who travel frequently, are comfortable with technology, and like to plan ahead;

◆ Value-added service buyers who are uncomfortable with maps and computers but appreciate things that make life easier; and

◆ Wired with children, who have high incomes and long commutes but value convenience.

More experience with ATIS will allow more precise definitions of user segments and lead to a better understanding of each segment's reasons for accessing and reacting to travel information.

Traveler Reactions

Travelers typically go through several stages before becoming regular ATIS users (*3*):

◆ Awareness—the traveler has basic information about the availability and attributes of an ATIS;

◆ Consideration—the traveler begins to consider ATIS as an option before making trips;

◆ Choice—the traveler makes ATIS an option for assessing an identified travel need;

◆ Trial use—the traveler decides to try ATIS to gain familiarity with its potential benefits and costs; and

◆ Repeat use—the traveler continues to use ATIS, although experience may lead to reconsideration.

Repeat use makes it possible to study systematic traveler response to real-time information. Responses may affect nontripmaking as well as tripmaking decisions.

Nontripmaking Responses

◆ *Reduce stress and anxiety.* Several surveys have found that tripmakers appreciate having travel information available (*4*)—respondents claim that the information reduces the anxiety or stress of not knowing the travel conditions.

◆ *Organize nontravel activities at trip endpoints.* With ATIS, tripmakers may be better able to organize the activities they undertake at departure or arrival. With an accurate, revised estimate of arrival time, a person unexpectedly stuck in traffic may be able to call ahead and rearrange the schedule at the destination to minimize the impacts of the delay. A person who wants to complete a task at one location but needs to get to another location at a certain time may use travel time information to determine if that is possible.

A simulation study showed that pretrip ATIS can reduce early and late schedule delays significantly, as well as reduce late arrivals (*5*). In the Washington, D.C., metropolitan area, pretrip information reduced the number of late arrivals by 62 percent and the total schedule delays by 72 percent.

◆ *Adjust daily activity schedule.* People schedule daily activities based on the time needed for each and on the time required for travel between activities in different locations. Because of uncertainty about travel times, people incorporate "slack" into the schedule to reduce the probability of disruptions from worse-than-expected travel conditions.

A study of scheduling choices indicated the amount of slack that commuters think they must build into departure times (*6*). Approximately 40 percent of survey respondents stated that they schedule commute trips to arrive at work at least 15 minutes before start time; the planned-for delay increases with the distance from work, suggesting a direct relation to perceptions of travel-time variability.

Gerald Stone, California PATH Program

Variable message sign alerts drivers of the fee for high-occupancy toll lane in Orange County, California.

Reliable information on travel times and traffic conditions would allow commuters to reduce or eliminate the slack. The freed-up time might lead to a different organization of the day's activities and perhaps to fewer trips (because of increased trip-chaining opportunities), to more trips (because of more activities), or to changes in trip timing. These adjustments are plausible, but data are not available.

◆ *Modify habitual tripmaking behavior.* Tripmakers rely on habit in making travel decisions. Improved travel information may lead not only to short-term changes in travel decisions, but also to long-term changes in habitual behavior, as documented among commuters in Osaka, Japan, after the installation of a variable message system (VMS) that predicted travel times (*7*). However, decision-making inertia played a role—in short-term responses, drivers were reluctant to switch from habitual routes; in longer-term responses, drivers were reluctant to change, even if the VMS showed that the habitual route was the inferior alternative.

◆ *Change residence or employment location.* The activity changes brought about by ATIS could lead people to reconsider residential and employment locations. For example, if ATIS makes travel times more predictable, households could move farther away from job locations but still maintain the same average commute time. In this way, ATIS could have an impact on urban form and structure (*8*)—however, such effects may not be noticeable or significant until ATIS is deployed more extensively.

Tripmaking Responses

◆ *Decision to travel or not.* Surveys of noncommuters for the San Francisco, California, area's TravInfo® project show that information about bad travel conditions can induce tripmakers to cancel trips—particularly discretionary trips (*9*).

◆ *Choice of destination or destinations.* The literature offers scant information about the effects of ATIS on destination choice or on trip chaining—the decision to visit several places for several purposes in one trip. Choices among multiple destinations are typical of shopping trips (*10*), but opportunities to group multiple purposes and destinations into a single trip chain are difficult to characterize.

◆ *Departure time choice.* In surveys of Seattle, Washington, area commuters who received travel information from radio, television, and telephone services, 40 percent indicated some flexibility in scheduling and selecting the morning route; 23 percent indicated no flexibility; but 64 percent reported that they rarely changed departure time as a result of pretrip information (*11*).

In an experiment using travel-choice simulators, the process by which drivers make departure-time decisions based on ATIS messages was modeled as a sequence of decisions leading to an adjustment of the habitual departure time (*12*). The departure time adjustment was influenced by system attributes such as trip-time variability, tripmakers' short and longer term experiences, and the nature, type, and quality of real-time information supplied by ATIS.

Advanced traveler information systems help commuters plan trip routes.

◆ *Mode choice.* Less than 1 percent of early callers to San Francisco's TravInfo service asked to be connected to the transit menu after learning about bad traffic conditions (*13*); however, as experience with the system increased, up to 5 percent asked to be connected to the transit menu, and of those connected, 90 percent chose transit.

◆ *Route choice.* Many surveys and simulator studies have demonstrated that ATIS influences route choice. Nonetheless, the nature of the guidance and the conditions experienced beforehand can affect driver response—that is, the driver's perception of the accuracy and reliability of the message is key.

Researchers have found an "accuracy threshold" below which drivers will ignore ATIS messages (*14*). Similarly, factors that increase drivers' confidence in the accuracy of the messages tend to increase the likelihood of response; these include observation of congestion immediately before receiving the message and favorable past experiences with ATIS. Although drivers tolerate some error in ATIS messages, those familiar with an area expect higher degrees of accuracy.

Some drivers prefer descriptive information about traffic conditions; others prefer prescriptive recommendations of routes. In some travel-choice simulator experiments, combining prescriptive recommendations with the justifying descriptive information has produced the highest rates of route switching.

Several other idiosyncratic influences condition a driver's route choice response to ATIS messages. Some studies have observed freeway bias (*15, 16*)—drivers are more likely to comply with messages that suggest diverting from a nonfreeway to a freeway than with messages to switch from a freeway to a nonfreeway.

◆ *Incident diversion response.* A special case occurs when a driver becomes aware of an incident affecting traffic conditions ahead. ATIS can provide drivers with timely information about the location and nature of an incident and can suggest routing alternatives.

The driver must choose among three possibilities: do not divert (ND); divert and return to the original path (DR); divert and do not return to the original path (DNR). The DR route switch represents a temporary detour around the cause of delay; DNR entails choosing a completely new route. A study to determine the best modeling structure for incident-related routing decisions concluded that the "maintain route" choices of ND and DR best fit the observed distribution—for both choices, the majority of the route remains the same (*17*).

◆ *Driving behavior.* Traveler information also can influence driving behavior during a trip, for example by warning about hazardous road conditions. A study found that suggesting appropriate freeway speeds via VMS—with no obligation for drivers to comply—produced a small decrease in average travel speeds but also a reduction in the variability of the speeds (*18*). The reduction in speed variability delayed the onset of congested conditions at maximum flow, increasing the throughput of the freeway. Speed advisory VMS is now deployed on several freeways in the Netherlands.

◆ *Parking search and choice.* Parking guidance and information (PGI) systems inform drivers about the availability of parking. Messages generally are displayed on a series of VMS, so that traffic traveling toward the city center receives progressively more detailed information. The messages may be based on current occupancies or on the occupancies predicted for the time a vehicle passing the VMS would arrive.

Often the municipal government operates the parking facilities and the PGI system; however, in some arrangements in England, for example, privately operated parking facilities provide data to the municipal PGI system. Benefits of PGI systems include minimizing parking search traffic, which can comprise 30 percent or more of road traffic in some city centers (*19*).

What Information Do Users Want? How Much Will They Pay For It?

A travel-choice simulation study compared en route decision-making responses to "basic" and "enhanced" ATIS (*20*). Basic ATIS consisted of descriptive information on incidents and congestion, with qualitative estimates of travel delays; enhanced ATIS included the basic services plus information on alternative routes, details on incidents, and a map display of real-time traffic conditions. The analysis of how users translated the information into travel improvements indicated that the following information was most valuable:

- ◆ Incident location, type, and delays;
- ◆ Queue lengths; and
- ◆ Recommendations and directions for alternative routes.

Drivers in the experiments most frequently referred to the real-time map of traffic conditions; however, human factors questions remain about the best way to present the map.

Few currently pay to receive travel information, and survey conclusions about willingness to pay are fraught with uncertainty. According to one study, willingness to pay for travel information may be affected by the uncertainty of travel time; situational and contextual factors such as trip purpose, departure or arrival time flexibility, and trip chaining requirements; and socioeconomic factors such as age, gender, income, and education (*21*). However, individuals who are aware of ATIS, who access real-time information through communication or computing devices, or who already receive travel information via phone, radio, or other conventional sources are more likely to express a willingness to pay.

Researchers at the University of Michigan Transportation Research Institute studied the stated rankings of different types of travel information by drivers for commute trips, trips in a familiar area, and trips in an unfamiliar area (*22*). For commute trips and trips in familiar areas, information on travel delays and travel time reliability on the original and alternate routes were ranked highest; for trips in unfamiliar areas, the availability of travel directions for alternate routes ranked high.

In another study, drivers who had field-test experience with prototype in-vehicle navigation devices were surveyed about preferences for update frequency, network coverage, and information personalization (*23, 24*). Basic improvements in the information quality of available sources—for example, radio reports—were highly valued, but the utility of information quality improvements decreased as more were added.

The drivers valued improved geographic coverage and update frequency but perceived door-to-door coverage as a small benefit compared with coverage of freeways and arterials. Similarly, respondents preferred updates several times an hour but rated the value of nearly continuous updates as small to negligible. Most indicated a willingness to pay for real-time traffic information; but a few indicated they would not pay.

A San Francisco Bay Area survey asked automobile and transit users to rank possible information features and prices of a hypothetical ATIS (*21*). The most desirable content options were constant updates, alternate route information, in-car computer information, expected delay data, and route-time comparisons. Many respondents indicated a willingness to pay at least some amount for high-quality, real-time traffic information; the majority preferred to pay per request instead of by monthly fee.

User Benefits

User responses to ATIS range from relatively simple route switching to the complex rearrangement of a daily activity schedule—a range that exceeds the gamut of impacts considered in most transportation project evaluations. Conventional evaluations usually compute user benefits as a change in the consumer surplus, defined as the difference between what a person is willing to pay (in money or in time) and the amount actually paid. Willingness to pay is deduced from the travel demand curve expressing the amount of travel at different cost levels or times; in this way, conventional evaluations tie user benefits to reductions in travel cost or time.

However, this approach is unlikely to capture the full range of ATIS-produced user benefits. For example, people who are able to carry out more activities because of better travel information may say that ATIS made them better off even though they travel more—the benefits from the additional activities more than offset the opportunity cost and disutility of the time spent traveling.

A proposed general method for evaluating ATIS user benefits would estimate willingness to pay directly from results of stated preference surveys of current or potential users, instead of from a conventional time- or cost-based demand curve (*25*). The surveys can ask respondents to trade off service attributes against cost; a well-designed survey, properly conducted and analyzed, can provide reliable information on willingness to pay for different services or systems.

The method would avoid many of the complications of a model-based approach—such as first estimating how ATIS users may rearrange daily activities and tripmaking and then evaluating the travel and nontravel benefits and costs—the responses to the stated preference surveys would incorporate these effects. This method can be both simpler and more accurate than conventional transportation evaluations of the unique properties of ATIS.

ATIS is still in the early stages of deployment and adoption. By improving travelers' tripmaking decisions, ATIS can produce widespread effects at the individual and the network levels. Better understanding of travelers' responses to information will lead to better planning and operation of ATIS. Improved understanding will come with system deployments combined with focused efforts to collect data on the impact of ATIS on user behavior.

References

1. French, R. L. *In-Vehicle Route Guidance in the United States: 1910–1985*. In *2nd International Conference on Road Traffic Control*, 1986.
2. Mehndiratta, S. R., S. Peirce, M. Kemp, J. Lappin, and C. Cluett. A Profile of the Emerging ATIS Consumer: Evidence from Five Metropolitan Model Deployment Initiative Sites. *ITS Quarterly*, Vol. 8, No. 1, 2000.
3. Polydoropoulou, A., and M. Ben-Akiva. The Effect of Advanced Traveller Information Systems on Travellers' Behavior. In *Behavioral and Network Impacts of Driver Information Systems* (R. Emmerink and P. Nijkamp, Eds.), Ashgate Publishing, Brookfield, Vt., pp. 317–352.
4. Khattak, A. J., J. L. Schofer, and F. S. Koppelman. Effect of Traffic Information on Commuters' Propensity to Change Route and Departure Time. In *Journal of Advanced Transportation*, Vol. 29, No. 2 (1995), pp. 193–212.
5. Wunderlich, K. E., M. H. Hardy, J. J. Larkin, and V. P. Shah, *On-Time Reliability Impacts of Advanced Traveler Information Services*. Mitretek Systems, Falls Church, Va., 2001.
6. Mahmassani, H. S., and G.-L. Chang. Experiments with Departure Time Choice Dynamics of Urban Commuters. *Transportation Research B*, Vol. 20B, No. 4 (1986.), pp. 297–320.
7. Uchida, T., Y. Iida, and M. Nakahara. Panel Survey on Drivers' Route Choice Behavior Under Travel Time Information. In *Proceedings of the Conference on Vehicle Navigation and Information Systems*, 1994, pp. 383–388.
8. Boyce, D. E. Route Guidance Systems for Improving Urban Travel and Location Choices. *Transportation Research A*, Vol. 22A, No.4 (1988), pp. 275–281.
9. Khattak, A. J., Y. Yim, and L. Stalker. Does Travel Information Influence Commuter and Noncommuter Behavior? Results from the San Francisco Bay Area TravInfo Project. *Transportation Research Record: Journal of the Transportation Research Board, No. 1694*, TRB, National Research Council, Washington, D.C., 1999, pp. 48–58.
10. Kraan, M., H. S. Mahmassani, and N. Huynh. Interactive Survey Approach to Study Traveler Responses to ATIS for Shopping Trips. Presented at TRB 79th Annual Meeting, Washington, D.C., 2000.
11. Mannering, F. L., S.-G. Kim, W. Barfield, and L. Ng. Statistical Analysis of Commuters' Route, Mode and Departure Time Flexibility. *Transportation Research C*, Vol. 2, No.1 (1994), pp. 35–47.
12. Srinivasan, K., and H. S. Mahmassani. Dynamics in Departure Time Choices of Commuters: A Comparison of Alternative Adjustment Mechanisms. Presented at Transportation Research Board 80th Annual Meeting, Washington, D.C., 2001.
13. Yim, Y., and M. A. Miller, *Evaluation of the TravInfo Field Operational Test*. California PATH Program, Institute of Transportation Studies, University of California, Berkeley, 2000.
14. Kantowitz, B. H., R. J. Hanowski, and S. C. Kantowitz. Driver Acceptance of Unreliable Traffic Information in Familiar and Unfamiliar Settings. *Human Factors*, Vol. 39, No. 2 (1997), pp. 164–176.
15. Hato, E., M. Taniguchi, and Y. Sugie. Influence of Traffic Information on Drivers' Route Choice. In *Proceedings of the 7th World Conference on Transportation Research*, Sidney, Australia, 1995, pp. 27–40.
16. Kitamura, R., P. P. Jovanis, M. Abdel-Aty, K. M. Vaughn, and P. Reddy. Impacts of Pretrip and En Route Information on Commuters' Travel Decisions: Summary of Laboratory and Survey-Based Experiments from California. In *Behavioral and Network Impacts of Driver Information Systems* (R. Emmerink and P. Nijkamp, Eds.), Ashgate Publishing, Brookfield, Vt., 1999, pp. 241–267.
17. Abdel-Aty, M. A. Modeling Incident-Related Routing Decisions by Using a Nested Logit Structure. *Transportation Research Record 1645*, TRB, National Research Council, Washington, D.C., 1998, pp. 103–110.
18. Smulders, S. Control of Freeway Traffic Flow by Variable Speed Signs. *Transportation Research B*, Vol. 24B (1990), pp. 111–132.
19. Allen, P. A. Driver Response to Parking Guidance and Information Systems. *Traffic Engineering and Control*, Vol. 34, No.6 (1993), pp. 302–307.
20. Llaneras, R. E.. and N. D. Lerner. The Effects of ATIS on Driver Decision Making. *ITS Quarterly*, Vol. 8, No. 3 (2000), pp. 53–63
21. Wolinetz, L., A. J. Khattak, and Y. Yim. Why Will Some Individuals Pay for Travel Information When It Can Be Free? Analysis of a Bay Area Traveler Survey. In *Transportation Research Record: Journal of the Transportation Research Board, No. 1759*, TRB, National Research Council, Washington, D.C., 2001, pp. 9–18.
22. Wallace, R., and F. Streff. Developing Advanced Traveler Information Systems: Considering Drivers' Information Needs. *UMTRI Research Review*, Vol. 23, No. 6 (1993), pp. 1–13.
23. Kemp, M., and J. Lappin. Need to Know. *ITS International*, Vol. 21 (1999), pp. 57–58.
24. Mehndiratta, S. R., M. Kemp, J. Lappin, and D. Brand. What Advanced Traveler Information System Information Do Users Want? Evidence from In-Vehicle Navigation Device Users. *Transportation Research Record: Journal of the Transportation Research Board, No. 1679*, TRB, National Research Council, Washington, D.C., 1999. pp. 41–49.
25. Brand, D. Applying Benefit–Cost Analysis to Identify and Measure the Benefits of Intelligent Transportation Systems. *Transportation Research Record 1651*, TRB, National Research Council, Washington, D.C., 1998. pp. 23–29.

Customer-Driven Intelligent Transportation Systems

The Next Generation

THOMAS A. HORAN

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Robert Crandall, the former chairman and chief executive officer of American Airlines, once remarked that his Sabre information system was one of the most important advances in travel in the last 30 years. The comment was not without merit; Sabre facilitated discounts, customer loyalty programs—such as frequent flyer benefits—and new hub-and-spoke service designs that translated yield management into value fares and increased service.

The explosion of the information dimension in the airline travel business has an important message for surface transportation professionals—the public is ready, willing, and able to take charge of its transportation choices. But the Sabre information system had to be in place to realize the benefits of yield management. Similarly, surface transportation professionals must create timely, useful, reliable, and interpretable information systems so that consumers can choose modes, times, and routes of travel.[1]

In the last decade, the Intelligent Transportation System (ITS) program has provided information systems for surface transportation. Transportation planners, policy makers, engineers, and service providers need to consider how these systems can accommodate the needs of users of the nation's highway, transit, pedestrian, and bicycle systems.

Infrastructure–Customer Connection

ITS is a multifaceted research and demonstration program; however, the original vision included a strong public-sector role in creating a consumer

[1] For more on the cross-industry comparison: Horan, T., and W. Reany. *Network Management Approaches: Cross-Industry Comparisons and Implications for ITS Development.* California PATH Program, Berkeley, Aug. 2001 (draft).

TravInfo® uses public–private partnerships to gather up-to-the-minute traffic information.

information platform. For example, Mobility 2000 articulated the vision for a publicly supplied information system that would enable "value added" private-sector traveler information services (*1*). In the last decade, a major lesson from demonstrations and deployments has been that the relationship of the consumer to the infrastructure is more complex than originally envisioned, both in terms of information flow and of the value and use of the information.

Several early demonstrations provided experience in delivering accurate and reliable information about transportation system conditions. During the mid-1990s, the TravInfo demonstration project in San Francisco, California, sought to create a state-of-the-art platform offering multimodal information to travelers. However, institutional and technical limitations

hampered the timely deployment of the publicly financed and managed traffic-sensing system (2).

These limitations have prompted a change in the flow of information. The Bay Area's Metropolitan Transportation Commission now is evaluating public–private partnerships for the production of traveler information—for example, using data from wireless probes. The consumer can become part of the information production. Through cell phones, call-ins, and probes, travelers and their vehicles are assuming an active role in the information system in U.S. metropolitan areas.

The original view was that traveler information would be perceived as valuable, and private-sector resellers would customize the information for users. Market niches are still being pursued, but traveler perception of the value of the information has not yet translated into a strong willingness to pay. This finding has been consistent in demonstrations in Boston, Massachusetts; Phoenix, Arizona; and Washington, D.C.

The 511 national traffic information telephone number can be seen as an astute branding and marketing approach to increase awareness of available traffic information; however, the service may not translate into a paying market. Baseline traffic information will continue either publicly subsidized or cross-subsidized through other value-added services and advertising.

Broadening the Consumer View

Although demonstrations suggest a modest private market for broad-based traveler information services, some consumers may perceive value in the information, and a viable service-delivery model may develop. For example, an initiative in Seattle, Washington, identified several different groups of potential users, as well as the travel information sources appropriate to each. Interest in television-based video information services was found among those averse to technology, and high-end, web-based information appealed to savvy Internet users.

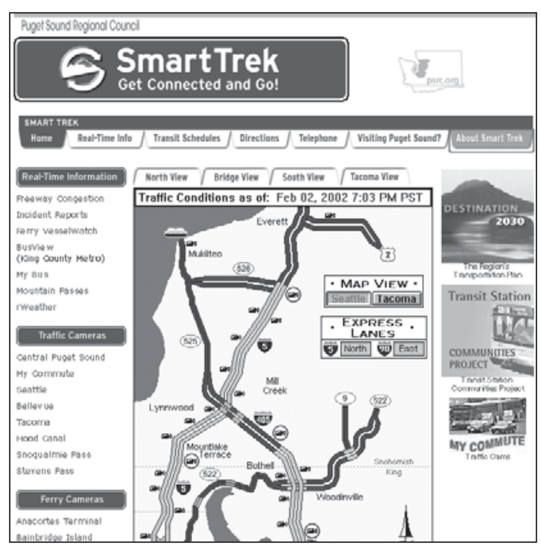
Findings from Seattle and other sites point to the need for a more detailed understanding of market niches for traveler information. A recent summary of lessons learned from national advanced traveler information system (ATIS) field tests identified three market segments, dubbed "control freaks," "web heads," and "information seekers." The first two are often market leaders in new ATIS services and in e-services generally. But information seekers who are less technologically agile represent a large group. The three segments use various styles of travel, and include alternative-mode travelers as well as "flexible" travelers.

Alternative-Mode Travelers

Providing reliable and timely information to alternative-mode travelers has been difficult. As regional ITS programs integrate bus and light rail information systems, interested travelers will gain a useful data source. But alternative-mode traveler information can expand to a variety of niches, such as special transit systems in recreational and national park areas, car-sharing programs in university towns, and jitney systems at airports. As wireless bandwidth becomes more available to residential and mobile users, innovative systems can provide information to—and possibly increase the numbers of—alternative-mode travelers.

The SmartTrek project in the Seattle–Puget Sound region is a telling example. Although a variety of sources offer travel condition information, the SmartTrek website is the most extensive.

Under the leadership of the Washington State Department of Transportation, the project has developed an array of information on various modes, including highway, rail, car sharing, and ferries. Moreover, consumers can customize the types of information available (e.g., video or graphics) and



SmartTrek website provides specific, timely traffic conditions for alternative-mode travelers in the Seattle–Puget Sound region.

the platform for delivery (e.g., Internet or cell phone). An evaluation revealed a high degree of user satisfaction; more than 90 percent of respondents thought that the regional online information was useful and reported that SmartTrek affected decisions about either travel time or means of travel (*3*).

Commercial Deliveries

Sites like SmartTrek engage the personal traveler in an active role in the transportation system, but commercial travel represents a significant opportunity as well. Local commercial delivery has grown rapidly in the last decade. According to a recent study, commercial truck travel increased by more than 37 percent, from 96 billion miles in 1990 to 132 billion miles in 1999; the industry now carries more than 72 percent of the estimated $7 trillion worth of goods shipped nationwide.[2]

Although commercial operators are major stakeholders in both the urban and rural transport systems, protocols are only developing now to integrate commercial travel needs with transportation management plans. For example, some regions are considering flexible working hours at ports to improve the intermodal transfer from shipping to freight. Moreover, there are few models of well-coordinated reservation or parking systems to facilitate downtown deliveries.

The original demonstrations of ITS systems for commercial vehicles focused on the technical dimensions of commercial operations, particularly across state lines. However, the rise of dynamic small delivery services has created a new wave of demand on the transportation system. The next generation of regional ITS development and service should incorporate this new wave of commercial delivery activity.

Flexible Travelers

Another ATIS target market is the flexible traveler—the unsung hero of the transportation system—who can and does change time of travel to gain a more reliable and quicker means of transportation. The flexible traveler may be key to introducing yield management to transportation systems.

A Washington, D.C., demonstration found that ATIS was equally useful for improving reliability and timeliness of service (*6*). Travelers assigned the same importance to knowing with certainty that they could arrive in time for a 9:00 a.m. meeting as to saving time on the commute and arriving earlier. The transportation-telecommunications literature has examined the impact of telecommute programs, but the impact of flexible commute arrangements may be more important in smoothing out the spikes in travel demand.

The clientele is ready—a recent study found that even in a slowing economy, flexible work arrangements remain critical (*7*). In a survey of more than 1,000 employers, Hewitt Associates found that 73 percent offer flexible work options. The most common arrangements are flextime (58 percent) and part-time employment (48 percent). Other popular options include work at home (29 percent), job sharing (28 percent), compressed workweeks (21 percent), and summer hours (12 percent). Flexible travelers can adjust work hours depending on such variables as perceived commute time. This partial telecommuting and flextime arrangement can benefit from accurate ATIS estimates of travel times.

Flexibility also can apply to solutions for commercial traffic. To some extent, the commercial industry already is shifting away from peak hours; for example, commercial delivery services often wait until after the peak period to deliver products and goods to congested urban areas.

However, a recent conference on e-freight revealed that additional traffic and parking information also could make commercial delivery more efficient.[3] The growth of small-package delivery services has raised customer interest in on-time delivery, usually at peak travel times, such as business mornings. Systems that provide certainty for consumers and operators can enhance individual productivity as well as overall system performance.

Flexible, Demand-Predictive Systems

A common theme among these trends, research projects, demonstrations, and technological developments is the transformation of the transportation system. The concrete, asphalt, and steel structure on which uninformed consumers travel inefficiently is becoming dynamic, user-specific, demand-responsive, and

[2] The estimate of 72 percent does not include the 12 percent share of courier services.

[3] For a summary of the E-Freight Transportation Conference; Portland, Oregon: www.intermodal.org/e-freight.html/.

Mayday Plus system integrates Global Positioning Systems, in-vehicle sensors, satellite and cellular phone technology, and emergency response systems to provide automatic notification of crash location and severity.

information-intensive. The consumer relationship with the surface transportation system is becoming more like that with the air travel reservation system.

Economists have maintained that pricing is the simplest, preferred mode for conveying information about demand relative to supply. When demand increases relative to fixed supply—as in peak hours—the price rises; when demand falls relative to supply, the price falls correspondingly. When assessing air travel choices, consumers accept that price discounts occur off peak and price premiums apply to business days. Yet most parts of the United States have never tried the option of congestion pricing or value pricing on roadways.

Electronic toll collection has provided savings to customers. For example, New York's E-Z Pass program has found widespread acceptance among users despite problems with customer support (*8*). E-Z Pass is becoming the de facto standard for the Middle Atlantic states, with seven now using the system.[4] These kinds of technologies are providing transactional platforms for a more dynamic, information-based transportation system.

However, because high-occupancy toll lanes raise policy concerns about equity in pricing, researchers should look at automatic vehicle identification (AVI) technology to facilitate reserved use of the transportation system—combining the values of certainty and flexibility. Like the virtual queuing used by other yield-management schemes—such as FastPass at California's Disneyland—a computer-based system would provide for just-in-time access, spreading demand across the peak period and avoiding unnecessary and unproductive time in queues. In this scenario, a portion of the high-occupancy vehicle (HOV) demand vacancies would be made available, perhaps via an Internet reservation auction requiring AVI preregistration. HOV users would not need reservations.

These and other more mainstream "managed lane" approaches are under consideration—the key is designing the lanes to take advantage of the value of predictability, contributing to system goals of mobility and access.[5]

Emergency-Use Partnerships

The transportation system must function safely as well as efficiently; information systems must facilitate rapid response to emergencies on the transportation network. New private-sector telecommunications and cellular services have played a pivotal role in bringing safety information networks online. From 1990 to 2000, 911 emergency calls from mobile devices multiplied from 20,000 to 120,000 per day (Figure 1)—mobile telematics play a substantial role in safety services.

The new e-911 mandate—determining location based on a cell-phone call—will usher in a new era of emergency service. The recent demonstration of Mayday Plus in Minnesota demonstrates the possibilities of enhanced access to emergency services. The two-year demonstration integrated cellular communications, Global Positioning Systems, and a special emergency-response communications system at the Mayo Clinic and the Minnesota State Patrol emergency dispatch centers.

Through in-vehicle devices, the Mayday Plus system provided authorities with automatic collision notification and information on location and crash severity. More than 100 vehicles in the Rochester region were outfitted with an automatic crash-notification device. The evaluation included both technical and user elements and found that the system

[4] Delaware, Maryland, Massachusetts, New Jersey, New York, Pennsylvania, and West Virginia; www.ezpass.com/interagency.shtml#i.

[5] For more information on the managed-lane concept: www.wsdot.wa.gov/mobility/managed/.

had responded to a safety concern of rural travelers—75 percent of respondents noted the system's value in enhancing rural safety (*9*).

Institutional initiatives such as the national ComCare Alliance in Washington, D.C., are forming partnerships to ensure the delivery of critical services within the narrow "golden hour" between an accident and the onset of medical services. With a large percentage of fatal accidents in rural areas, e-911 provides a valuable tool, but new partnerships involving healthcare providers, emergency services, and the state police are needed to adopt ITS.

Next-Generation Directions

A new 10-year ITS Program Plan is under development. The current version recognizes the consumer's importance, stating that the ITS program should focus on "providing effective, end-to-end, seamless, multimodal transportation services for people wherever they live, work, and play regardless of age or disability…and helping make travel time more productive, by flexibly enabling more travel choices for more people" (*10*). The following are promising research directions for a user-friendly system.

Personalized Transportation Information

Even the prescient Robert Crandall could not have foreseen the extent to which consumers would take control of travel choices. The Sabre system was designed for travel agents, but the World Wide Web has "disintermediated" the travel agent. Sabre gave birth to Travelocity, which remains a shining star in the e-commerce galaxy, among others that follow consumer-focused principles.

For the ITS program, the corresponding challenge is to devise and implement an information system that can satisfy the individual traveler and affect overall system choice and performance. The lesson from customer relationship management—and from previous customer-centered management models—is that information systems can allow for highly tailored relationships with customers while generating overall system efficiencies. This points to the need to develop a more flexible transportation management network that can respond to personalized information and choice.

Flexible Network Management

Managing complex systems like the surface transportation system requires principles and knowledge from several fields: transportation, engineering, economics, social science, and information systems. The PeMS system (see article, page 18) is an example of the next generation of archival-predictive models that hold promise for combining traffic data with management control. These models evoke a new level of operations management that must be integrated with policy, financing, and engineering approaches to transportation management.

An interesting parallel can be found in the energy sector. Recognizing the dynamic nature of energy systems, the Electric Power Research Institute has initiated a cooperative $30 million, five-year program with the Department of Defense to investigate what energy management can learn from complex system dynamics, to devise more reliable and adaptive energy systems (*11*).

Surface transportation may require a similar effort—a research program that draws on advances in complexity theory, user-driven systems, and ITS lessons and developments, to enhance research on information-intensive surface transportation infrastructure. The endeavor would be consistent with a recent National Science Foundation finding that better theories and principles for IT and infrastructure performance are needed to ensure the efficient operation of the nation's civil systems.[6]

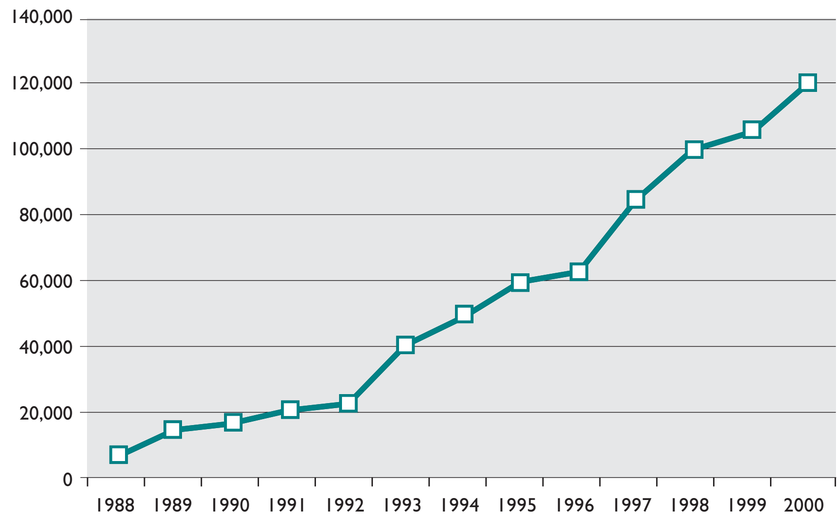


FIGURE 1 Estimated number of wireless emergency calls per day, United States. (SOURCE: Cellular Telecommunications Industry Association).

[6] For a summary of the National Science Foundation–ICIS Information Technology and Infrastructure Workshop: www.nyu.edu/icis/itworkshop/.

Telephone number 511 will provide traveler information nationwide.

Broadening System Information

The information system has played a key role in creating a dynamic air travel market. Surface transportation lacks a comparable system. Although providing information to consumers, ITS has not achieved levels of acceptance and use similar to those of the air travel reservation system.

Information about choice enhances system efficiency. Several policy, market, and technological circumstances have constrained choice in surface transportation; metropolitan areas, however, are pursuing modal options—transit, light rail, car sharing, and e-commuting. The ITS system should provide access to choices among these options, including price as well as time.

Information systems should enhance comprehensive knowledge of how real-time systems are performing, including comparisons with past performance. ITS can improve system performance by producing tools for transportation managers to leverage real-time information into dynamic, systemwide management. Publishing information on system performance will build awareness and may stimulate use among the traveling public (*12*).

Although evaluations of ITS performance are ongoing, some trends are emerging. Most notably, ITS often is credited as cost-effective in near-term transportation improvements, but not as a core strategic element for future transportation systems. A strategic approach should integrate supply, demand, and the power of information technology to manage the system tactically and strategically.

Institutional Allegiances

The institutional challenge of day-to-day operations has received attention in the National Dialogue on Systems Operations. The customer-driven focus adds another dimension—the need to link information systems directly to customers. Transportation managers have much to gain from travelers who will use the information to alter travel time or mode, enhancing personal and consequentially system mobility.

But creating an appropriate and workable institutional partnership can be challenging. The next generation of systems will need to execute partnerships in travel service, navigation, electronic tolling, safety, and emergency services that were hoped for but not fulfilled in the first generation of ITS deployment.

The recent retrenchment in the technology sector has raised concern about the private sector's ability to provide information systems and services to the public. What happens if private-sector partners do not receive adequate return on investment to justify participation in ITS programs? For more than a decade, the ATIS industry has struggled to gain profitability and now functions as part of the larger database, mapping, and radio advertising market segments. Similarly, the major private-sector participants in advanced traffic management systems (ATMS) often are rooted in public-sector contracting, with less attention to fulfilling the needs of end users.

Perhaps the public sector can reduce these uncertainties by articulating a strategic commitment to purchasing and advocating user-friendly transportation information systems. The transportation planning process offers a venue. The regional ITS architecture conformity requirements can be a starting point for the strategic vision—the architecture lays out a general scheme for deploying ITS. The next generation of information systems for surface transportation should build on this planning framework to articulate a strategic vision of customer-oriented transportation information services integrated with the physical and institutional aspects of the system.

Consumer-Driven Systems

The time is right to reconfigure the surface transportation industry to plan, manage, and disseminate information on behalf of system users. During the first decade of ITS testing, the paradigm was for government-provided, industry-assisted forms of information to which customers would respond with beneficial effect on transportation system performance.

The next-generation challenge is to devise a self-organizing information system, realizing benefits through a dynamic market with incentives for just-in-time travel, travel substitution, and full-cost travel. This may include AVI technology for reservation processing, ATIS systems for pretrip information, and ATMS databases to create predictable travel arrangements.

Surface transportation is much too diffuse for the dogged personality of a Robert Crandall to drive its development; but the underlying paradigm needs revamping. Properly configured ITS can provide the information platform to accomplish this mission.

References

1. Mobility 2000. *Mobility 2000 Presents Intelligent Vehicles and Highway Systems*. Texas Transportation Institute, Dallas, July 1990.
2. Yim, Y., and E. Deakin. *TravInfo Field Operational Test Institutional Evaluation Final Results*, California PATH Program, Berkeley, February 2000.
3. Jenson, M., C. Cluett, K. Wunderlich, A. DeBlasio, and R. Sanchez. *Metropolitan Model Deployment Initiative: Seattle Evaluation Report, Final Draft*. U.S. Department of Transportation, Washington, D.C., May 2000.
4. Lappin, J. What Have We Learned from Advanced Traveler Information Systems and Customer Satisfaction? In *What Have We Learned About Intelligent Transportation Systems?*, U.S. Department of Transportation, Washington, D.C., December 2000, pp. 65–86; www.itsdocs.fhwa.dot.gov//JPODOCS/REPTS_TE/@9W01!.PDF.
5. *Stuck in Traffic*. The Road Information Program, Washington, D.C., May 2001.
6. Wunderlich, K., M. Hardy, J. Larkin, and V. Shah. *On Time Reliability Impacts of Advanced Traveler Information Services: Washington, D.C., Case Study*. Mitretek, Washington, D.C., January 2001.
7. *Findings from 2001 Worklife Survey*. Hewitt Associates, Lincolnshire, Ill., April 2001.
8. Vollmer Associates. *E-Z Pass Evaluation Report*. New York State Freeway Authority, Aug. 2000.
9. Castle Rock Consultants. *Mayday Plus Operational Test Evaluation*. Minnesota Department of Transportation, St. Paul, April 2000.
10. Intelligent Transportation Systems of America. *Ten-Year Program Plan* (draft), 2001, www.itsa.org.
11. Amin, M. National Infrastructures as Complex Interactive Networks. In *Automation, Control and Complexity: New Developments and Directions* (T. Samad and J. Weyrauch, Eds.), J. W. Wiley, New York, 2000.
12. Skabardonis, A. Freeway Performance Measurement (PeMS) Project. Presented to Freeway Operations Committee, 78th Annual Meeting of the Transportation Research Board, Washington, D.C., 1999.

511: America's Traveler Information Number

JIM WRIGHT

For many years, departments of transportation (DOTs) have provided traveler information as part of incident management programs. However, with the advent of the U.S. National Intelligent Transportation Systems (ITS) Program in the early 1990s, traveler information developed into a separate service to assist in pretrip and en route planning.

During the last 10 years, the number of ITS field deployments for traveler information has grown considerably, and many sources—including transportation agencies—now provide traveler information over the telephone. Hundreds of different telephone numbers deliver roadway and transit information throughout the United States—some areas offer up to 25 different numbers for transit information only.

These many telephone services provide updates and summary reports on travel times, incidents, road closures due to construction and maintenance, weather conditions, transit schedules, route planning, parking, and other location-specific details. However, each source has its own 10-digit phone number.

Recognizing the difficulties this poses for transportation agencies, U.S. DOT decided to implement a three-digit number nationwide and in March 1999 petitioned the Federal Communications Commission (FCC) for a single phone number exclusively for traveler information. Many state DOTs, transit operators, metropolitan planning organizations, and local transportation agencies supported the petition. In July 2000, FCC assigned 511 as the nationwide telephone number for traveler information.

To assist in the deployment of the nationwide system, more than 30 public and private organizations have formed the 511 Coalition, led by the American Association of State Highway and Transportation Officials and including the American Public Transportation Association, ITS America, and the Federal Highway Administration. The coalition has two operating entities: a policy committee and a working-level committee.

Since the beginning of 2001, the coalition has worked to define the content, consistency requirements, cost-recovery mechanisms, and institutional leadership for a national 511 system, considering such questions as

- What are the standards for content and quality?
- What elements require national uniformity?
- How much will users pay?

The coalition met in August 2001 to establish "launch model" policies for content, consistency, and user costs. The coalition partners are considering resolutions to adopt these launch policies.

March 19–21, 2002, the coalition is convening a 511 Deployment Summit to share the experiences of the early adopters, to view demonstrations of new technologies from private companies, to review cost-recovery models, and to seek new ideas for expanding 511.

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TRB REPORT

Standards for Intelligent Transportation Systems

ANDREW C. LEMER

For more than a decade, transportation professionals have been working to realize the dream of smart or intelligent transportation systems (ITS). These smart systems will use up-to-the-minute information about the movement of people and goods to control and operate roads, highways, and transit. Applying modern computer and communications technologies, ITS will reduce congestion, increase travel speeds, improve safety, save energy, and more.

Making ITS a reality is a complex task. ITS will combine hundreds of distinct products and services for traffic management, public transportation operations, emergency response and incident management, advanced vehicle control and safety, commercial vehicle operations, electronic payment of tolls, railroad grade-crossing safety, and many others. ITS will require cooperation among agencies at local, state, and federal levels of government and in the private sector.

Thousands of individual drivers and passengers will interact daily, determining a system's performance. To make the challenge even more interesting, the electronics, telecommunications, and information technologies of ITS are evolving at breathtaking rates.

The Intermodal Surface Transportation Efficiency Act of 1991 and the 1998 Transportation Equity Act for the 21st Century assigned to the U.S. Department of Transportation (DOT) a substantial role in ITS research, development, and deployment. Because ITS spans the traditionally distinct concerns of highways, public transportation, and other surface modes, U.S. DOT created a Joint Program Office (JPO) to manage the programs that have grown out of the legislation. Prominent among these programs are development and deployment of a national architecture and supporting standards and protocols to promote the use of ITS in the United States.

Gerald Stone, California PATH Program

Gerald Stone, California PATH Program

Transportation manager John Thai, California PATH Program, changes real-time sign in Anaheim, California.

Open System

The National ITS Architecture, released in 1996, is a framework that identifies the functions of components—for example, displaying messages to motorists about traffic conditions on the highway ahead—as well as the various ways that the components can interconnect. This national architecture will allow states, metropolitan areas, and substate or multistate regions to tailor ITS to their needs.

The underlying concept is that ITS should develop as an open system in which products from many manufacturers can be used together, and new products can be developed without proprietary designs hindering use. In other words, ITS components should be interoperable.

Proponents argue that open systems encourage competition among firms and technologies. Critics claim that the commercial advantages of developing innovative products are curtailed if proprietary ideas must be made generally available, even if licensing fees or other arrangements allow the inventors to reap some benefits.

The Apple personal computer, for example, employs proprietary standards, which have deterred software developers and limited the market for compatible products. In contrast, IBM's open standards for the Wintel PC underlie the creation and growth of hundreds of companies producing hardware components, software, and peripheral devices that can work together. Open ITS appeals to state and local agencies that would avoid purchases of proprietary equipment that can be replaced and upgraded only by single suppliers.

Open standards are the means for achieving open systems. For example, technical standards define the characteristics and configuration of ITS components and the interfaces between them, the types of data produced or used, and the ways the data are to be communicated. Open standards for procuring new ITS equipment and installations should ensure the interoperability of components, maintain active competition among suppliers, and protect buyers from the costs of selecting a system that becomes obsolete as soon as newer devices debut.

Developing Standards

ITS comprises two types of components:

◆ Intelligent vehicles—in-vehicle systems to assist drivers and intervene in vehicle control; and

◆ Intelligent infrastructure—systems that monitor operating conditions and prevent or quickly respond to problems, provide information to travelers and operators, and support intelligent vehicle operations.

JPO's principal focus is on standards for intelligent infrastructure.

The ITS standards are being developed through consensus. JPO has cooperative agreements with several standards development organizations (SDOs) that serve as forums in which representatives of private-sector enterprises (e.g., equipment manufacturers or designers), government, and other interested parties (e.g., user groups) can work together. The resulting standards are then available for design and procure-

Committee for Review of the U.S. Department of Transportation's Standards Program for Intelligent Transportation Systems

A. Ray Chamberlain, Vice President and Area Manager, Parsons Brinckerhoff, Denver, Colorado, *Chair*

William G. Agnew, General Motors Research Lab (Ret.), Washington, Michigan

Irwin Dorros, President, Dorros Associates, Morris Township, New Jersey

Jonathan L. Gifford, Associate Professor, George Mason University, Fairfax, Virginia

William F. Johnson, Executive Director, Research and Development, Transport Canada, Montreal, Quebec

Thanos Kipreos, Senior Director, Standards and Technology, Telecommunications Industry Association, Arlington, Virginia

Samuel Krislov, Professor, University of Minnesota, Minneapolis

Alexander Lopez, Senior Project Manager, Metropolitan Transit Authority of Harris County, Houston, Texas

James R. Robinson, Director, ITS Programs, Virginia Department of Transportation, Richmond

Steven E. Shladover, Deputy Director, Program Development, Partners for Advanced Transit and Highways, University of California, Richmond

Scott E. Stewart, Director, IBI Group, Toronto, Ontario

Philip J. Tarnoff, Director, Center for Advanced Transportation Technology, University of Maryland, College Park

James L. Wright, Division ITS Engineer, Minnesota Department of Transportation, Roseville

ment. The standards are voluntary unless adopted as specifications or regulations by agencies or others.

The consensus process is slow, and JPO's activities have drawn criticism. For example, the ITS Standards Program includes more than 80 documents in various stages of development. That number increases as industry and professional groups identify other standards needed, subject to the department's willingness and resources to sponsor development. Although development has proceeded in earnest since the release of the National ITS Architecture, few standards have progressed to field testing, and determining that standards are met is not always straightforward.

Some are concerned that U.S. DOT will use conformance with the standards to determine the eligibility of ITS installations for federal funding; many question if substantial benefits are achievable with national standards. Some fault the SDO-based devel-

Other TRB Reports on Intelligent Transportation Systems

In 1998, a TRB study committee, acting at the request of the Joint Program Office (JPO) of the U.S. Department of Transportation (DOT), provided an assessment of the National Automated Highway System concept authorized and funded in the Intermodal Surface Transportation Efficiency Act of 1991.[1] JPO subsequently requested TRB reviews of two other programs: the Intelligent Vehicle Initiative (IVI) and the Intelligent Transportation Systems (ITS) Standards Program (see accompanying article).

The IVI program seeks to enhance highway safety by accelerating deployment of driver-assistance technologies—such as collision-avoidance systems—in passenger, commercial, transit, and special-purpose vehicles. In 1999 a TRB study committee chaired by Alexander MacLachlan, retired Senior Vice President for Research and Development, E. I. du Pont de Nemours & Co., undertook a three-year peer review of the IVI program.

In July 2001, in the last of three letter reports to JPO, the committee concluded that the IVI program represents an important initiative and is making progress.[2] However, opportunities for advances require increased high-level private-sector involvement and more visible leadership by U.S. DOT in human factors issues. Discussions are under way with JPO about continuing expert review of the IVI program.

After the report of the TRB Committee on ITS Standards, JPO asked that an expert committee continue to review and advise on ongoing and planned activities of the ITS Standards Program, particularly on U.S. DOT's role in achieving adoption of ITS infrastructure standards. In its first letter report, the TRB committee endorsed JPO's shift from a focus on development to a focus on deployment as an appropriate allocation of resources for activities most likely to enhance the benefits from federal investments in ITS.[3]

The committee also agreed that independent validation and verification can determine whether products conform to standards. The committee recommended that buyers should be responsible for assuring that purchased ITS products undergo independent validation and verification, but suppliers should pay for the immediate costs of testing. In addition, DOT should address and allocate funds to maintain standards and expand the program's focus to include in-vehicle components.

[1] *Special Report 253: National Automated Highway System Research Program: A Review*, TRB, National Research Council, Washington, D.C., 1998.

[2] The three reports are available online: www.TRB.org/trb/publications/reports/iviltrpt2001, www.TRB.org/trb/publications/reports/iviltrpt2000, and www.TRB.org/trb/publications/reports/iviltrpt.

[3] www.TRB.org/trb/publications/reports/its_sept_2001.pdf.

opment process as costly, time-consuming, and discouraging the participation of smaller companies. Some observe that ITS technology is evolving more rapidly than standards are being developed—the standards may be obsolete before ever being applied.

Examining the Program

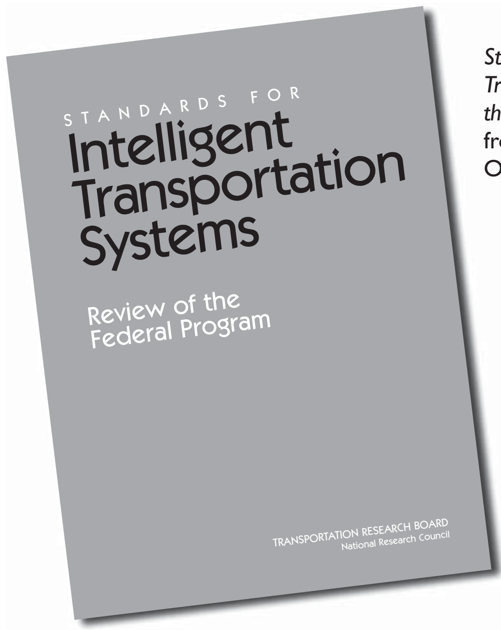
In 1999, JPO asked the Transportation Research Board (TRB) to review the ITS Standards Program. The National Research Council-appointed study committee included professionals in transportation systems development and management, transit operations, automotive technology, telecommunications and electronics, systems engineering, and policy studies (see sidebar, page 39). The committee reviewed and critiqued the strategy, addressing several questions:

- Is the strategy for standards development and adoption appropriate to the program's goals?
- Is the strategy continuing with the needed standards development while transitioning the focus from development to adoption and deployment of standardized products and services? Are the right processes in place, and are U.S. DOT's leadership and expertise appropriately involved?
- How might the program's current and planned activities be altered or expanded to improve the impact and the likelihood of success?

The committee met three times in six months during 2000. A TRB report, *Standards for Intelligent Transportation Systems: Review of the Federal Program*, published in January 2001, presents the deliberations and the conclusions of the meetings.

The committee confirmed overall that JPO has taken a sensible and orderly approach to the development and implementation of selected ITS standards, relying on established SDOs, a proven strategy in U.S. and international practice. However, JPO should explain more clearly the rationale for selecting standards.

Arguments for some degree of interoperability of ITS components nationwide are compelling, but the basis for distinguishing between standards that warrant national uniformity and those for which regional variations may be acceptable is insufficient. The committee found no convincing analyses showing that national interests were served by including or considering certain standards. Federal rulemaking, which enforces standards as a criterion for funding, should be used sparingly, if at all.



Standards for Intelligent Transportation Systems: Review of the Federal Program is available from TRB (see Publications Order Form in this issue).

On the other hand, the committee recognized that JPO's efforts could play an important role in assuring that U.S. ITS technology is well represented in global markets. U.S.-based SDOs participate with foreign counterparts in setting international standards important in domestic markets, but high travel costs and diplomatic policies (e.g., "one country, one vote," regardless of the size of a nation's market) have restricted U.S. participation. JPO can strengthen U.S. competitiveness in the global ITS marketplace.

After the initial study, JPO requested ongoing advice on efforts to encourage adoption and application of the federally sponsored ITS infrastructure standards. The National Research Council appointed a new committee early in 2001, including many members from the first study. The study committee met three times in 2001 and plans a similar schedule for 2002. Discussion has focused on obstacles to widespread deployment of ITS infrastructure and on strategies that JPO could pursue to reduce the obstacles. Effective, usable standards can help.

Andrew C. Lemer is principal of Matrix Group, Baltimore, Maryland.

CALENDAR

TRB Meetings

2002

April

3–5 3rd International Large Truck and Bus Safety Symposium*
Knoxville, Tennessee
Richard Pain

14–18 ASCE 2nd International Conference on Urban Public Transportation Systems*
Alexandria, Virginia
Peter Shaw

15–19 Geophysics 2002*
Los Angeles, California
G. P. Jayaprakash

21–25 3-D Visualization in Transportation
Salt Lake City, Utah
Richard Pain

25–26 ASCE Context-Sensitive Highway Design Workshop*
San Antonio, Texas
Stephen Maher

28–May 1 3rd National Seismic Conference and Workshop on Bridges and Highways*
Portland, Oregon
Stephen Maher

May

5–7 Conference on Transportation and Economic Development
Portland, Oregon
Jon Williams

12–16 North American Travel Monitoring Exposition and Conference (NATMEC)*
Orlando, Florida
Thomas Palmerlee

June

1–4 Visibility and Simulation Symposium
Iowa City, Iowa
Richard Cunard

23–26 5th National Access Management Conference
Austin, Texas
Kimberly Fisher

23–26 27th Annual Summer Ports, Waterways, Freight, and International Trade Conference
Pittsburgh, Pennsylvania
Joedy Cambridge

26–29 Highway Capacity and Quality of Service Committee 2002 Midyear Meeting and Conference
Milwaukee, Wisconsin
Richard Cunard

July

14–16 1st International Conference on Bridge Maintenance, Safety, and Management*
Barcelona, Spain
Frank Lisle

August

2–6 7th International Conference on Application of Advanced Technology in Transportation*
Cambridge, Massachusetts
G. P. Jayaprakash

4–9 T2002: 16th International Conference on Alcohol, Drugs, and Traffic Safety*
Montreal, Canada
Richard Pain

13 Design and Construction of Transportation Facilities in Melange—Block in Matrix
San Luis Obispo, California
G. P. Jayaprakash

17–22 9th International Conference on Asphalt Pavements*
Copenhagen, Denmark
Stephen Maher

18 DAWG Forum on Pavement Performance Data Analysis
Copenhagen, Denmark
A. Robert Raab

September

18–20 8th National Conference on Transportation Planning for Small and Medium-Sized Communities: Tools of the Trade*
Cincinnati, Ohio
Kimberly Fisher

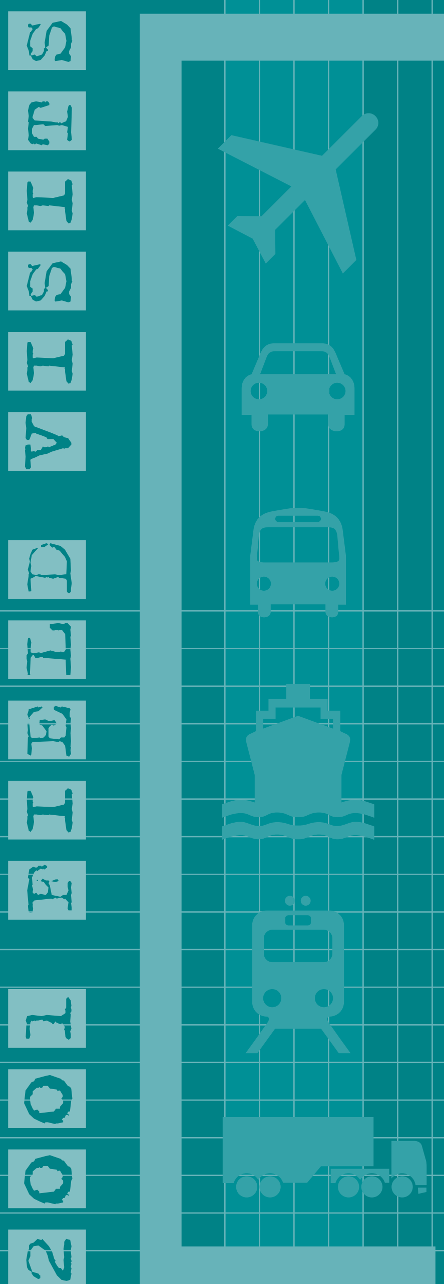
October

27–30 11th International High-Occupancy Vehicle Conference
Seattle, Washington
Richard Cunard

27–30 15th National Conference on Rural Public and Intercity Bus Transportation
Huron, Ohio
Peter Shaw

Additional information on TRB conferences and workshops, including calls for abstracts, registration and hotel information, lists of cosponsors, and links to conference websites, is available online (www.TRB.org/trb/calendar). Registration and hotel information usually is available 2 to 3 months in advance. For information, contact the individual listed at 202-334-2934 (fax 202-334-2003; e-mail lkarson@nas.edu).

*TRB is cosponsor of the meeting.



Security Redefines the Agenda

The Transportation Research Board's 2001 Field Visit Program

At the start of 2001, state departments of transportation (DOTs) and other transportation organizations were focusing on the performance-based delivery of services to augment the traditional role of implementing projects. As the year ended, the events of September 11 emphatically brought to the fore issues involving the security of transportation systems.

Specialists in the Transportation Research Board's Technical Activities Division identify current concerns and learn about activities in the transportation community. The TRB Annual Meeting, Board-sponsored conferences and workshops, standing committee meetings and communications, publications, and contact with thousands of organizations and individuals provide TRB staff with information from the public and private sectors on all modes of transportation.

A major source of this information is the annual field visit program—TRB staff meet on site with representatives of each state department of transportation and also with representatives of universities, transit and other modal agencies, and industry. The objectives of the field visit program are to

- ***Learn about the problems organizations are facing and supply pertinent information from states, industry, or educational institutions to help solve these problems;***
- ***Learn about research in progress or in planning and exchange information on similar efforts, preventing duplication;***
- ***Identify new methods and procedures that also might apply elsewhere;***
- ***Identify innovative or experimental work not widely published but deserving attention;***
- ***Describe TRB's range of services to new staff at the transportation agencies that support TRB; and***
- ***Identify potential candidates for TRB committees.***

Through the 2001 field visits and information from other sources, the TRB Technical Activities Division staff identified issues, concerns, and recent program changes in transportation.

Performance-Based Transportation

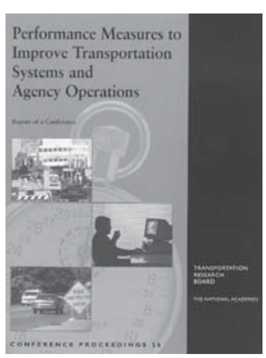
Transportation organizations around the country are relying on performance measures that can be used effectively in decision making. The focus has changed from the more conventional "inputs" and "outputs" to "outcomes" that connect with customers. A TRB conference in November 2000 stressed that performance measures must be understandable not only to transportation organizations, but also to customers.

Agencies are reaching out to customers—in particular, the traveling public, the private sector, and elected officials. Several DOTs have hired public relations firms to improve communication with customers. Some states are using market research to monitor progress and also to inform and educate the public.

The Kentucky Transportation Cabinet, for example, has hired marketing firms; assigned public information officers to each district; held barbecues; and sponsored booths at fairs, malls, and other public attractions. New technology—the Internet, visualization software, and new survey techniques—also may help to engage the public in transportation decision making.

Most jurisdictions are implementing their own performance measures voluntarily. However, state DOTs are concerned that the federal government may use performance measures to compare state or local agencies and to allocate funds.

Performance-based management that considers outcomes has applications to many areas under the purview of transportation organizations. In the area of transportation and the environment, the concept of "environmental stewardship" is gaining acceptance—that is, a transportation agency should act as a steward striving to improve the environment. Many state DOTs that formerly attempted to minimize a project's potentially negative impact on the environment—focusing on inputs—now are focusing on outcomes by enhancing the environment as opportunities arise. Several agencies have noted that environmental stewardship involves changes in maintenance activities and have expressed the need for sharing best management practices.



One of many conference proceedings published by TRB in the past year, *Conference Proceedings 26: Performance Measures to Improve Transportation Systems and Agency Operations* reports on TRB's meeting in Irvine, California, in fall 2000.

To address increased workloads with limited in-house staff, more states have shifted quality control to contractors or have adopted construction warranties with performance-based specifications. Michigan may extend its 5-year warranties to 10 years by allowing contractors to control more of the design parameters. New Mexico is requiring warranties for project corridors. Indiana also is evaluating performance-related specifications.

States are using instrumentation to monitor the geotechnical performance of transportation projects. In maintenance operations, agencies have used management systems for more than 30 years to track personnel, equipment, and materials costs. Recent improvements have incorporated such data as asset condition, customer complaints and survey results, workload plans and forecasts, and outcomes measurements and evaluations.

States are relying on standard business decision analyses to determine the cost of downtime and to avoid unnecessary expenditures in fleet management. Several agencies realized cost savings by partnering on equipment purchases, and others have noted improvements in productivity through performance specifications and ergonomically designed equipment.

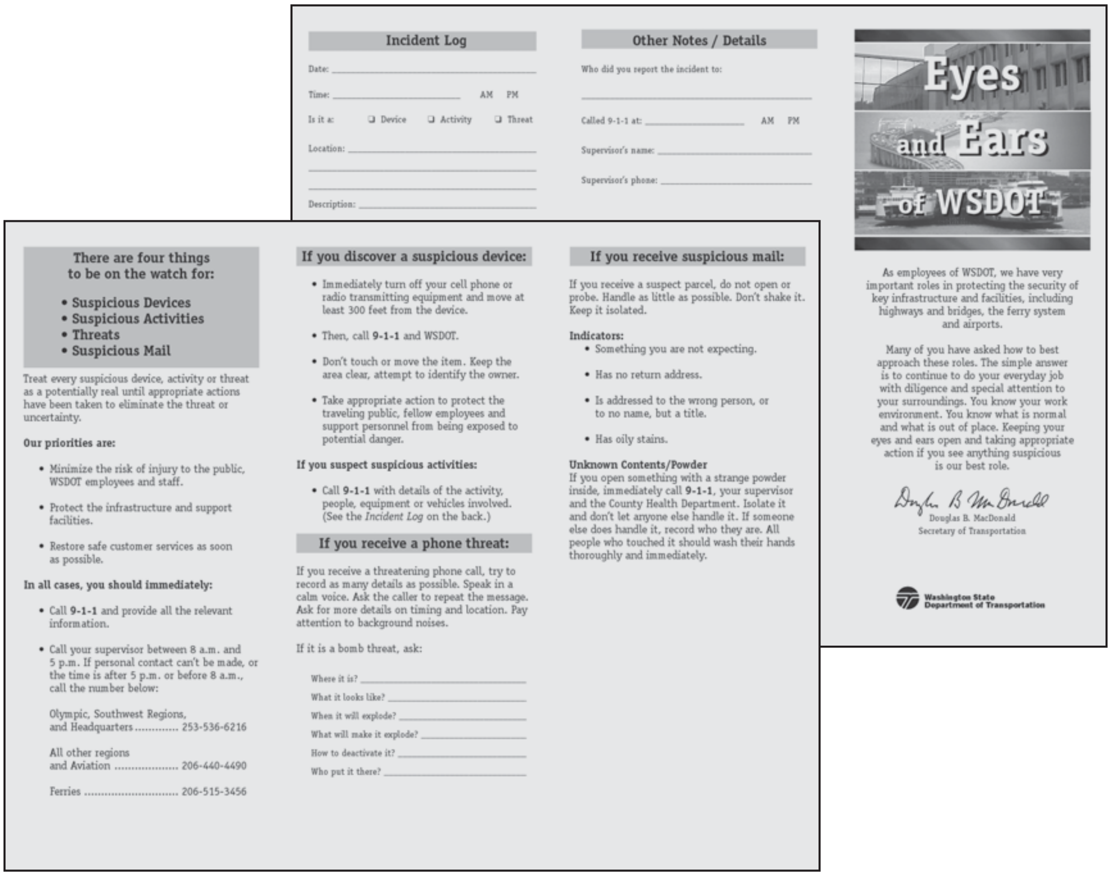
Participants in the National Dialogue on Transportation Operations, coordinated by the Federal Highway Administration (FHWA), agree that federal, state, and local agencies must optimize system performance to "meet or exceed customer expectations." Active management of the transportation system is necessary to ensure public safety, security, and system reliability.

Interest in the development and use of performance measures to present the results of operations activities and to communicate these results to decision makers and the public is increasing dramatically. Performance measures can be applied to focus programs, compare projects, communicate results, and improve customer understanding and awareness of operations. In January 2002, TRB published *Conference Proceedings 26: Performance Measures to Improve Transportation Systems and Agency Operations*, which reports the state of the art and the practice.[1]

Transportation Security

The tragic events of September 11, 2001, have made system security one of the highest priorities of transportation agencies. Florida DOT has charged maintenance crews to observe and report any suspicious activities observed during daily rounds. Washington State DOT has distributed a brochure

[1] The book is available for purchase (www.TRB.org/trb/bookstore/) and is posted on the TRB website (www.TRB.org).



Incident Log

Date: ____

Time: ____ AM PM

Is it a: ❑ Device ❑ Activity ❑ Threat

Location: ____

Description: ____

Other Notes / Details

Who did you report the incident to: ____

Called 9-1-1 at: ____ AM PM

Supervisor's name: ____

Supervisor's phone: ____

Eyes and Ears of WSDOT

As employees of WSDOT, we have very important roles in protecting the security of key infrastructure and facilities, including highways and bridges, the ferry system and airports.

Many of you have asked how to best approach these roles. The simple answer is to continue to do your everyday job with diligence and special attention to your surroundings. You know your work environment. You know what is normal and what is out of place. Keeping your eyes and ears open and taking appropriate action if you see anything suspicious is our best role.

Douglas B. MacDonald
Secretary of Transportation

Washington State Department of Transportation

There are four things to be on the watch for:

- **Suspicious Devices**
- **Suspicious Activities**
- **Threats**
- **Suspicious Mail**

Treat every suspicious device, activity or threat as a potentially real until appropriate actions have been taken to eliminate the threat or uncertainty.

Our priorities are:

- Minimize the risk of injury to the public, WSDOT employees and staff.
- Protect the infrastructure and support facilities.
- Restore safe customer services as soon as possible.

In all cases, you should immediately:

- Call **9-1-1** and provide all the relevant information.
- Call your supervisor between 8 a.m. and 5 p.m. If personal contact can't be made, or the time is after 5 p.m. or before 8 a.m., call the number below:

Olympic, Southwest Regions, and Headquarters 253-536-6216

All other regions and Aviation 206-440-4490

Ferries 206-515-3456

If you discover a suspicious device:

- Immediately turn off your cell phone or radio transmitting equipment and move at least 300 feet from the device.
- Then, call **9-1-1** and WSDOT.
- Don't touch or move the item. Keep the area clear, attempt to identify the owner.
- Take appropriate action to protect the traveling public, fellow employees and support personnel from being exposed to potential danger.

If you suspect suspicious activities:

- Call **9-1-1** with details of the activity, people, equipment or vehicles involved. (See the *Incident Log* on the back.)

If you receive a phone threat:

If you receive a threatening phone call, try to record as many details as possible. Speak in a calm voice. Ask the caller to repeat the message. Ask for more details on timing and location. Pay attention to background noises.

If it is a bomb threat, ask:

Where it is? ____
What it looks like? ____
When it will explode? ____
What will make it explode? ____
How to deactivate it? ____
Who put it there? ____

If you receive suspicious mail:

If you receive a suspect parcel, do not open or probe. Handle as little as possible. Don't shake it. Keep it isolated.

Indicators:

- Something you are not expecting.
- Has no return address.
- Is addressed to the wrong person, or to no name, but a title.
- Has oily stains.

Unknown Contents/Powder
If you open something with a strange powder inside, immediately call **9-1-1**, your supervisor and the County Health Department. Isolate it and don't let anyone else handle it. If someone else does handle it, record who they are. All people who touched it should wash their hands thoroughly and immediately.

Washington State Department of Transportation's *Eyes and Ears of WSDOT* brochure outlines employees' role in security of transportation facilities.

outlining employees' role as the *Eyes and Ears of WSDOT*. The brochure emphasizes employees' role in the security of key facilities, advising, "Continue to do your everyday job with diligence and special attention to your surroundings. [Keep] your eyes and ears open and [take] appropriate action if you see anything suspicious…."

Transportation planners in particular are struggling to understand how the September 11 attack will change procedures. Possible effects include changes in long-distance trip mode choices, the need for redundancy in transportation alternatives, and the increased importance of travel demand management.

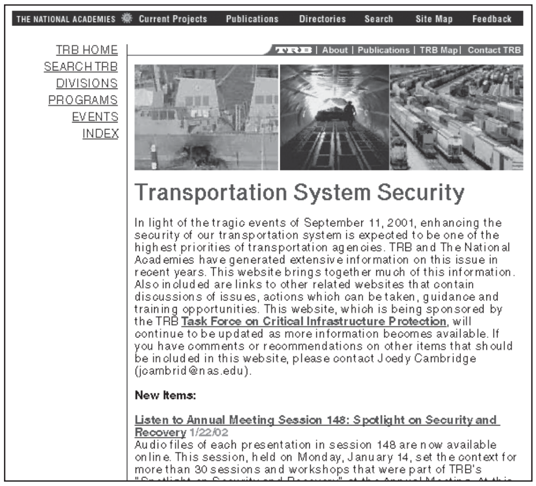
The September 11 attacks created uncertainties for the aviation industry. Insurance premiums for war and passenger liability could increase 15-fold and 8-fold, respectively. Even a major federal aid package cannot offset the unprecedented damage and losses. It is difficult to predict the long-term impacts, but the industry is in financial straits, and predictions are that one or two major carriers may fail.

Public agencies are taking a different look at the role and responsibilities of traffic operations. The traffic engineer's goal of ensuring the safe and efficient movement of people and goods now has a different context. Many transportation leaders have suggested that traffic operations should be part of a coordinated public safety and homeland security effort. Some have recommended that the public safety community should assume a greater role in highway system operations. Emergency preparedness and homeland security have become strategic issues that will influence transportation operations and incident management programs.

Mobility and safety have been two fundamental tenets of transit. Now the effect of security—a subset of safety—on mobility and transit is apparent. In New York City and Washington, D.C., transit employees acted heroically and provided leadership on September 11. Port Authority Trans Hudson (PATH) and New York City Transit (NYCT) staff responded quickly and appropriately, preventing more deaths and injuries.

Within days after the attacks, TRB created a website on transportation security,[2] assembling much of the extensive information generated and published on the topic by TRB and the National Academies in recent years. Also included are links to related websites that offer discussions of issues, actions that can be taken, guidance, and training

[2] www4.TRB.org/trb/homepage.nsf/web/security/.



In response to the terrorist attacks in September, TRB created a website on transportation security.

opportunities. Sponsored by the TRB Task Force on Critical Infrastructure Protection, the website provides examples of good practices in general transportation, aviation, and marine and surface transportation.

In November, TRB and the American Association of State Highway and Transportation Officials (AASHTO) surveyed state DOTs on security readiness and issues. The results were released at the January 2002 TRB Annual Meeting.

States Visit TRB

TRB staff visited the states, but state representatives also came to TRB in 2001. Representatives from more than 40 state departments of transportation convened May 9–11, in Washington, D.C., to share information and provide advice on a range of activities. State representatives have served as the link between TRB and state DOTs since 1924.

After a briefing on current TRB activities, the representatives formed discussion groups, generating recommendations to TRB on

◆ Enhancing communications between TRB and state DOTs;

◆ Optimizing state visits for DOTs and TRB;

◆ Developing and delivering publications that are useful and timely to the state DOTs;

◆ Ensuring that committees address issues of most concern to state DOTs; and

◆ Identifying new products and services of value to state DOTs.

The recommendations are on the agenda for the updated TRB strategic plan and for the TRB Technical Activities Quality Improvement Program.

Institutional Issues

Management and Administration

Asset Management

From 1956 to 1992, the United States made huge investments in new highway and urban rail system infrastructure. The 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) sought to reorient national transportation program priorities to preserve the investment and to operate the system.

ISTEA mandated that state DOTs and metropolitan planning organizations (MPOs) establish asset management systems for highways, bridges, and transit facilities and equipment. Although most states agreed in principle about the need for transportation asset preservation, the federal mandate was not popular, and eventually Congress repealed the management systems requirement.

However, transportation asset management has resurfaced as an issue. AASHTO, which represents highway and transportation departments in the 50 states, has created a Task Force on Asset Management, chaired by John Craig, Director of the Nebraska Department of Roads. The task force drafted a strategic plan for transportation asset management, adopted by the AASHTO Board of Directors in December 2000. This plan's goal is to "champion concepts and practices that integrate transportation investment decisions regarding operation, preservation, and improvement of transportation systems for member agencies."

This mission views assets as more than physical infrastructure and may include system operations, human assets, and data systems. The task force was instrumental in initiating a National Cooperative Highway Research Program (NCHRP) project, Asset Management Guidance for Transportation Agencies.[3]

In a parallel development, FHWA created an Office of Asset Management during a 1998 reorganization to provide leadership and expertise in the systematic management of highway infrastructure assets. The office has three key responsibilities, indicative of a shift from a command-and-control approach to partnership with the implementing agencies:

◆ Provide asset management principles for highway program administration;

◆ Develop asset management policies for pavement, bridge, and system preservation; and

◆ Partner with AASHTO, other FHWA offices, and other organizations to conduct nationwide programs.

[3] NCHRP Project 20-24(11).

TRB state representatives from more than 40 state departments of transportation gathered at the Board in Washington, D.C., in May 2001 to recommend ways for TRB services to remain on target.

A third, parallel activity is under way at TRB. The Task Force on Asset Management, chaired by Tim Lomax of the Texas Transportation Institute, will focus on asset management from the perspective of research needs and international and private industry practices.

Some states—for example, New York, Michigan, and Montana—have made significant progress in developing sophisticated asset management systems. In California, the DOT is rolling out the Integrated Maintenance Management System (IMMS), which will facilitate investment decisions among different elements of the transportation system. California also is tying the IMMS to the Governmental Accounting Standards Board (GASB) Statement 34 procedures.

GASB 34

State and local transportation agencies are grappling with GASB Statement 34, a new requirement for state DOT asset management. GASB is an independent group that establishes financial accounting standards for state and local governments. There is no legal requirement that governments must follow the standards, but most do, to demonstrate to outside auditors and others that generally accepted accounting practices are followed in the financial management of public funds.

GASB 34 requires a full annual accounting of capital assets including infrastructure and information on depreciation. The original GASB 34 was rewritten to offer an alternative to depreciation, called the "modified approach," which allows results from an accepted asset management system that reports the condition of the infrastructure and the cost of maintenance to the state-set standards. If the infrastructure condition falls below the standard, the state or local government must revert to the depreciation method for financial statements.

Since the transportation system is the principal infrastructure that states and many local governments own, DOTs must bear the brunt of complying with GASB 34. The new reporting requirements take effect for fiscal years ending after June 15, 2002.

State DOTs are developing a variety of responses. Some regard GASB 34 as unnecessary and burdensome and will do the minimum necessary to comply. Others see the requirement as an opportunity to improve asset management systems and create links to financial management and budgeting. Many are scrambling to determine the historic costs of highways and bridges.

An AASHTO-sponsored workshop in spring 2001 found that about half the state DOTs intend to use the depreciation method initially, although some said they may migrate to the modified approach. The other half will adopt the modified approach and report asset conditions. Many are counting on their bridge and pavement management systems to provide much of the needed information. FHWA and the GASB staff are encouraging state DOTs to adopt the modified approach.

An oddity of GASB 34 is that depreciation is the stricter, fallback standard. However, financial depreciation of long-lived assets such as highways provides little useful information about the condition or about the funds needed to ensure maintenance. The private sector uses asset depreciation for two purposes: (*a*) tax advantages, and (*b*) matching investments with income from investments within the proper time frame. Neither of these applies to government. Therefore GASB 34 compliance will provide more useful information only with the modified approach reporting infrastructure condition.

To assist state DOTs with GASB 34, NCHRP has initiated a $325,000 project, Review of DOT Compliance with GASB 34.[4] In spring 2002 a consultant will

- Survey state DOTs about compliance with GASB 34;
- Analyze and catalog the different approaches; and
- Assess the impact of GASB 34 on transportation finance and management of transportation assets.

Planning

Rural Transportation Issues

Rural areas now are contending with a complex, regulated environment. For example, air quality regula-

[4] NCHRP Project 19-04.

tions historically have focused on urban areas, but the implementation of the 8-hour standard means that a large number of rural areas must perform conformity analyses. This raises several problems, including institutional responsibility for the analysis and the method of estimating emissions in rural areas that do not have travel demand models.

Rural areas also are grappling with land use, growth, and economic development issues and are reacting in diverse ways. Some rural areas are striving to control or guide development to preserve valued characteristics. But research and experience in rural growth management is scarce. Other rural areas seek economic development, employment, and an improved tax base, and need information about the transportation investments that can help. The issues of planning for freight traffic (described below) are even more critical and difficult for rural areas to handle.

Rural officials and residents want to influence transportation decisions. TEA-21 required a study and report to Congress on the effectiveness of local officials' participation in state transportation planning and programming. The report is now complete, and state and local officials are examining their roles in transportation planning.

Debate continues over specifying and formalizing the consultation process. AASHTO has opposed the one-size-fits-all approach, maintaining that each state should design its own process. The consultation process is difficult for rural areas that often have small staffs and no one dedicated to planning. To play a larger role in transportation decisions, many rural areas must hire and train planning staff.

Project Planning and Development

Transportation agencies at all levels face increasingly complex project planning and development processes. One source of complication—but in the opinion of many an improvement in decision making—is an emphasis on involving the public and resource agencies, such as those responsible for historic preservation and environmental affairs. Transportation agencies are working to connect with the public early in the planning process, but must resolve such challenges as getting the word out effectively, engaging the public throughout the long planning process, overcoming language barriers, and guiding meetings to consensus.

Some states have made extraordinary efforts; for example, the Kentucky Transportation Cabinet has hired marketing firms, appointed public information officers in each district, held barbecues, and sponsored booths at fairs, shopping malls, and other public gathering places. New technology—such as the Internet, visualization software, and new survey techniques—may help to engage the public in transportation decision making.

Transportation agencies also are contacting and coordinating with resource agencies early in the planning process, to focus efforts on alternatives that avoid sensitive issues. Some transportation agencies are funding positions in resource agencies to guarantee the availability of staff to participate in planning transportation projects.

Performance Measures

Transportation agencies are adopting performance measures for nearly every aspect of transportation and every program stage to assist in policy development, planning, programming, construction, operation, and maintenance.

The planning process incorporates performance measures to increase accountability and effectiveness, to improve communication with the public, and to monitor improvement. Steve Pickrell and Lance Neumann have defined performance-based planning as "the use of performance measures to influence agency decisions—particularly policy and resource allocation decisions…. [It is a] systematic and ongoing process that must be integrated into an agency's…planning, management, and decision making…."

Jurisdictions voluntarily are implementing performance measures for their own use. Federal agencies have considered using performance measures to compare state or local agencies and possibly to make funding decisions; however, state and local agencies are concerned about this application. Ongoing reauthorization discussions will raise and clarify the issue.

Transportation agencies are increasing efforts to engage the public in decision making and planning; for example, by providing information at state fair exhibits and shopping malls.

The doubling of truck traffic in Kentucky in the last 10 years has generated support for research to improve freight forecasts and truck movement.

Planning for Freight

An increase in freight traffic and the increasing importance of global market competition has focused the attention of the planning community on freight. For example, the Kentucky Transportation Cabinet has seen a doubling in truck traffic in the last 10 years and has supported research to improve freight forecasts and the movement of trucks across the state.

Forecasting freight flows at the state and regional levels historically has taken a back seat to passenger travel forecasting. To improve freight forecasts, transportation planners across the country are increasing contact with private-sector freight transport customers and shippers. Planners are studying the freight movement decision process and the factors that affect demand.

Multistate Jurisdictional Corridors

The Transportation Equity Act for the 21st Century (TEA-21) established the National Corridor Planning and Development Program and the Coordinated Border Infrastructure Program to develop multijurisdictional alliances or coalitions. The coalitions study transportation issues that cross state and national borders and encourage collaboration on solutions. Coalitions operate on a volunteer basis, tying the level of commitment directly to the benefits received.

Examples of coalitions include the I-95 Corridor Coalition, the Route to the Plains, and the Latin American Trade and Transportation Study. Coalitions have helped to

- Develop compatible tools;
- Forecast and plan for large-scale changes in transportation demand—such as increases in Latin American trade; and
- Identify and develop large-scale transportation projects that cross jurisdictions—such as the proposed I-69 corridor and the Midwest Regional Rail Initiative.

TRB cosponsored the National Forum on Challenges with Multistate-Jurisdictional Transportation Issues in June 2001. The forum briefed executive and legislative decision makers on corridor options. Seven case studies focused on lessons learned through the coalitions. Conference participants recognized that the creation of funding mechanisms for these new organizations would prove controversial.

Planning for Elderly Population Growth

The Bureau of the Census forecasts that by 2010 the population 60 years of age and older will be increasing at a rate three and-a-half times that of the total population. Constituting 16.5 percent of the population in 1995, the segment will grow to 24.6 percent by 2025. An increase in the number of persons with disabilities is expected to accompany the increase in the older population. The two trends will have profound effects on transportation system use.

Providing transportation services for the elderly will require increases in transit and paratransit services; in Kentucky, for example, approximately 50 percent of transit riders now are over 60 years old. The cost of providing services for the elderly and disabled will be tied to community design and the availability of alternatives to the automobile. For

Trends affecting transportation include growth of the elderly and disabled populations and the resultant need for expanded transit and paratransit services.

Warsaw, Poland, was site of TRB-sponsored TRANSED 2001: The 9th International Conference on Mobility and Transport for Elderly and Disabled People, in July 2001.

example, suburban and rural communities that have limited transit or that require long trips to retail and service establishments will face higher costs per capita than central cities in serving the elderly. Planners are examining the land use and transportation system designs that can allow the older population to maintain residence; planners also must consider the needs of older drivers and pedestrians.

TRB sponsored TRANSED 2001: The 9th International Conference on Mobility and Transport for Elderly and Disabled People, in Warsaw, Poland, in July 2001. The conference attracted transportation professionals from around the world to discuss the provision of safe, independent transportation for all. The program sessions afforded opportunities to exchange knowledge and experience in policies, technical approaches, and organizational processes to provide transportation options for people with limited mobility.

Planning Data

New transportation planning models and other planning tools in development require new and additional data. The models and tools must respond to the complex questions posed to transportation planning officials. Land use forecasting models, for example, must quantify and forecast the relationship between transportation and land use, which requires more detailed data for extended periods. TRANSIMS and other travel demand forecasting models that include microsimulation can respond to air quality forecasting and intelligent transportation systems (ITS) planning questions; however, microsimulation relies on highly detailed network information as well as additional data to perform sophisticated analyses.

These data needs are emerging as funding for data collection and analysis is being reduced. New tools that could improve data collection and analysis—like the Geographic Information Systems Innovative Survey—require staffing and funding.

In addition, the 2000 Census long form, which produced data used extensively by transportation planners, probably will be replaced by the American Community Survey, a continuous data collection program. The transportation planning community will need to develop new analytical techniques to use these data in long-range transportation tools, environmental justice analyses, and project analyses.

Security in Long-Range Planning

Transportation planners are struggling to understand the changes stemming from the September 11 terrorist attacks. Possible effects include changes in mode choices for long-distance trips, the need for redundancy in transportation alternatives, and the increased importance of travel demand management. Planners will be working to address these issues.

Environment

Streamlining

Many state DOT staff assert that efforts to streamline the environmental review process are not progressing and may be adding complications. Many of the complaints that the environmental process is delaying transportation projects are anecdotal, and a systematic study is needed to determine the problem.

A recent study by NCHRP and AASHTO, Environmental Streamlining: A Report on Delays Associated with the Categorical Exclusion and Environmental Assessment Processes (October 2000),[5] focused on categorical exclusions (CEs) and environmental assessments (EAs), the most common classes of review. CEs and EAs involve the lowest level of environmental impacts but are perceived as delaying project development.

The study surveyed state DOTs about CEs, EAs, and causes of delay; 33 responded, reporting that 98 percent of projects require only CEs and EAs, and only 2 percent need Environmental Impact Statements. CE preparation caused some delay for 63 percent of respondents, and 81 percent reported delay associated with EAs.

The average delay for both categories tripled the length of the projects. The environmental compliance requirements that most commonly contribute to delays are Sections 4*f*, dealing with public lands and historic resources; 106, covering historic and cultural resources; and 404, for wetlands. The study concluded that "the results…demonstrate that despite a growing focus on highway project types

[5] NCHRP Project 20-7.

that intrinsically generate fewer environmental impacts, federal environmental review requirements can frequently add delay to…project development."

The study did not look at the internal causes of the holdups in environmental review. The environmental office of one large state DOT examined all projects flagged for delays in environmental review and found that most of the problems were from design changes made after review had begun, necessitating subsequent review. In a streamlining effort, the state has ordered a lockdown on design changes after the start of environmental review.

Environmental Stewardship

A new approach to the interaction between transportation and environment adopts the concept of stewardship. Previous approaches assumed that the transportation system created unintended, negative impacts on the environment—such as air pollution, noise, destruction of wetlands, and the division of communities; transportation agencies worked to minimize and possibly mitigate these impacts—for example, with noise barriers or wetlands replacement.

The new approach views the transportation agency as a steward of the environment, responsible for preservation and improvement. DOTs may have to change their internal culture, expanding from engineering project delivery to include enhancing the environment. This shift should introduce a less adversarial relationship between the state DOTs and environmental permitting agencies, as well as a more positive relationship with the public. Most state governors portray themselves as friends of the environment; the stewardship approach aligns the DOT with these aspirations.

Some dismiss the stewardship approach as a public relations gimmick, yet DOTs have made substantive environmental improvements through such actions as creating parkland, preserving historic buildings, restoring streams, and installing new municipal sewer lines and water mains. Context-sensitive design is a good example of the stewardship approach, striving for a product in harmony with the surrounding community or countryside, fulfilling community goals, and improving the area for residents.

New York State DOT has been a leader in the stewardship movement; staffer Gary McVoy, with Mark Sengenberger and Elizabeth Novak, published a seminal paper, "New Paradigm for State Department of Transportation Environmental Initiatives," in TRB's journal.[6] The 2001 TRB Annual Meeting included a half-day workshop on environmental stewardship, and the 2002 program featured a full-day workshop.

[6] In *Transportation Research Record: Journal of the Transportation Research Board, No. 1702,* pp. 92–96.

Aviation

Major Airlines

One year ago, the airline industry was contending with many challenges, including the squeeze of rapidly rising demand and slowly increasing capacity; rising fuel and labor costs were concerns. The system was both fragile and complex. A fickle economy exposed the fragile balance, and by spring 2001 the airlines were bracing for a bad year—declining business, rising personnel costs, and labor disputes bleakened prospects for early recovery. Learning from the downturn a decade ago, airlines quickly cut overhead, parking older, less efficient aircraft and instituting layoffs.

The September 11 attacks left the industry with an even more uncertain future. Insurance premiums for war and passenger liability could increase 15-fold and 8-fold, respectively. Even with a major federal aid package, the damages and losses are unprecedented. The long-term impact of these events is difficult to predict, but some analysts describe the industry as near financial collapse, and predictions are that one or two major carriers will fail.

Regional Airlines

Before September 11, the lack of airport capacity, the threat of congestion pricing, and labor issues—such as increasing wages and poor labor relations—were the primary issues for regional airlines. Now the priorities are increased security and increased insurance and credit costs, as well as the need for restoring passenger confidence and passenger loads. Increased loads are important for independent regionals and for those that code-share with major airlines. Regionals depend on business activity and reflect the overall state of the economy.

Current priorities for airlines include heightening security and controlling insurance and credit costs, as well as restoring passenger confidence and recovering passenger loads.

General and Business Aviation

General aviation (GA) is asking itself—and the government—many questions. Topping the list are questions about access to airspace and airports and about security needs and requirements at GA airports. Will trends lead to mandatory avionics equipment for GA aircraft—for example, Mode S transponders, enhanced ground proximity warning and flight management systems, the newest automatic dependent surveillance and Instrument Flight Rules equipment, and others? Will system delays—including regulatory demands, such as filing flight plans 24 hours in advance—become a greater problem for business aviation?

Aircraft shipments declined during the first half of 2001; what will happen now? Student pilot starts had been declining, and the possibility of increased cost and diminished accessibility of flight training could depress that market further. Business aviation may need to respond to increased demand as security and the need for personal contact with current and prospective customers become driving forces.

At the political level, the GA-business community has become aware of the need to communicate to decision makers GA's essential role in the health and development of the "aviation ecosystem." At the economic level, unanswered questions range from how the entry of commercial airlines may affect the growth of fractional ownership to how and where the emerging class of microjets will fit into the airspace system.

State Aviation

In coordination and cooperation with the industry, state aviation departments are working to increase security and safety, not only at commercial but also at GA facilities. Maintaining adequate aviation budgets in each state is a priority, to meet local and national aviation user and airport development needs.

Planning is under way for reauthorization of the Aviation Investment and Reform Act for the 21st Century (AIR-21) with attention to obtaining the necessary levels of aviation funding in 2002 transportation appropriations. Two objectives are to maintain or increase funding for the Airport Improvement Program (AIP) and to protect air service to small communities by funding the AIR-21 Small Community Air Service Program in 2002.

Additional goals include maintaining adequate funds for the Emergency Air Services program and proceeding with Global Positioning System (GPS), Wide Area Augmentation System (WAAS), and Local Area Augmentation System (LAAS) implementation, while evaluating potential vulnerabilities in these technologies. Three other goals include working with the Federal Aviation Administration to add a tenth state to the State Block Grant Program; demonstrating the importance of land use compatibility around airports; and protecting runway approaches against obstructions.

The Small Aircraft Transportation System concept has generated interest. Some states are supportive, but others await additional information, including the results of a National Research Council–TRB study.[7]

Airports

The economic slowdown has brought airports some respite from the race to match capacity with demand; however, long-term projections show inadequate capacity in many areas. The outcome will hinge on

[7] *Special Report 263: Future Flight: A Review of the Small Aircraft Transportation System Concept* (forthcoming).

Long-term projections continue to show inadequate capacity in many airports.

Kentucky applies context-sensitive design, which focuses on community context in designing facilities, to build roads and bridges, as in this historic town center.

decision makers. A short-term outlook—or the inadequate availability of funding—could mean long-term shortages; however, the longer view holds that the economic downturn is an opportunity to minimize gaps between capacity and demand by pressing for capacity enhancements now.

Manufacturers

To counter Airbus's commitment to develop the 500–800 seat A-380, Boeing is producing the Sonic Cruiser, projected to increase cruise speed by 10 percent. Both companies are making major gambles. After September 11, Boeing estimated a 2002 sales decline of 100-plus aircraft and layoffs of 20,000 to 30,000 within 15 months. Industrywide estimates project up to 100,000 layoffs, as engine makers and other suppliers respond to reductions in deliveries and in flying hours.

In summary, the aviation industry is in a state of flux; the many conflicting variables render the outcomes unpredictable. Nonetheless, despite current problems, optimism remains high in the industry.

Highways

Highway Design

Some states handle highway design in-house; others send the majority of the work to consultants. The trend is to outsource design work to the private sector, often causing—or caused by—agency staff reductions. However, states are concerned about quality control of consultants' work. Some have emphasized design-build projects, but legal restrictions in some states may prevent the arrangement.

Context-Sensitive Design

States are applying "context-sensitive design" principles, but questions remain. Context-sensitive design focuses on the community context in designing a facility; early and continuous involvement of stakeholders is key.

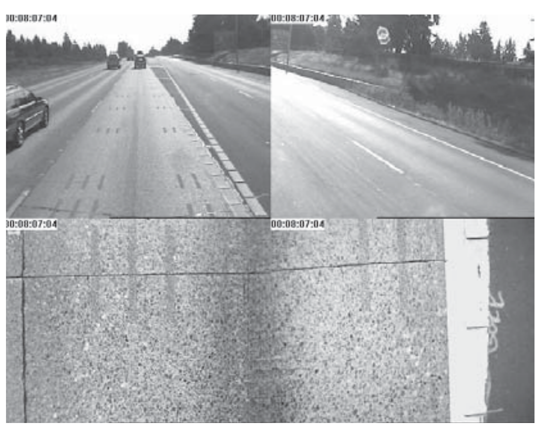
Several states are seeking relaxation of strict standards in the AASHTO "Green Book," especially for lower-volume roadways; other states, however, are not comfortable with relaxing the standards, preferring to adhere to recognized values, considering legal accountability. States need assurance—either the Green Book standards are valid, tested, and should be applied strictly, or there is a reasonable basis from a safety standpoint for the narrower pavements, shorter sight distances, and steeper grades as advocated by the proponents of flexibility.

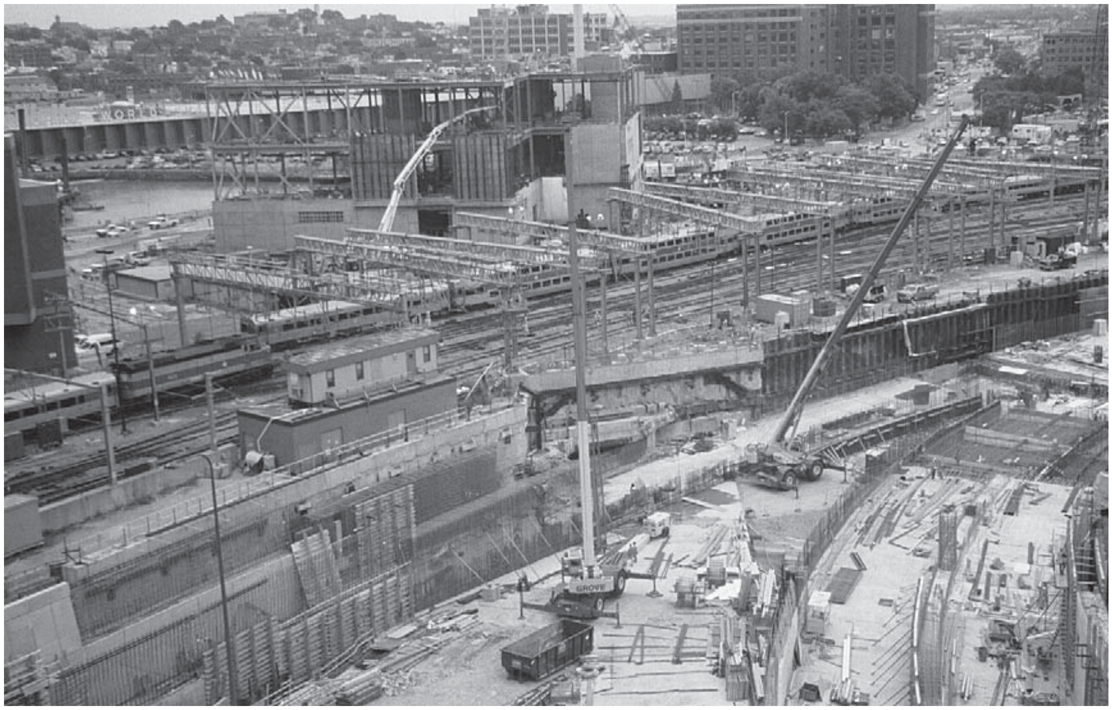
Pavement Design

In pavement design, the emphasis is on rehabilitation. The states' pavement management systems provide data not only for calibration of analytical tools but also for improved prediction of pavement performance.

As part of its Integrated Maintenance Management Program, Virginia DOT started using pavement management software in June 1999 to develop paving schedules for interstate, primary, and secondary roads. A specialized van equipped with high-speed video cameras, road sensors, computers, and satellite referencing capabilities collects field data; a fully functioning system will be in place by 2002.

Washington State DOT uses automated data collection van (*left*) that travels at highway speeds collecting video images of the pavement surface (*three samples below*), as well as measurements of pavement rutting, wear, and smoothness.





Field visits brought TRB Technical Activities staff to first-hand inspections of such complex transportation projects as the "Big Dig" in Boston, Massachusetts, which includes bridges, tunnels, and several modes.

Washington State's Pavement Management System takes digital photos of roadways every four feet in the summer and fall. Virginia, Texas, and Maryland are among the states developing life-cycle cost analysis for the selection of flexible or rigid pavements. Wisconsin is comparing concrete and asphalt shoulders and the effect on mainline pavements. States are looking forward to the 2002 revision of the AASHTO Guide for Design of Pavement Structures.[8]

Bridge Design

In bridge design, states continue to adopt the load and resistance factor design (LRFD) specifications, developed under an NCHRP project and endorsed by AASHTO's Highway Subcommittee on Bridges and Structures.[9] However, many states need upgraded computer software to apply the LRFD specifications. There is some concern also about the application of LRFD to geotechnical problems—such as structure foundations—and about the many rules of thumb formerly used in structure design but not included in the LRFD specifications.

Highway Materials and Construction

Highway construction—mostly reconstruction, rehabilitation and resurfacing—is a major activity in many states. For example, the Arkansas State Highway and Transportation Department is in the second year of a five-year program to rehabilitate a major part of its Interstate system; in the third year an estimated 300 miles could be in some stage of construction. Grant Anticipation Revenue Vehicle bonds are funding the program.

To handle large workloads with limited staff, more states have begun to shift quality control to contractors or to expand the use of construction warranties. Michigan is considering an extension of warranties from 5 to 10 years by allowing contractors more control over design parameters. New Mexico is using warranties on project corridors. One state, Indiana, is evaluating performance-related specifications; one project is completed, and another is planned for this year.

Approximately half of the states have evaluated the design-build contracting technique under FHWA's Special Experimental Project No. 14 (SEP-14). Arizona and Florida have used this technique most frequently. FHWA is developing regulations for design-build contracting as mandated by TEA-21; the regulations will list FHWA's criteria and procedures for approving the use of design-build contracts.

According to a federal regulation,[10] all quality control and quality assurance personnel on National

[8] NCHRP Project 1-37.

[9] NCHRP Project 12-33.

[10] *C.F.R.* 637.

Highway System projects must be trained and qualified. Various state and regional training and certification groups and others from the transportation construction industry are collaborating on nationwide training initiatives through the Transportation Curriculum Coordination Council.

With high traffic volumes, rapid construction remains a concern. Three NCHRP projects and one Synthesis address the issue:

◆ Avoiding Delays During the Construction Phase of Highway Projects, nearing completion;[11]

◆ Guidelines for Selecting Strategies for Rehabilitating Rigid Pavements Subjected to High Traffic Volumes;[12]

◆ Durability of Early-Opening-to-Traffic Portland Cement Concrete for Pavement Rehabilitation;[13] and

◆ *NCHRP Synthesis of Highway Practice 293: Reducing and Mitigating the Impacts of Lane Occupancy During Construction and Maintenance.*[14]

In addition to rapid construction, states are concerned about extending the durability of constructed infrastructure. Most states consider the Superpave asphalt mix design procedure—a subject of several ongoing research projects—a way to improve the service life of asphalt pavements. High-performance concrete is also gaining state acceptance for structures and pavements.

Soils, Geology, and Foundations

State DOTs are turning attention to the geotechnical aspects of the design-build approach. Experience varies from none or limited for most states to extensive for a few, and the lessons learned by these few DOTs is of great interest to all. Utah DOT has identified the key elements for a successful project:

◆ A well-prepared request for proposal,

◆ A thorough and conscientious process to select the design-build team, and

◆ Conscientious follow-through with a qualified geotechnical oversight engineer.

Many areas in the United States have soft ground conditions, which require improvement before construction. A promising technique under investigation in several states is deep soil mixing, a system of chemical stabilization. The research objectives are to improve understanding of the technique, establish quality assurance and quality control, and develop specifications.

Steven Bartlett, University of Utah

Interstate 15 reconstruction by Utah DOT includes nearly completed geofoam embankment with vertical face (*top*) and lime cement stabilized soil; (*below*) lime cement column rig.

Steven Bartlett, University of Utah

The premature deterioration of concrete blocks in retaining walls, observed in some states, has raised questions about durability. A national pooled-fund study will determine the cause of the deterioration and recommend tests and specifications.

Experience-sharing and the development of hazard- and risk-assessment systems are addressing the problem of landslides along transportation corridors. Geofoam is a new lightweight material being considered for repair of unstable slopes, along with waste rubber tire and wood fiber. A final report of the pooled-fund study to develop a design guideline for

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[11] NCHRP Project 20-24(12).

[12] NCHRP Project 10-50A.

[13] NCHRP Project 18-04B.

[14] Available for purchase, www.TRB.org/trb/bookstore/.

rockfall catchment areas was scheduled for release at the end of 2001. Practitioners with extensive experience in landslides provided input to the project, under the lead of Oregon DOT.

Most states favor new technologies, such as cone penetrometer tests (CPTs), to characterize subsurface conditions. However, usability depends on local and regional geological conditions. States with predominantly igneous and metamorphic rocks or glacial tills are not well suited for CPT technology. Some states are using instruments to monitor the geotechnical performance of transportation projects—for example, inclinometers for slopes, settlement plates for fill material settlement, piezometers for pore water pressure during embankment construction, and strain gages and load cells for soil nails.

Since aggregate is the predominant constituent of concrete and asphalt mixes for pavements, the affect of aggregate characters on pavement performance is a subject of practical interest. AASHTO has funded several national research projects on the topic; several states also have undertaken related studies. The Micro-Deval test to determine the abrasion resistance or durability of coarse and fine aggregate has potential as an alternative to the Los Angeles abrasion test and the sulfate soundness test. However, experience with the device is limited; most efforts related to the Micro-Deval device appear to be investigative, with a primary focus on the test's suitability for characterizing aggregate.

Highway Maintenance

Among the most frequently cited issues in transportation maintenance are changes in maintenance management systems; the effectiveness of maintenance contracts; the safety of the traveling public and roadway workers; workforce recruitment, training, and retention; advances in winter services; pavement preservation; decision analyses for fleet management; and environmental considerations.

Maintenance Management Systems

Transportation agencies have used maintenance management systems for more than 30 years to track personnel, equipment, and material costs associated with maintenance operations. Recent improvements have incorporated asset condition, customer input from complaint and survey systems, workload planning and forecasting, and measuring and evaluating outcomes.

Changes in maintenance management technologies and procedures include the use of laptop and handheld computers for more efficient data entry, GPS location information for infrastructure inventory and work activities, and statistical sampling with

Real-time display in New Jersey promotes safety for travelers, as well as roadway workers.

a quality assurance program to verify levels of service (LOS) within and across jurisdictions.

Maintenance Contracts

Managed outsourcing and area contracts are the primary types of maintenance agreements. With managed outsourcing—the predominant contracting method—the DOT identifies when and where work is to be performed.

Many agencies, on the other hand, are using area contracts, typically multiyear, lump-sum agreements covering most of the maintenance activities in one or more geographic areas or on a given roadway. The contractor is responsible for determining when maintenance is necessary to maintain a specific LOS; agency personnel verify compliance by statistical sampling within a quality assurance program. Several agencies have expressed the need for the maintenance community to share information on the effectiveness of the various types of contracts, including warranties, penalties, snow and ice specifications, and emergency contracting guidelines.

Work Zone Safety

The safety of the traveling public and roadway workers remains paramount for transportation organizations. Safety improvement efforts include vehicle detection and information display technologies, which provide real-time decision information to drivers in work zones; technologies and procedures to improve safety in nighttime operations; and truck-mounted attenuators (portable crash cushions).

The National Work Zone Safety Information Clearinghouse, a cooperative partnership of the

American Road and Transportation Builders Association and the Texas Transportation Institute, posts a website with information on work zone safety.[15] Ways to reduce worker exposure to roadway hazards include improving the efficiency and effectiveness of maintenance operations to reduce time on the roadway and performing maintenance activities on temporarily closed roadway sections.

Personnel

Workforce recruitment, training, and retention continue to challenge many agencies. Some are hiring trainees, training to develop skills, and then promoting to entry-level positions. Maintenance of ITS installations is an area of growing need. One agency is developing online instructional technologies to offer courses to a geographically dispersed workforce. Several agencies report large numbers of vacancies and difficulty retaining qualified personnel at pay rates sometimes 25 percent below those for similar positions in other organizations.

Winter Services

Agencies are adopting the total storm management approach to winter services, including Road Weather Information Systems (RWIS), which report road conditions to the public via the Internet and at rest areas; temperature measurement devices on supervisors' vehicles; service patrol routes that take advantage of the characteristics of anti-icing material and procedures; automated anti-icing spray systems on selected roadway sections and bridge decks; and automatic bridge deck heating systems. The improved procedures, materials, and equipment under a total storm management approach can translate into savings in lives, property, and expenses and can minimize environmental impacts.

One agency has developed a Winter Cost Index based on traction measurements from observed conditions and on the time needed to restore bare pavement after the end of each event; the index matches closely with winter expenses. The index communicates cost information and helps in allocating funds to field units.

Pavement Preservation

Pavement preservation programs are working to reduce the number of deficient pavements, extend the useful life of pavements, and provide consistent and adequate funding for preservation. Improved pavement condition at lower cost is the result of applying the right treatment at the right time. A successful transition from a reactive to a preventive pavement maintenance program requires ongoing educational efforts and support from all stakeholders, including DOT management, legislators, roadway users, adjacent land owners, and the contracting industry.

Fleet Management

Fleet management systems should incorporate standard business decision analysis to determine the cost of downtime and to perform cost avoidance analyses. Several agencies saved on equipment purchases by partnering, and several increased use of performance specifications and ergonomic features on equipment to improve productivity. Regional equipment expositions with manufacturers and agency employees displaying products and inventions are effective ways of educating and sharing information within the maintenance community.

Environmental Issues

Work continues on integrating environmental considerations into maintenance operations and activities, including winter services, pavement sweepings and marking materials, facility design, vehicle and equipment maintenance, alternative fuel programs, stormwater runoff, and environmental awareness training. Several agencies reported changes in maintenance activities as a result of implementing environmental stewardship and have expressed the need for developing and sharing best management practices.

Highway Operations

Security

Public agencies are taking a new and different look at the role and responsibilities of traffic operations. The goal of assuring the safe and efficient movement of people and goods has gained a different context since September 11. Many have suggested that the Public Safety and Homeland Security office should coordinate traffic operations. Some recommend that the public safety community should assume a greater role in operating the highway system. Nonetheless, emergency preparedness and homeland security have become strategic issues that will influence transportation operations.

However, cooperative relationships among many of the essential players in transportation safety and security were already in place before September 11. Most major urban areas—more than 50 throughout the United States—have implemented regional programs for incident management, a planned and coordinated process to detect and remove highway traffic disruptions and restore capacity as safely and as quickly as possible. The institutional relationships established for these incident management programs can provide a starting point for coordinating and developing mul-

[15] wzsafety.tamu.edu/.

tidisciplinary and interagency network operations and emergency services. (FHWA, AASHTO, and TRB are cosponsoring a Workshop on Incident Management, in March 2002 in Irvine, California, to focus on the roles of emergency services, public safety, and transportation operations agencies.[16])

System Data

Accurate, real-time, systemwide transportation information is a critical component for operations in safety and security. Without real-time traffic data, system operators and travelers are unable to make informed decisions. Travelers need to decide on travel mode and route, and traffic managers need to evaluate system performance, determine incident location, make effective decisions on diverting traffic, and implement major evacuations.

However, real-time transportation data are not generally available for most highways. Progress has been limited in deploying the "infostructure." According to recent studies, approximately 20 percent of the nation's urban freeways and less than 10 percent of urban arterial roadways have been instrumented for real-time data collection, and implementation plans indicate that less than half of the urban freeway system will be instrumented by 2010.

Congestion

Although the focus for operations may be on emergency preparedness and homeland security, highway congestion remains a daily occurrence in all large metropolitan areas—a source of frustration and agitation for millions of commuters and travelers. Once an urban problem, congestion affects all areas of the country. In 1981, 25 percent of urban highways were classified as congested; by the mid 1990s the proportion had risen to more than 45 percent with more than 4 billion hours lost to delays in the top 70 metropolitan areas each year.

The Texas Transportation Institute has reported that the length of the combined morning and evening peak travel periods has doubled, from less than three hours in 1982 to almost six hours today. The time Americans spend in traffic has increased 236 percent since 1982 and the average annual delay per person has climbed from 11 hours in 1982 to 36 hours. The estimated nationwide cost of traffic congestion in time lost and fuel consumed totals $78 billion per year. Traffic congestion affects millions as well as the economy.

Environmental, land use, political, and budget constraints hamper the traditional solution, capacity expansion. Building new roads alone will not lead the way out. Many transportation leaders are encouraging agencies to emphasize also the efficient and effective management of the roadway network.

Congestion, once only an urban problem, continues to affect all areas of the country.

Management and Research Agenda

The nation has invested significantly in capital improvements to the transportation infrastructure, but the processes, personnel, and equipment for operating the system have not received comparable funding increases. The results are inadequate numbers of personnel, deficient training, and insufficient equipment to manage and operate the highway system.

FHWA, AASHTO, the Institute of Transportation Engineers (ITE), TRB, and other highway-related organizations and constituencies have initiated a National Dialogue on Transportation Operations (NDTO) to stimulate leadership and support for operations. NDTO focuses on the need for more efficient management of the highway system, holding that a critical mission of federal, state, and local agencies should be to optimize system performance to "meet or exceed customer expectations." Active management can ensure public safety, security, and transportation system reliability.

TRB, U.S. DOT, AASHTO, ITE, and other organizations have developed a strategic national research agenda for operations and mobility, identifying major research theme areas:[17]

- Customers, customer expectations, and customer needs;
- Maximizing efficiency and minimizing congestion;
- Information needs and requirements;

[16] www.TRB.org/trb/meetings/.

[17] The final report is posted on TRB's website (www.TRB. org/).

- Transportation safety;
- Environmental impacts;
- Intermodal interfaces and efficiency; and
- Crosscutting issues.

The development and use of performance measures to quantify operations activities and to communicate the results to decision makers and the public can help to focus programs, compare projects, explain results, and improve customer understanding and awareness of the role of operations. *NCHRP Report 446: A Guidebook for Performance-Based Transportation Planning*[18] includes a comprehensive list of performance measures that U.S. transportation agencies have used, broken down into eight categories: accessibility, mobility, economic development, quality of life, environmental and resource conservation, safety, operational efficiency, and system condition and performance. The report also describes how to use performance measures in developing a transportation program.

Other Issues

Ramp metering to improve freeway flow by controlling access during congestion has been used in the United States since the early 1960s. However, in response to driver complaints, Minneapolis–St. Paul, Minnesota, recently turned off ramp meters to allow a state DOT evaluation. The Minnesota DOT field data analysis indicates that ramp metering is efficient and cost-effective and improves safety, performance, and air quality on the metered freeways. However, the study notes that the goal of moving freeway traffic efficiently must be balanced against public concerns about queue length at ramp meters.[19]

Road rage and aggressive drivers are terms that have entered our language to describe driver dissatisfaction with congestion and delays. The media, politicians, and highway agency personnel use the terms regularly to refer to driver behavior in accidents or altercations. Public agencies are implementing countermeasures, including enforcement that targets aggressive drivers and roadway design modifications that calm traffic.

Photo enforcement against red-light running also has been a frequent news topic as communities have set up cameras to detect and record violations. Many citizen and safety groups consider the cameras an effective deterrent that improves intersection safety. However, recent court decisions and political and citizen opponents have noted that in some cases communities overlooked engineering solutions before installing cameras.

Traffic calming also is gaining popularity in the United States, typically using a variety of physical features within the roadway to slow drivers and encourage acceptable behavior. Features commonly installed include speed humps, chicanes, chokers, and small traffic circles. Advocates frequently cite improved safety and quality of life in residential areas; yet opponents raise concerns about increased response times for emergency vehicles, hindrances to snow removal, and potential liability.

Used extensively in other nations, the modern designed roundabout successfully has replaced signalized intersections and diamond interchanges in several areas of the United States. When properly designed, roundabouts have effectively reduced delays and improved safety.

The rolling blackouts that affected many west-coast states in summer 2001 provided an incentive for rapid deployment of light-emitting diode (LED) traffic-signal lamp technology. Public agencies are installing LED devices to conserve energy and reduce life-cycle costs. The principal benefits are the reduced power consumption and improved durability from solid-state design. In addition, the flexibility of LEDs allows alternative design of traffic control devices—for instance, some communities have implemented pedestrian signals incorporating a countdown timer to indicate to pedestrians the amount of time left in the crossing phase.

In November 2001, TRB released the interactive CD-ROM edition of the *Highway Capacity Manual* (HCM 2000). A companion to the book or a standalone, the CD-ROM offers the complete text and exhibits of both the metric and U.S. customary versions of the printed book with the addition of step-by-step tutorials, narrated example problems, explanatory videos, navigation tools, and hyperlinks between sections of the manual.[20]

Highway Safety

The highway and traffic safety arena has produced good news and bad news. The bad news is a slight increase in fatalities (41,800 in 2000 vs. 41,611 in 1999) on the nation's roads. For the first time in many years, the number of vehicle miles traveled decreased by .1 percent; as a result, the vehicle death rate per hundred million vehicle miles hovers around 1.55. The good news is a slight decrease in injuries, from

[18] To order via the Internet: www.TRB.org/trb/bookstore/.

[19] The Twin Cities Metro Area Ramp Meter Study Final Report is available on the Minnesota DOT website (www.dot.state.mn.us/rampmeterstudy/reports.html/).

[20] The CD-ROM requires Microsoft Windows. For more information about HCM 2000 and the HCM 2000 CD-ROM, visit the TRB Electronic Bookstore (www.TRB.org/trb/bookstore/) or contact the TRB Business Office (202-334-3213; email TRBSales@nas.edu).

120 to 119 per hundred million vehicle miles (3,236,000 vs. 3,219,000).

The other good news is an increase in seat belt use nationwide, from 70 to 73 percent. However, seat belt use varies by state, with percentages ranging from the high 40s to high 80s. All levels of government and private safety organizations are providing a needed emphasis on infant and child booster seats.

Nonmotorized Modes

Pedestrian and bicycle safety issues are garnering attention. Almost 12 percent of highway system fatalities involve pedestrians; safer pedestrian facilities and operations are needed.

Facing congestion and mobility problems, states and local communities are providing walking and biking facilities; the hope is that people will find these more convenient, enjoyable, and healthy to use than automobiles. Planning agencies are increasing involvement in balancing transportation with nonmotorized modes; for example, New York MPOs sponsored the Creating Walkable Communities Conference.

Also contributing to the attention are concerns about personal health—inactivity and obesity are public health concerns for adults and children, and walking and bicycling can provide transportation and health benefits. With the convergence of these motivations, states and communities are fostering pedestrian and bicycle modes for improved transportation safety, more sustainable communities, and personal health. An NCHRP project recently completed a Guide for the Planning, Design, and Operation of Pedestrian Facilities,[21] to complement the AASHTO guide for bicycle facilities; the guidelines comply with forthcoming access requirements.

In addition to these nonmotorized transportation improvements, local communities often must improve the safety of streets before citizens consider getting out of their cars. Albuquerque's Safe Streets program has demonstrated improvements in traffic safety, as well as a decline in crime against persons and property. The program focused enforcement on the most visible indicators that "no one cares about traffic safety," by adding saturation patrols, follow-up patrols, freeway speed enforcement, and sobriety checkpoints. The five-year period before the program had experienced a 51 percent increase in crashes; the program brought a 12 percent decline in crashes. The severity of crashes was reduced even more dramatically, with 18 percent fewer injury crashes and 34 percent fewer fatal crashes.

Safe Streets program in Albuquerque, New Mexico, addresses issues of crime and safety.

Impaired Drivers

The zero tolerance concept was evaluated for blood alcohol concentration (BAC) in youth in four states. Maine reduced the permissible BAC level from .02 to .00; nighttime single vehicle injury (NSVI) involving drivers under 21 years of age declined 36 percent. Oregon raised the age for .00 BAC from 18 to 21; the result was a 40 percent reduction in NSVI crashes. Florida and Texas recorded changes of up to 5 percent. Increased enforcement of the laws may reduce these kinds of crashes further.

The cost of the crashes resulting from driving while impaired—mainly from alcohol—is rarely appreciated. The National Highway Traffic Safety Administration has produced and made available on its website state fact sheets listing costs attributed to alcohol-related crashes in each state.[22]

The national fact sheet shows, for example, that alcohol is a factor in 35 percent of U.S. crashes and that the cost of these crashes was $110 billion in 1998—$40 billion in actual monetary costs and $70 billion in quality-of-life losses. Other people, governments, and organizations—not the drinking driver—paid $51 billion of that total cost. Of the $127 billion in U.S. auto insurance payments, 16 percent go to settle claims from alcohol-related crashes. Clearly, strengthening legislation and programs to reduce drinking-and-driving crashes will reap cost benefits.

Helmet Laws

As states repeal motorcycle helmet laws, injuries and fatalities to riders without helmets have mounted at the highest rate. Several evaluations—most recently in Texas and Arkansas—have demonstrated the safety and cost benefits of legislating helmet use. After repeal of the law, helmet use rates fell from more than 97 percent in both states to 66 percent in Texas and 52 percent in Arkansas. Head injuries increased from the 18 to 20 percent range in Arkansas to 23 to 31 percent. Fatalities increased 31 percent in Texas and 21 percent in Arkansas, confirming the conclusion of the 1991 General Accounting Office report that "under universal helmet laws, more states experienced 20 to 40 percent lower fatality rates than during periods without laws or under limited laws."

[21] NCHRP Project 20-07 (Task 105); AASHTO is publishing the guide (www.transportation.org/).

[22] www.nhtsa.dot.gov/injury/alcohol/facts.htm/.

Break-out session during the Florida Safety Conscious Planning Forum.

Analysis and Planning

Pennsylvania introduced the practice of analyzing corridors for safety problems 12 years ago, and FHWA has developed and published manuals for conducting corridor analyses and safety programs. Oregon adopted the corridor approach 10 years ago and reports success, identifying 14 corridors for crash data analysis and developing multidisciplinary approaches to increasing safety. The state publicly designated the corridors through the media and on-road signage. All the corridors experienced reduced crash rates. For example, one route had recorded 13 fatalities in the 16 months before the program, but no fatalities in the 4 years afterward.

Oregon's truck safety corridor has led to a decrease in the number of crashes.

Six states—Tennessee, Maryland, Texas, Florida, Oregon, and Michigan—conducted one- or two-day Safety Conscious Planning Forums to develop statewide action plans for adopting safety and security criteria in transportation planning, in compliance with a TEA-21 mandate. The forums convened state safety professionals—from the DOT, motor carriers, and governor's highway safety office—with DOT and MPO transportation planners. Each workshop issued a report on the proceedings and the action steps identified; a summary report and toolkit based on the six forums will be available in early 2002 as an electronic TRB Circular.[23]

Marine and Intermodal

Ports and Waterways

The Marine Transportation System (MTS) initiative has received increasing support from U.S. DOT Secretary Norman Y. Mineta. The nation's ports and waterways also have garnered the attention of the U.S. Congress, with several legislative proposals and hearings, particularly on port security and congestion. Much discussed and debated is the need for a Sea-21 program for the U.S. marine transportation system infrastructure, similar to TEA-21 and AIR-21 for land and air transportation, respectively.

Port Security

Although port security was receiving attention before the events of September 11, the industry and the public are concerned about the vulnerabilities and threats facing the nation's ports and waterways. Florida has

[23] www.TRB.org (click on Online Documents, then click on Circulars).

accelerated funding for enhanced security at 14 deepwater ports. A recently enacted state law requires the ports to implement security plans and meet basic standards for facility security, employee training, and personnel screening.

Ports throughout the country are working with federal agencies and local authorities to assess vulnerabilities and to coordinate plans and procedures to reduce threats to and from landside and waterside operations. Law enforcement agencies at all levels, with support from the National Guard and a new sea marshal program, face a formidable task—combating the terrorist threat while dealing with other responsibilities ranging from preventing cargo crime and drug trafficking to promoting marine and environmental safety.

Construction on Doremus Bridge in New Jersey is part of Port Authority of New York and New Jersey's infrastructure improvement project to speed the flow of freight.

Accommodating Trade Growth

With trade volumes projected to double or triple in the next 20 years, highways and rail systems will be strained and many ports will have to accommodate ever-larger ships and an increasing volume of traffic. Projects such as the Alameda Corridor in Southern California; the FAST Corridor in the Seattle-Tacoma, Washington, area; and the Portway project in New Jersey are among the major infrastructure projects under way to speed the flow of freight to and from major ports.

Port of Palm Beach security measures include use of fingerprinting badge systems and (*below*) identification of truckers.

To relieve surface congestion, coastwise and inland waterway alternatives are receiving consideration as environmentally safe, fuel-efficient, and often less expensive options. The Coastwise Coalition is promoting services to detour the congested I-95 corridor. Ports are looking for technological solutions to make intermodal connections more efficient—reducing wait times for truckers, increasing productivity and throughput, enhancing safety, and allowing information to flow seamlessly from one system to another.

Waterside infrastructure improvements are accommodating growth. Replacement of the navigation lock on the Industrial Canal in New Orleans, Louisiana, has begun. The lock now accommodates only the smallest ships, and barge operators encounter long delays.

In Alaska, the Port of Anchorage is undertaking a $10 million dredging project to improve access to its terminals, particularly for container traffic. Barge operators, together with the Alaska Railroad, are investing in improvements for handling commodities such as bulk chemicals, heavy equipment, and steel pipe.

The Port Authority of New York and New Jersey (PANYNJ), which expects cargo volumes to double in the next decade, has embarked on a multibillion dollar project to dredge harbor channels to 50 feet. The U.S. Army Corps of Engineers has proposed deepening the main channel of the Delaware River to 45 feet, which would benefit the Delaware River port com-

plex, particularly the Port of Wilmington, a major economic generator for the state. The Great Lakes Region is debating investment in widening and deepening Seaway locks and channels, modernizing the infrastructure, and upgrading port facilities on the Great Lakes–Seaway System, to accommodate larger ships and attract new services.

Controversy over enlarging the locks on the Upper Mississippi River–Illinois Waterway led the Department of the Army to request a National Research Council review.[24] If river traffic continues to increase, so will congestion; the result will be higher shipping costs and less ability to compete in world markets. However, lock extensions are a major investment with environmental consequences; more work remains before the final decisions.

Port of Savannah, Georgia, includes the James D. Mason Intermodal Cargo Transport Facility, which currently is able to handle three unit trains per week and will expand to five.

Port Initiatives

Gulf Region developments include a proposed ship-barge transfer facility to be built near the mouth of the Mississippi River by a private company, and the proposed Millennium Port, which Louisiana hopes will capture a greater share of Latin American trade.

Alabama offers a corporate income tax credit to spur investment in port facilities. This complements the "Amendment One" funding package of $100 million earmarked for revitalizing the Alabama State Docks at Mobile, including a new metals cargo terminal, upgrades of rail track and interchanges, and a new container terminal.

In Florida, the Port of Tampa has opened a new container terminal, part of a three-year capital improvement program that includes cruise facilities and improvements to bulk and cold storage facilities. Port Manatee is the staging area for a major underwater pipeline project, which will produce revenues to support expansion of the cargo facilities.

Complementing the PANYNJ dredging project are plans to expand and relocate rail facilities and services, as well as build a new intermodal facility. The agency is implementing the Port Inland Distribution Network to move containers quickly out of port facilities via barge or rail to regional distribution centers, then by truck to the final destinations.

The North Carolina State Ports Authority (NCSPA) has entered into a joint venture with a private firm for a new grain facility to handle import and export cargo. NCSPA has issued "special user" bonds to finance the facility.

At the Port of Savannah, Georgia, the first phase of the James D. Mason Intermodal Cargo Transport Facility (ICTF) opened in June, able to handle three unit trains per week. One of several facilities that the Georgia Ports Authority is developing, ICTF will handle five unit trains per week when completed.

On the West Coast, the Port of Oakland, California, has embarked on its Vision 2000 for major infrastructure projects, including the 150-acre Joint Intermodal Terminal (JIT) on former Navy property. The JIT will consolidate rail traffic and provide direct, near-dock, mainline access for the Union Pacific and Burlington Northern.

The Ports of Seattle and Tacoma also are focusing on intermodal connections. The Port of Seattle has formed a Cargo Terminals Group to explore ways to

Vision 2000 program at Port of Oakland, California, includes newly completed Hanjin Terminal; facilities currently under construction include 150-acre container facility, 88-acre Joint Intermodal Terminal, and 110-acre Union Pacific Railroad rail terminal.

[24] *Inland Navigation System Planning: The Upper Mississippi River-Illinois Waterway*. www.nap.edu/catalog/10072. html/.

Virtual coordination center manages traffic using array of communication technologies at Intermodal Yard at Port of Tacoma, Washington.

improve service to customers and integrate cargo services. To manage train traffic in and out of the port, Tacoma has set up a virtual coordination center using an array of communications technology.

Several ports throughout the country—particularly smaller ports—are creating niche opportunities for specialized-product and smaller carriers. For example, the Port of Everett, Washington, serves a carrier that transports oversized containers of aircraft components between Japan and the United States.

Container Overload

Empty freight containers—the result of trade imbalances between the United States and partners in Asia and Europe—are an increasing problem at ports and inland points and are contributing to freight congestion. PANYNJ estimates that almost two containers enter the port for every one shipped out. Once emptied, containers often go into storage; containers can be seen stacked eight high at one facility in an industrial area near the New Jersey Turnpike.

Ordinances to limit the size and height of facilities close to residential areas or in areas where land is becoming desirable for other uses—and therefore more expensive—are common. Containers from Charleston, South Carolina, are moved to North Charleston, and stacked high opposite residential neighborhoods for miles, increasing concern about safety hazards.

An ordinance proposed in Chicago last year would have restricted the way containers are stacked and would have imposed regulations and licensing fees on intermodal yards. In response, the intermodal industry worked with the community to develop a compromise.

The Virginia Port Authority, with the cooperation of marine terminals, has implemented an "empty container benchmark." However, the problem of how and where to store empty containers is likely to increase as fast as solutions can be found.

Information Technology

Ports are investing in information technology; for example, the Jacksonville (Florida) Port Authority is spending $7 million on an information technology master plan to collect and share information on terminal operations with its tenants. PANYNJ has launched FIRST (Freight Information Real-Time System for Transport), an online information sharing program for port users.

Efforts also are under way to provide mariners with critical up-to-date information on tide, current, and weather conditions through the Physical Oceanographic Real-Time System (PORTS), developed by the National Oceanic and Atmospheric Administration. The Maritime Exchange and Delaware River Port Authority are among the most recent to agree to fund and operate PORTS, strengthening the Delaware River and Bay region for ocean shipping technology and automation.

Ferry Transportation

On September 11, ferries and other marine craft—such as dinner boats, tugboats, and small private vessels—played a major role in evacuating people from lower Manhattan. Ferries once again proved to be vital components in emergency response. N.Y. Waterways ferries served as waterborne ambulances, carrying injured firefighters across the Hudson River. (Another vessel, Navy hospital ship *USNS Comfort,* berthed in lower Manhattan to provide short-term lodging and services for police, fire fighters, and disaster recovery personnel.)

This past year, funding requests to the Ferry Boat Discretionary (FBD) Program—created under ISTEA and continued under TEA-21—far exceeded the

funds available. In FY 2001, 22 states and Puerto Rico submitted proposals for 53 projects with a total price tag of $75.6 million—but only $14.7 million in discretionary funding was available.

Among the states receiving funds were Rhode Island, which implemented high-speed ferry services between Providence and Newport; and Georgia, which combined FBD funds with other federal, state, and local sources to launch a water taxi service between Savannah and Hutchinson Island. The Erie–Western Pennsylvania Port Authority received $3 million in state funds for construction of a new cruise and ferry terminal on the Erie Bayfront, facilitating plans for a passenger-and-automobile ferry to Canada.

Illinois has received a new ferry to cross the Illinois River between Grafton and Brussels Township in Calhoun County. Moved by a towboat, the ferry barge can carry 24 cars, as well as two legal-highway-limit trailer rigs or the equivalent.

The St. Johns Ferry, which crosses the St. Johns River between Mayport and Fort George Island, Florida, experienced a revival through privatization and $8 million in Florida DOT and federal funding. The service saves 44 miles on a round-trip in city traffic, enhances tourism, and is convenient for commuters.

In other markets, new high-speed ferries are competing with traditional ferry services. In Rhode Island, the high-speed vessels move passengers to Block Island in half the time of traditional ferries. In California, high-speed vessels cut the transit time between Long Beach and Catalina Island to less than one hour. Fast ferries also are serving routes in Massachusetts and in New York between Long Island and Wall Street.

Other states receiving FBD funds for projects ranging from new vessels to terminals and landing ramps include Alabama, Connecticut, Delaware, Hawaii, Iowa, Kentucky, Maine, Michigan, Missouri, Montana, North Carolina, Ohio, Oregon, Texas, Utah, Virginia, Washington, West Virginia, and Wisconsin.

Freight Intermodalism

In February 2000, TRB hosted a national conference on Global Intermodal Freight: State of Readiness for the 21st Century in Long Beach, California. Participants assessed how far the nation has come in addressing the findings and recommendations of the National Commission on Intermodal Transportation. U.S. DOT highlighted its various agencies' efforts to improve intermodal connections. Shippers presented needs and requirements, and carriers discussed service and facility advances; state and local agencies showcased projects and initiatives, focusing on public–private partnerships and financing options.[25] A tour of the Alameda Corridor route, as well as waterside tours of the Ports of Los Angeles and Long Beach, offered first-hand evidence of the intermodal connections needed for efficient freight and passenger movement.

Intermodal connections for freight range from road and rail access routes to state-of-the-art cargo-handling equipment and communications technology to maximize throughput and minimize transloading times and costs. Landside infrastructure planning and investments must ensure that access to ports, waterways, and airports is sufficient to sustain current and projected traffic and operations for freight as well as passengers.

Portway International–Intermodal corridor in Newark and Elizabeth, New Jersey.

State and local agencies have undertaken many intermodal projects, some in partnership with the private sector. In July 2000, New Jersey broke ground on the Portway International–Intermodal Corridor program to improve freight movement at the airport-seaport complex in Newark and Elizabeth.

In Houston, Burlington Northern and Santa Fe Railway Co. (BNSF) has introduced new direct intermodal container service to Barbours Cut Terminal. With support from the Houston–Galveston Area Council and Texas DOT, the Houston Port Authority used matching funds to build the facility, which will reduce truck emissions and congestion.

In Pennsylvania, Norfolk Southern has opened the new Rutherford Intermodal Terminal near Harrisburg. Originally a Reading Railroad switching yard,

[25] *Conference Proceedings 25: Global Intermodal Freight: State of Readiness for the 21st Century*. www.TRB.org/trb/bookstore/.

the facility is at the junction of six routes and will serve intermodal traffic to and from the north and south—primarily domestic freight—as well as from the east and west—primarily Asian imports on the land-bridge route across the United States.

In Illinois, a portion of the Joliet Arsenal was transferred from the U.S. Army for the development of the Deer Run Industrial Park. Adjacent to the park, BNSF plans to build a full-service intermodal terminal, container railyard, and automotive facility. Illinois DOT will provide an estimated $50 million to upgrade area roads, bridges, and other components for the project.

Another former military facility, Rickenbacker International Airport in Columbus, Ohio, is adding two new cargo facilities to expand its role as an international distribution center. In Denver, Colorado, backers are promoting the Transport Project at Front Range Airport, which offers access to Union Pacific rail lines and interstate truck routes—a multimodal project similar to the Alliance project near Dallas, Texas.

Many state and local officials recognize the need for cooperation, coordination, timely decision making, and action to improve transportation system efficiency; ensuring an integrated multimodal transportation system to meet the needs of users and the expectations of the public is a shared responsibility.

E-Commerce

E-commerce poses challenges for public-sector planners and decision makers, military transportation and logistics personnel, and the commercial freight transportation and logistics sectors. In the public and private sectors, as well as the military, demand is increasing for fast, reliable tracking of freight shipments across all transport modes.

Real-time information on shipments from origin to destination, both domestically and internationally, is essential to the new logistics and to market competitiveness. The impact of e-commerce on personal travel also demands attention from public-sector planning officials.

U.S. Customs uses electronic systems to process cargo, aircraft, and other vessels entering and exiting the United States.

Rail

Economics

Class I freight railroads set volume records for ton-miles, tonnage, and intermodal traffic in 2000. Class I ton-miles rose by 2.3 percent to 1.47 trillion, up from 1.43 trillion in 1999. Rail tons reached 1.74 billion, up from 1.72 billion in 1999, as increases in coal, primary metal products, and metallic ores (among other commodity groups) more than offset declines in farm and lumber products. U.S. railroads hauled 9.2 million intermodal trailers and containers in 2000. Intermodal traffic now accounts for approximately 20 percent of Class I revenue, second only to coal.

Despite traffic gains in 2000, railroads faced financial challenges. Class I freight revenue rose to $33.1 billion in 2000—a 1.2 percent increase, but less than the growth in tonnage and the rate of inflation. Moreover, even though railroads continued to increase efficiency in 2000 (fuel efficiency, locomotive and employee productivity, and traffic density all showed gains), traffic growth and cost increases caused the railroads to incur record operating expenses.

Diesel fuel prices were the source of a substantial portion of the cost increases in 2000. Overall, the average price per gallon of railroad fuel rose from 55 cents in 1999 to 87 cents in 2000, a 58 percent increase that added $1.2 billion to annual expenses. Class I railroads consume about 3.7 billion gallons of diesel fuel per year.

The increased expenses drove Class I net income down from $3.0 billion in 1999 to $2.5 billion in 2000. Overall revenue per ton mile (a useful surrogate for rail rates) continued its two-decade decline, falling to 2.26 cents. Since deregulation in 1981, revenue per ton-mile has fallen by 29 percent in current dollars and by 59 percent in inflation-adjusted terms, saving rail customers billions of dollars per year.

The service requirements of rail customers are increasingly stringent. Railroads have added new services and enhancements such as on-time guarantees, express carload service for perishables, and rapid run-through service that avoids congested rail yards. Most major railroads also offer comprehensive web-based car ordering, car tracing, pricing, and billing capabilities.

Freight Rail

Freight railroading is capital intensive. Unlike other transportation modes, railroads operate almost exclusively on privately owned rights-of-way, and massive expenditures are needed to maintain plant and equipment, upgrade facilities, and expand capacity. Class I

Despite decreasing levels of rail traffic in most commodity categories, coal traffic rose more than 5 percent in 2001.

capital expenditures, which totaled $6.1 billion in 2000, typically account for some 20 percent of industry revenues, far more than in other industries—in the manufacturing sector, for example, capital expenditures account for less than 4 percent of revenues. In addition, railroads spend $11 billion to $12 billion per year on repair and maintenance of infrastructure and equipment.

The economic slowdown—especially in the manufacturing sector—affected freight railroad traffic in 2001. In the first nine months, traffic levels were down in most commodity categories, with significant declines in metallic ores and metals (reflecting the severe downturn in the U.S. steel sector), motor vehicles and equipment, and chemicals. Coal traffic, however, rose more than 5 percent; the most important commodity carried by U.S. freight railroads, coal accounted for some 44 percent of rail tonnage and 21 percent of rail revenue in 2000.

Passenger Rail

In 2000, freight railroads continued to work cooperatively with passenger rail authorities on using freight-owned track to extend passenger rail service. Freight railroads recognize the public benefits of passenger service and have accommodated shared-track operations under mutually beneficial agreements.

Many states and groups of states are improving passenger rail services—including commuter, intercity, and incremental high-speed services. Most operate on or are planned for freight-owned lines; however, a constitutional amendment in Florida calls for an intrastate high-speed rail system on dedicated lines. In 2001, the Florida legislature created a High-Speed Rail Authority to plan and develop the system.

Virginia's plans for high-speed rail service between Richmond and Washington, D.C., would use a freight line with the addition of a third mainline track in an incremental program over the next 6 to 10 years. Under the Midwest Regional Rail Initiative nine states are updating an implementation plan for a 3,000-mile high-speed rail system, with Chicago as the hub. California is investing in rail infrastructure and rolling stock for its incremental high-speed rail program. Similarly, Washington State has invested in passenger train equipment to extend service to the Cascade Corridor in partnership with Oregon, Amtrak, and the freight railroads.

Supporting state efforts to improve intercity passenger rail, the Federal Railroad Administration is engaged in projects to develop a nonelectric locomotive, improve train control systems, and develop technologies to reduce grade-crossing hazards. Amtrak's high-speed Acela Express service has contributed to increases in ridership in the Northeast Corridor. Nonetheless, Amtrak faces financial challenges systemwide; pending legislation may offer some relief.

To preserve rail service for many communities and to stimulate economic development, many states are investing in shortline and regional freight railroads to act as feeders to Class I carriers. For example, Pennsylvania DOT awarded $7 million for 42 projects throughout the state that include construction, maintenance, repair, and rehabilitation of rail lines, rail sidings, and grade crossings. Many states have grant and loan programs for similar purposes.

Transit

Transit flourished in 2001, with significant improvements in ridership, service, equipment, technology, research, and funding. Until September 11, the two fundamental tenets of transit had been mobility and safety. Now the need for security—as a subset of safety—daily affects mobility and the provision of transit.

September 11 Repercussions

In New York City and Washington, D.C., transit employees acted heroically and provided leadership on September 11. PATH rerouted or stopped trains heading to the World Trade Center (WTC) from New Jersey. Several trains already at the WTC or nearby were moved quickly away to New Jersey. This crisis decision making saved many lives.

Utah's TRAX University line—which opened in December 2001—provided service to the 2002 Olympic Games in Salt Lake City.

NYCT must cope with damaged tunnels, stations, and infrastructure on the WTC No. 1 and No. 9 subway lines, which must be rebuilt. Quick decision making rerouted trains and bus service away from the WTC area, and within days the rest of Manhattan was moving again.

On September 11, Metrorail in Washington, D.C., evacuated downtown workers expeditiously, as soon as the magnitude of the terrorist threat became clear. Since then, transit providers nationwide have operated with uncertainty—learning to expect the unexpected. Major transit systems have experienced hoaxes, copycat scares, and jittery, fearful riders. Almost every event requires serious treatment, disrupting service and possibly calling for hazardous materials response teams. Solidifying the transit infrastructure and increasing the level of security may require budget reallocation.

Ridership

The good news for transit before September 11 included an overall transit ridership increase of 2.93 percent as of the second quarter of 2001. Ridership on heavy rail, bus, and demand response vehicles increased 4.87 percent, 1.87 percent, and 7.99 percent, respectively. Although TEA-21 expires September 30, 2003, established funding levels are expected to be renewed or raised.

Bus Rapid Transit

Bus transit is undergoing a renaissance in service, equipment, fuels, and technology. Demonstrations of bus rapid transit (BRT)—an express form of service on exclusive rights-of-way or on arterials with signal preemption—are under way through the Federal Transit Administration (FTA) in Boston, Massachusetts; Charlotte, North Carolina; Cleveland, Ohio; Dulles Corridor, Virginia; Eugene, Oregon; Hartford, Connecticut; Honolulu, Hawaii; Miami, Florida; San Juan, Puerto Rico; and Santa Clara, California. Other cities are participating in the FTA program by demonstrating aspects of BRT: Albany, New York; Chicago, Illinois; Los Angeles, California; Louisville, Kentucky; Montgomery County, Maryland; Alameda and Contra Costa, California; and Pittsburgh, Pennsylvania.

The TRB Committee on Bus Transit Systems (A1E01) conducted a Conference on Bus Rapid Transit in Pittsburgh, August 12–14, 2001, cosponsored by FTA, the American Public Transportation Association, and the Port Authority of Allegheny County. New bus equipment, alternative fuels, passenger information systems, and ITS technology offer improvements in service reliability, customer service, and safety. Pittsburgh is testing ITS collision avoidance systems for its buses.

Rail Transit

Rail transit is changing too. Heavy rail systems are rehabilitating infrastructure and expanding in some areas; Boston, Chicago, and New York are making infrastructure improvements to older parts of the systems. Commuter rail expansion is under consideration in Chicago and Northern Indiana and in Los Angeles, San Diego, and San Francisco, California. New service has been approved for the North Star route in Minneapolis, Minnesota, and South Florida is double-tracking—adding a second track and upgrading—along 44 miles.

Light rail transit (LRT) is maturing even as new services start up. The Dallas, Texas, system has grown rapidly and loaned vehicles to Salt Lake City, Utah, for the 2002 Winter Olympics. Salt Lake City's East-West Connection line opened for the event. Cordless LRT vehicles—using either diesel or electric technology—will debut on the Camden-Trenton, New Jersey line. New starts are under way in Minneapolis (Hiawatha Line); Houston, Texas; and Phoenix, Arizona.

Other Issues

More communities are addressing difficult planning and investment choices: light rail, BRT, or high-occupancy vehicle facility? Transit must grapple with a variety of questions, such as how to coordinate transit with the school bus fleet; what fuel propulsion technologies to choose; and how to improve service for disabled riders under the Americans with Disabilities Act.

The aging population requires more paratransit, nonfixed route services, and rural public and intercity bus transportation. Getting workers to jobs also entails targeted transit services. But many transit employees are retiring in the next five years, and many agencies will confront these decisions—and the pressing issues of security—with fewer staff and less institutional knowledge and memory.

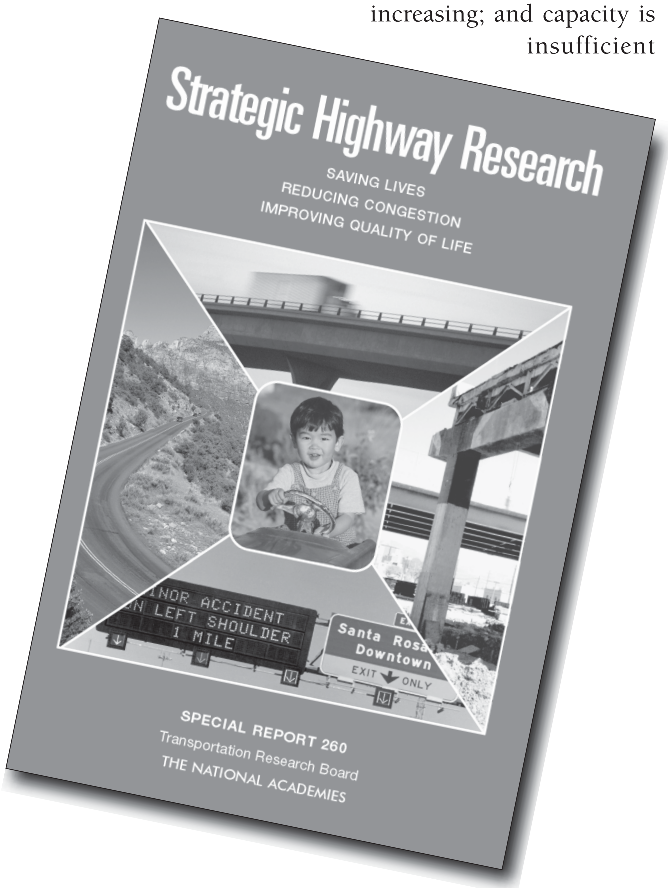
NEW TRB SPECIAL REPORT

Strategic Highway Research

Saving Lives, Reducing Congestion, Improving Quality of Life

ANN M. BRACH

Highway transportation faces critical problems that demand attention: tens of thousands of lives are lost and millions of injuries occur each year on America's highways; bridges and pavements are deteriorating; congestion and delays are increasing; and capacity is insufficient to meet growing mobility and economic needs. A policy study committee of the Transportation Research Board, appointed at the request of the U.S. Congress, has recommended a Future Strategic Highway Research Program (F-SHRP) aimed at developing solutions to these problems. The committee has published its findings and recommendations in *Special Report 260: Strategic Highway Research: Saving Lives, Reducing Congestion, Improving Quality of Life*.



Special Report 260: Strategic Highway Research: Saving Lives, Reducing Congestion, Improving Quality of Life, is available from TRB (see Publications Order Form in this issue).

Serving Customers

The highway network is the backbone of America's transportation system, supporting mobility and economic needs at the community, regional, national, and global levels. Americans use the highway system to make more than 90 percent of passenger trips and to move 69 percent of total freight in terms of value. Highways also accommodate buses, bicycles, and pedestrians and provide links among all modes of transportation.

In June 1998, the U.S. Congress passed the Transportation Equity Act for the 21st Century (TEA-21), reauthorizing the federal-aid highway program, and asked TRB "to conduct a study to determine the goals, purposes, research agenda and projects, administrative structure, and fiscal needs for a new strategic highway research program."

TRB assembled a committee of leaders from the highway community, chaired by C. Michael Walton of the University of Texas at Austin, with Bradley L. Mallory of the Pennsylvania Department of Transportation as vice chair (see sidebar, page 71). The primary task of the committee was to propose a research program aimed at strategic highway needs; members were chosen for demonstrated ability to provide strategic leadership in public agencies, private-sector firms, academia, and user and stakeholder associations within the highway community. The committee worked in cooperation with TRB's Research and Technology Coordinating Committee, which performs

Proposed Program's Guiding Characteristics

The Future Strategic Highway Research Program (F-SHRP) should have the following characteristics to guide program development: F-SHRP should be

- Focused on nationally significant topics for which a research program of critical mass and continuity can achieve breakthroughs in highway practice;
- Complementary to other highway research and technology programs;
- Open to research in nontraditional highway-related areas;
- Customer service-oriented;
- Stakeholder-driven;
- Time-constrained;
- Systems-oriented; and
- Implementation-oriented.

a continuing review of the Federal Highway Administration's (FHWA's) research and technology programs.

The committee noted that everyone in some way is a customer of the highway system, and that customers expect high levels of service—highway transportation is no exception. The committee therefore identified a theme for the study: "providing outstanding customer service for the 21st century."

Strategic Problem-Solving

For decades, research programs have promoted innovation in the nation's highway system. FHWA, state departments of transportation (DOTs), and the National Cooperative Highway Research Program (NCHRP) conduct the largest of these programs and provide research and technology services across the spectrum of highway-related disciplines.

Occasionally, special-purpose research programs have concentrated additional resources on strategic areas to accelerate progress in solving critical problems. The American Association of State Highway Officials Road Test in the late 1950s and early 1960s developed design standards for the nascent Interstate highway system. The first Strategic Highway Research Program (SHRP), in the late 1980s and early 1990s, addressed some of the critical infrastructure and operations problems of state highway agencies. SHRP's success prompted the congressional request for the TRB study on strategic problem-solving initiatives.

The study committee conducted extensive outreach to identify highway needs and research opportunities. Stakeholders representing user groups, the private sector, interest groups, and universities, as well as federal and local agencies and state DOTs, participated in the outreach through presentations, briefings, focus group sessions, and an interactive website.

The outreach identified hundreds of highway needs and research opportunities. From this wealth of ideas the committee determined research areas that could have significant effect on highway system performance for customers. The committee recommended the establishment of F-SHRP with four strategic focus areas and research program goals.

1. Renewal: Accelerating the Renewal of America's Highways

Develop a consistent, systematic approach to highway renewal that works rapidly, causes minimum disruption, and produces long-lived facilities.

After decades of constant use, much of the highway system needs extensive renewal, often while the facilities remain in service. The public demands that the work be done quickly, with as little social and economic disruption as possible. F-SHRP will produce a systematic method of analyzing renewal needs and evaluating alternative strategies, and will develop tools and technologies for agencies implementing a new model of highway renewal.

2. Safety: Making a Significant Improvement in Highway Safety

Prevent or reduce the severity of highway crashes through more accurate knowledge of crash factors and of cost-effective countermeasures.

Each year, almost 42,000 people are killed on the nation's highways, and 3 million are injured. In 1999 the cost of these crashes approached $182 billion.

Although progress has been made in highway safety in the last several decades, increases in vehicle-miles traveled threaten to boost the absolute numbers of fatalities and injuries even as fatality and injury rates fall. Inadequate knowledge of crash factors and of the effectiveness of countermeasures limits progress. F-SHRP will use a combination of traditional crash analysis and advanced data collection technologies to gain a fundamental understanding of crash factors and to assess the cost-effectiveness of countermeasures.

3. Reliability: Providing a Highway System with Reliable Travel Times

Provide highway users with reliable travel times by preventing and reducing the impact of nonrecurring incidents.

Highway use and congestion are growing in many areas of the country. Congestion makes the highway

system more susceptible to unforeseen variations in travel time, and users have become more sensitive to these variations. Nonrecurring incidents—crashes, broken-down vehicles, spills, work zones, and special events—are major causes. F-SHRP will develop strategies and tactics to reduce the impacts of nonrecurring incidents by studying incident characteristics and user impacts, and by developing and applying tools and technologies for incident management and response.

4. Capacity: Providing Highway Capacity in Support of the Nation's Economic, Environmental, and Social Goals

Develop approaches and tools for systematically integrating environmental, economic, and community requirements into the analysis, planning, and design of new highway capacity.

With the anticipated growth in population and travel, and a projected doubling of truck tonnage by 2020, selected additions to highway capacity are warranted. However, provision of new capacity must address the relationships between highways and the economy, communities, and the environment. F-SHRP will formulate an integrated, systems-oriented approach to highway development that encompasses engineering, economic, environmental, social, and aesthetic considerations, and that uses appropriate tools and technologies to integrate these considerations systematically throughout the development process.

Getting the Job Done

The administrative structure for F-SHRP should include

- Essential quality control mechanisms (including open solicitation and merit-based selection of research proposals);
- The ability to carry out a large contract research program;
- Focused core staff and secure funding throughout the program's time frame; and
- The ability to institute stakeholder governance.

The funding mechanism used for SHRP also can work for F-SHRP: a takedown from the federal-aid highway funds apportioned under the next surface transportation authorizing legislation. F-SHRP will require approximately $75 million per year for six years.

F-SHRP should address the implementation of program results; however, the long-term responsibility for coordinating and facilitating implementation should be determined as soon as possible. A portion of the funding should support implementation activities appropriate to the research stage; full-scale implementation activities will require additional funding.

Committee on a Study for a Future Strategic Highway Research Program

C. Michael Walton, Professor of Civil Engineering, University of Texas at Austin, *Chair*

Bradley L. Mallory, Secretary, Pennsylvania Department of Transportation (DOT), *Vice Chair*

Joel D. Anderson, Executive Vice President, California Trucking Association

E. Dean Carlson, Secretary, Kansas DOT

Frank L. Danchetz, Chief Engineer, Georgia DOT

Henry E. Dittmar, President and Chief Executive Officer, Great American Station Foundation

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David R. Gehr, Director, Strategic Planning, Parsons Brinckerhoff, Inc.

Susan Martinovich, Assistant Director and Chief Engineer, Nevada DOT

Herbert H. Richardson, Director, Texas Transportation Institute

H. Gerard Schwartz, Jr., Chairman, Sverdrup Civil, Inc.

Thomas R. Warne, President, Tom Warne and Associates

David K. Willis, President and Chief Executive Officer, AAA Foundation for Traffic Safety

Next Steps

Special Report 260 provides a strategic direction for F-SHRP; additional, detailed planning is necessary before the research can begin. The American Association of State Highway and Transportation Officials and FHWA have agreed to fund the development of detailed research work plans through NCHRP under NCHRP Project 20-58.

Four contractors—one for each research program area—will develop detailed work plans under the guidance of four NCHRP panels; a fifth panel will provide leadership and oversight for the entire project. Research work plans and an administrative structure for F-SHRP will be prepared by fall 2003, in time for the congressional reauthorization of the highway program.

Ann M. Brach is Senior Program Officer, TRB.

Philip J. Tarnoff

Center for Advanced Transportation Technology, University of Maryland

A leader in the development of the intelligent transportation systems (ITS) industry, Philip J. Tarnoff, Director of the Center for Advanced Transportation Technology at the University of Maryland, draws on 39 years of experience in transportation research.

"Transportation research is somewhat unique in that it tends to be more applied than many other fields; the research addresses the practices of a conservative community that is often slow in its adoption of new research results," Tarnoff observes. "As a result, the benefits of transportation research are slow to emerge—research tends to be more evolutionary than revolutionary."

Tarnoff oversees research on the application of advanced technology related to ITS—for example, cellular geolocation; the development and delivery of web-based training in ITS, transportation engineering, and information technology; and the regional integration of ITS systems and transportation operations throughout Maryland.

Transportation research is somewhat unique in that it tends to be more applied than many other fields…[it] addresses the practices of a conservative community that is often slow in its adoption of new research results.

Before serving in his current role, Tarnoff was president of PB Farradyne, Inc., a subsidiary of Parsons Brinckerhoff. He describes his greatest achievement as founding the precursor Farradyne Systems, Inc., in 1984; the company has grown from one employee to more than 250 employees. PB Farradyne has become a leader in ITS systems consulting, systems integration, and software development.

During his tenure at Farradyne, Tarnoff spearheaded development of several systems, notably the TRANSCOM TRANSMIT System, the first U.S. system to measure traffic conditions by anonymously tracking vehicles with electronic toll tags. Implemented in metropolitan New York and New Jersey, the project involves the development of traffic monitoring and incident detection algorithms using vehicle probe data from electronic tolls and from traffic-management-equipped vehicles.

Tarnoff was vice president of the Planning Research Corporation's Engineering division from 1975 to 1984, research engineer at the Federal Highway Administration from 1970 to 1975, and vice president of the Kelly Scientific Corporation from 1966 to 1970.

Among Tarnoff's other notable contributions to ITS are

- The Real-Time Adaptive Control System, which can update traffic signal timing in real time in response to changing traffic conditions, functioning on congested as well as noncongested roadways. The system will offer the capability to recognize the need for new signal phasing and roadway operations.
- The Management Information Systems Transportation System, a software system for traffic control—Tarnoff was responsible for the analysis of city traffic control requirements and for the development of a functional definition for the system.
- The Pathfinder Project, which included the development of the first U.S. version of an in-vehicle navigation and motorist information system.
- The Wide-Area Video Detection System, which allows an automated identification of incidents.

Tarnoff has participated as a member of the Transportation Research Board's Committee on Signal Systems and as chair of the Committee on Communications of the Operations, Safety, and Maintenance of Transportation Facilities. He was the cochair of the Research and Technology Partnership Operations and Mobility Committee and TRB's Committee for the Review of the U.S. Department of Transportation's ITS Standards Program.

His affiliations with other professional organizations include membership in the Institute of Electrical and Electronics Engineers, the Transportation Research Center of Excellence, the Institute of Transportation Engineers, and the Consortium for ITS Training and Education.

Tarnoff earned a bachelor's degree in electrical engineering from The Carnegie Institute of Technology in 1962 and a master's degree in electrical engineering from New York University in 1963. He pursued graduate studies in mathematics at The Johns Hopkins University from 1963 to 1965 and transport planning at the University of Maryland in 1975.

Selected as the 2002 recipient of the Theodore M. Matson Award, Tarnoff has been recognized for his "outstanding contributions in the field of traffic engineering, including practical application of traffic engineering principles, valuable contributions through research, successful adaptation of research findings to practical traffic situations, and advancement of the profession through training and administration."

Christine M. Johnson

Federal Highway Administration, U.S. Department of Transportation

"How did a girl from Wyoming end up in transportation—urban transportation?" people often ask Christine M. Johnson, Program Manager, Operations Core Business Unit, Federal Highway Administration (FHWA), and Director, Intelligent Transportation Systems (ITS) Joint Program Office, U.S. Department of Transportation (DOT). "The truth is, there was no plan, just a series of accidents of personal history, opportunity, a thirst for knowledge, and an interest in the changes that research can generate," she replies.

"I enjoy being on the leading edge of change," notes Johnson. "I see research as a means of introducing new ideas and change into the transportation profession."

I enjoy being on the leading edge of change. I see research as a means of introducing new ideas and change into the transportation profession.

At FHWA's Operations Core Business Unit, Johnson pursues positive change as she develops national policy, legislation, research, and technology transfer. She has launched a national dialogue on transportation operations, published best practices for work zone operations and an incident management handbook, established the National Freight Council, and updated and published—one year ahead of schedule—the millennium edition of the *Manual on Uniform Traffic Control Devices*.

As director of the ITS Joint Program Office, Johnson is responsible for providing oversight and strategic direction for the national ITS research, development, and deployment program. She has overseen the development of the national architecture, national standards, and model deployment of ITS. She has been the driving force pushing ITS from the laboratory bench to the deployment and use by everyday citizens.

From 1993 to 1994 Johnson served as Vice President at Parsons Brinckerhoff, responsible for the firm's programs relating to the Intermodal Surface Transportation Efficiency Act of 1991. Before that, as assistant commissioner for Policy and Planning at the New Jersey DOT from 1990 to 1993, Johnson launched "smart highway operations" and implemented a statewide travel demand management program, as well as a highway access control program. She also was instrumental in the early discussions that led to the Interstate 95 coalition and the E-Z Pass system.

Joining the Port Authority of New York and New Jersey in 1984, Johnson was introduced to new dimensions of transportation. She started as a project coordinator of the Landside Access Policy Review and was promoted to assistant director for planning and development, in charge of transportation planning services in 1985. In 1987, she gained experience on the operational aspects of airport access in her role as general manager of the Aviation Customer and Public Services Division. As director of the Office of Transportation Planning from 1988 to 1990, Johnson initiated and executed the Regional Mobility Conference and provided leadership for the development of the Bi-State Transportation Forum—a consortium of the six major transportation agencies in the region.

Johnson is active in professional organizations, including ITS America, the American Association of State Highway and Transportation Officials, the American Society of Civil Engineers, and the Women's Transportation Seminar. She is also an active volunteer for the Transportation Research Board and has served on several committees and project panels, including the Transit Cooperative Research Program Project Panel on Transit Policy Research, the National Cooperative Highway Research Program Project Panel on Research Strategies for Improving User Cost-Estimating Methodologies, the ITS committee, and the committee for the Conference on Opportunities for Private Involvement in Urban Transportation.

A prolific author and presenter, Johnson has covered a variety of subjects, including *The Hole Story: Facts and Fallacies of Potholes*; "Toward Fragmentation: The Evolution of Public Transportation in Chicago"; "Transportation Management Systems: The Role of the Citizen, Technician, and Chief Executive Officer"; and "Edge City or Urban Redevelopment: The Future of Transportation and Land Use," the keynote address to the New York chapter of the Urban Land Institute.

Johnson has received many professional awards: FHWA's 1999 Heartland Award, presented for outstanding national contribution; the 1998 U.S. Presidential Award for Meritorious Achievement; the Institute for Transportation Engineers' 1998 National Award for Individual Contribution; and the 1997 U.S. DOT Secretary's Silver Medal for Achievement.

She received a bachelor's degree, a master's degree in urban planning and policy, and a doctoral degree in public policy analysis at the University of Illinois–Chicago. In 1998, Johnson was named one of the University's Outstanding Alumni.

NEWS BRIEFS

Detector unit alerts drivers to presence of large animals in roadway area.

High-Tech Alert for Large Animal Crossings

Detectors applying intelligent transportation systems (ITS) technology may prevent vehicle collisions with deer and other large animals on highways. The Western Transportation Institute at Montana State University has contracted with a Scottsdale, Arizona, firm to test a system of "roadway animal sensors."

The system would detect large animals entering a roadway, provide a warning, and turn off the warning after sensing that the animal has left the vicinity. The current design would use either a variable-message sign or a signal light that would flash above an animal-crossing warning sign.

At least 130 fatalities were attributed to collisions with deer, elk, and moose in 2000, and accidents caused more than $1.2 billion in property damage. The project will analyze the number and severity of incidents, the reactions of drivers, and the accuracy of detection.

For further information contact Steve Miller (telephone 480-483-1997) or visit www.sensor-tech.com.

Air-Bag Cutoff Switches Not Used Properly

Misuse of air-bag on-off switches is widespread, endangering nearly half the front-seat child passengers under 13 years old, according to a study by the National Highway Traffic Safety Administration (NHTSA).

Passenger-side air bags have saved more than 1,000 lives, but some passengers should not be exposed to air-bag deployment. As of April 2001, NHTSA had recorded 104 children's deaths attributed to the force of a deploying air bag. A 1995 NHTSA rule allowed manufacturers to install an on-off switch for passenger-side air bags in vehicles that only can accommodate a rear-facing child seat in the front—for example, pickup trucks and cars with no rear seats or small rear seats.

The NHTSA survey showed that the activating switch was on for 48 percent of air bags for child passengers 1–12 years old, potentially exposing them to serious injury or death from the force of deployment. Driver misinformation played a role—in most cases, the drivers told interviewers that the air bags should be turned off only for babies or for children younger than their passengers, or that they always kept the switch on because air bags were safe for all passengers.

Drivers transporting infants achieved the highest rate of compliance: 91 percent turned off the passenger-side air bags and only 9 percent left them on (two drivers in the survey, both driving someone else's truck, an unfamiliar vehicle).

The survey also uncovered a problem when drivers ride with adult passengers—18 percent of the switches were turned off. Many of these occurred in trucks that often transport children—the vehicle owners kept the activating switch turned off permanently to avoid exposing the child to deployment; however, this deprived adult passengers of air bag protection.

Combining results for all passenger age-groups, the air bag's on-off switch was misused 27 percent of the time. The study concluded that NHTSA and its partners must increase efforts to educate the public about the dangers of air bags for toddlers and preteens, and about the benefits for adults. Preliminary results of the survey are available at www.nhtsa.dot/cars/rules/regrev/evaluate/.

For further information contact Tim Hurd, NHTSA (telephone 202-366-9550).

Detecting Airborne Toxins in Transit Systems

The Washington, D.C., Metrorail (Metro) system has activated two devices to detect chemical and biological toxins in the air and will install the sensors at 10 more stations by December 2002. Since 1999, the Washington Metropolitan Area Transit Authority (WMATA) has been a partner with three federal agencies—the U.S. Departments of Energy, Justice, and Transportation—in a program to improve the safety and security of the Metro system against chemical or biological attack.

About the size of a shoebox, the newly-installed sensors continuously take in and analyze the air. If a toxic chemical is detected, the sensor sounds a local alarm and alerts the Metro operations control center.

A chemical released on a station platform can spread to adjoining stations when trains are running because railcars push and pull air through the subway tunnels. This piston effect is especially strong in older stations with flat ceilings—like those in Boston and New York City. Washington's coffered ceilings tend to weaken the effect.

However, the natural flow of wind in subway tunnels, even when no train is moving, complicates the containment of a chemical attack—isolating a chemical release is nearly impossible. To understand how air movement affects a chemical release in the subway, meteorologists have mapped airflows through Metro's stations and have developed computer models to predict the movement of a chemical plume, taking into account its concentration and the location of its release.

The models create a real-time map of the chemi-

cal plume, helping rescue officials make decisions about evacuation and response. The data also can help transit managers decide whether to channel the chemical fumes safely away from the station with ventilation fans.

One challenge has been developing sensors to differentiate toxic chemicals from a host of background chemicals commonly in the air of subway systems. The currently deployed devices cannot detect biological agents such as anthrax and smallpox.

WMATA is one of a few transit agencies with a multiyear strategic test and implementation program with the federal government. The results of the program will be shared with the transit industry in the United States and around the world.

This information was adapted from The Washington Post *article "Metro Set To Initiate Chemical Sensors," Tuesday, December 25, 2001.*

Providing Employer Incentives To Encourage Telecommuters

A pilot program called Ecommute allows businesses to earn clean-air credits for employees who telecommute. The credits then can be "traded" on the open market, offering a way for companies to make money for their efforts in saving energy and curtailing vehicle emissions.

Ecommute uses web-based software to track the miles and emissions saved when employees telecommute and then calculates the miles as credits. U.S. Secretary of Transportation Norman Y. Mineta was a speaker at the pilot program's kickoff last August.

For further information contact Grizelda Reed (telephone 909-396-5757) or visit www.the-partnership.org/ecommute/signup/.

New Center To Study Crash Injury

A Crash Injury Research and Engineering Network (CIREN) center has opened at the Medical College of Wisconsin, Milwaukee, to further the study of real-world automobile crashes and their prevention. The 10th national CIREN center also will work to improve the prognosis and treatment of crash trauma patients.

"Research into the injuries suffered by people in real-world crashes is a vital component of our program to make vehicles safer," noted National Highway Traffic Safety Administrator Jeffrey W. Runge at the October 2001 opening. "The CIREN trauma centers are in a unique position to carry out that detailed research."

The center will conduct basic and clinical research and use the findings to develop strategies to reduce fatalities and injuries in automobile crashes. CIREN also provides feedback to the automobile industry. Research findings and other information about CIREN are available at www-nrd.nhtsa.dot.gov/departments/nrd-50/ciren/ciren.html/.

For further information contact Kathryn Henry, U.S. DOT (telephone 202-366-9550).

In public–private partnership with Washington Metropolitan Area Transit Authority, Flexcar offers car sharing at several Metrorail stations.

Capital Area Rolls Out Car-Sharing Program

The Washington, D.C., metropolitan area has launched a car-sharing program that makes a limited number of cars available at or near select Metrorail stations for hourly rental 24 hours a day, 7 days a week. In operation since December 2001, the program expands service to area transit riders and enhances options for regional travel.

Cars have been available at eight stations, and eight more stations will add the service in March 2002. Metro has identified nine other stations and neighborhood areas for placement of cars during a 12-month period beginning in March, to ensure that all jurisdictions will have access to the program.

Users make reservations by telephone—and soon on the Internet—to pick up a car at one of the designated Metro stations. A monthly fee covers a set number of hours and miles and takes care of all costs including gasoline and insurance. A tiered fee structure benefits frequent users.

"This service will provide value, accessibility, and convenience to Metro customers, increasing Metro's role as a regional mobility manager," Metro General Manager Richard A. White said. "Research shows that programs such as this result in an increase in transit ridership and are seen as a benefit to transit riders."

For further information visit www.wmata.com/metrorail/car_sharing.htm or www.flexcar.com.

People in Transportation

Transit Chief on Board: Experienced in Public Service

Jennifer L. Dorn

"Transit is a key element of America's transportation system," notes Jennifer L. Dorn, the U.S. Department of Transportation's 14th Federal Transit Administrator. "When transit is planned carefully and executed well, it ensures access to goods, services, and activities in large cities, small towns, and rural areas."

Dorn's confirmation in summer 2001 was her third presidential appointment. She served previously as the Assistant Secretary for Policy at the Department of Labor under President George H. W. Bush and was the Associate Deputy Secretary of Transportation during the Reagan administration. Dorn also served as Director of the Office of Commercial Space Transportation from 1983 to 1985, and from 1991 to 1998 she was Senior Vice President of the American Red Cross. Most recently, she was president of the National Health Museum.

Dorn received a bachelor's degree from Oregon State University and a master's degree in public administration from the University of Connecticut. She is an ex officio member of TRB's Executive Committee.

For further information contact Karen Clarke, U.S. DOT (telephone 202-366-0787).

Emergency Physician Administers Safety

Jeffrey W. Runge

Jeffrey W. Runge, a nationally recognized physician expert in motor vehicle injury care and prevention, has begun his first year as head of the National Highway Traffic Safety Administration. A researcher and educator in emergency medicine, Runge has focused on the area of injury prevention and control, with particular interest in motor-vehicle injuries.

At the new Administrator's confirmation in summer 2001, U.S. Secretary of Transportation Norman Y. Mineta noted, "[Runge's] extensive background of research, education, and hands-on experience will make him a triple asset to the department."

Runge is certified by the American Board of Emergency Medicine and has served on the faculty of the Emergency Medicine Residency at Carolinas Medical Center in Charlotte, North Carolina, since 1984. He received a bachelor's degree from University of the South, in Sewanee, Tennessee, and a medical degree from the Medical University of South Carolina, Charleston.

Runge's affiliations include membership on the Trauma Care and Injury Control Committee and the Research Committee of the American College of Emergency Physicians. He has served the president of the North Carolina College of Emergency Physicians and speaker of the North Carolina Medical Society. Runge was a member of TRB's Committee on Alcohol, Other Drugs, and Transportation, and is an ex officio member of the Executive Committee.

For further information contact Liz Neblett, U.S DOT (telephone 202-366-9550).

Schubert To Chart Course of Maritime Administration

William G. Schubert

Captain William G. Schubert, a former maritime industry consultant and Maritime Administration official, was confirmed as Maritime Administrator on November 30, 2001. Schubert brings 27 years of professional maritime experience to his new post in the U.S. Department of Transportation.

Schubert has stressed the need to coordinate policy with the maritime industry, labor community, and government agencies in order to ensure the security of all U.S. ports and of the vessels entering U.S. ports. Maintaining shipbuilding and repair facilities and efficient intermodal transportation systems will be vital in supporting the nation's efforts in the war on terrorism.

"In view of our tremendous mission that lies ahead, it is important that the government, private industry, and labor communicate on a regular basis," said Schubert. "Everyone must do their part to ensure safe transportation as the U.S. moves forward with her allies."

Schubert sailed as a licensed deck officer with Reynolds Metals Company for 10 years after graduating from the U.S. Merchant Marine Academy. From 1984 to 1986, he worked as Master and Installation Manager at three offshore drilling platforms.

He began his 10-year career at the Maritime Administration in 1986 as a Special Assistant to former Maritime Administrator John Gaughan. From 1990 to 1995, he served as the agency's Regional Representative for the Southwestern United States. Before his confirmation, Schubert was president of the Houston, Texas-based International Trade and Transportation, Inc., a maritime consulting firm. Schubert is an ex officio member of TRB's Executive Committee.

For further information contact Robyn Boerstling, U.S. DOT (telephone 202-366-9963).

IN MEMORIAM

John Gray, 1932–2001

John Gray, former president and chief executive officer of the National Asphalt Pavement Association (NAPA), died in December 2001. He was known for his leadership, vision, and commitment to transportation progress through research and implementation.

A native of Arbroath, Scotland, Gray earned a bachelor's degree in civil engineering from Dundee Technical College and a master's degree in civil engineering from St. Andrew's University. His early employment included positions in public works engineering, both in Scotland and, from 1954 on, in the United States.

Following active service in the U.S. Navy Seabees from 1955 to 1957, Gray served as city engineer for Rockville, Maryland, from 1957 to 1961, when he was appointed the city's Director of Public Works. During his tenure, he was recognized nationally for the development and use of high construction standards and specifications for street pavements.

In 1963 Gray was appointed president and chief executive officer of NAPA, a position he held until his retirement in 1992. At NAPA, Gray gained national and international recognition for his efforts in developing high-performance hot-mix asphalt pavements. Through his leadership, he led his association and the hot-mix asphalt industry to a position of worldwide recognition.

In the mid-1980s Gray spearheaded landmark discussions between asphalt contractors and researchers that resulted in a range of initiatives fostering industry involvement in research and implementation. These initiatives included the creation of TRB task forces on innovative contracting practices and highway research in industry, development of a college text and an asphalt paving manual, and a European study tour of asphalt pavements. Gray was instrumental in founding the National Center for Asphalt Technology, located at Auburn University in Alabama.

In 1993 Gray received TRB's W. N. Carey Distinguished Service Award for outstanding service to transportation research and the Board. He earlier had been elected to the Asphalt Institute Roll of Honor and to the Hot-Mix Asphalt Hall of Fame. He was an ex officio member of TRB's Executive Committee from 1988 to 1992.

Wilfred Owen, 1913–2001

Transportation expert Wilfred Owen, former director of the transportation research program at the Brookings Institution, Washington, D.C., died in November 2001. His work was well known and frequently cited for insights, predictions, and research findings on economic growth and transportation. He is remembered for his erudition, collegiality, and quiet sense of humor.

Owen retired from Brookings in 1978 after a 32-year career. He then served as a consultant for several organizations, including the National Academy of Sciences, the Commerce Department, and the World Bank, as well as for planning companies from various foreign countries, including Korea, Cuba, Taiwan, and Brazil.

After receiving a bachelor's degree in economics from Harvard University, Owen moved to Washington, D.C., working as a researcher at the National Resources Planning Board in the 1940s before joining Brookings. Owen was an active member of several then HRB committees, including Highway Costs, Highway Finance, Economic Studies, Urban Research, International Cooperative Activities, and Long-Range Planning. His publications include several books: *Transportation and World Development*, *Cities in the Motor Age*, and *The Metropolitan Transportation Problem*.

George W. Ring, 1928–2001

Former TRB staff member George W. Ring, known for his devotion to highway pavement construction, died in December 2001. Following a distinguished career with FHWA, Ring came to TRB and worked as Design Engineer in TRB's Technical Activities Division (Division A) from 1985 to 1990. He made significant contributions to TRB's standing committees in design, pavement management, and structures areas.

Ring was the liaison to several National Cooperative Highway Research Program panels, including Instrumentation for Moisture Measurement—Bases, Subgrades, and Earth; Potential Benefits of Geosynthetics in Flexible Pavement Testing; Buried Plastic Pipe for Drainage of Transportation Facilities; and Repair of Joint-Related Distress in Portland Cement Concrete Pavements.

Involved as a committee member before and after his employment with TRB, Ring chaired the Committee on Subsurface Drainage and was a member of such committees as Low-Volume Roads, Design of Composite Pavements and Structural Overlays, Subsurface Soil-Structure Interaction, Engineering Fabrics, and Composite Pavement Design. He also contributed to several TRB task forces.

He was a graduate of Virginia Polytechnic Institute and State University, and the University of Virginia.

Cooperative Research Program News

Selecting Sign Materials To Optimize Performance

Engineering-grade retroreflective sheeting once was the only type of sheeting material available for traffic signs, but new alternatives have emerged, including engineering-grade, super-engineering-grade, high-intensity, and super-high-intensity materials (ASTM D4956 designations Types I through VI, with Types VII through IX pending). New products continue to be developed and introduced.

The vehicle fleet and driving population also have changed significantly, as have traffic levels and mix. Vehicle developments have included new headlight designs and technologies and tinted windows. The nature of the vehicle fleet has changed with the popularity of sport utility vehicles and the increased numbers of trucks on the road. These vehicles typically have a greater height differential between the headlights and the driver's eye, resulting in a greater observation angle.

In addition, the driving population is aging, and traffic control devices are being modified to meet older drivers' visual capabilities. Yet despite these changes, the methods used to design traffic signs and select materials for their fabrication have remained the same.

The Center for Computer Aided Design, Operator Performance Laboratory, University of Iowa, was awarded a $300,000, 28-month contract (NCHRP Project 04-29, FY 2001) to develop a simple, user-friendly decision-making tool to aid transportation agencies in selecting retroreflective materials for traffic signs, considering roadway conditions and other factors that critically affect sign performance.

For further information contact Christopher J. Hedges, TRB (telephone 202-334-1472, e-mail chedges@nas.edu).

Transportation Decisions Driven by Customer Needs

Customers are demanding more value from the products and services they receive and are becoming more diverse in defining value in terms of specific needs met. Public-sector organizations are trying to be more proactive in providing products and services that save time, reduce costs, and improve quality.

Howard/Stein-Hudson Associates has been awarded a $149,985, 16-month contract (NCHRP Project 20-53, FY 2001) to develop guidelines for collecting and using data on the needs and expectations of customer segments, to assist for transportation agencies in policy and investment decisions.

For further information contact Christopher J. Hedges, TRB (telephone 202-334-1472, e-mail chedges@nas.edu).

Bridge Design with High-Strength Structural Concrete: Shear Provisions

"Concrete strengths above 10.0 ksi [i.e., high-strength concrete] shall be used only when physical tests are made to establish the relationships between the concrete strength and other properties," according to the American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Bridge Design Specifications (Section 5.4.2.1). When the specifications were written, the data were insufficient to demonstrate that the provisions applied to concrete compressive strengths above 10.0 ksi.

However, research is addressing design issues involving high-strength concrete, and the FHWA Showcase Projects are encouraging the use of high-strength concrete in bridge structures. Therefore the LRFD specifications should be expanded to allow greater use of high-strength concrete.

This project will identify barriers in the LRFD specifications to the use of high-strength concrete and will emphasize the research necessary to remove the barriers related to shear. Project topics include—but are not limited to—the contributions of concrete to shear resistance in high-strength concrete, maximum and minimum transverse reinforcement limits, and bond issues related to shear.

The Department of Civil and Environmental Engineering, University of Illinois, has been awarded a $650,000, 36-month contract (NCHRP Project 12-56, FY 2001) to develop recommended revisions to the AASHTO LRFD Bridge Design Specifications. The project will extend the applicability of shear design provisions for reinforced and prestressed concrete structures to concrete compressive strengths greater than 10 ksi. In addition, the project will identify other barriers to the use of high-strength concrete.

For further information contact David B. Beal, TRB (telephone 202-334-3228, e-mail dbeal@nas.edu).

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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, typewritten pages), summarized briefly but thoroughly by an abstract of approximately 60 words. Authors should also 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 help readers better understand 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 photographic 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 is used. Foreign news articles should describe projects or methods that have universal instead of local application.

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

CALENDAR covers (*a*) TRB-sponsored conferences, workshops, and symposia, and (*b*) functions sponsored by other agencies of interest to readers. Because of the lead time required for publication and the 2-month interval between issues, notices of meetings should be submitted at least 4 to 6 months before the event. Due to space limitations, these notices will only appear once.

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

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

SUBMISSION REQUIREMENTS Manuscripts submitted for possible publication in *TR News* and any correspondence on editorial matters should be directed to the Director of Reports and Editorial Services, Transportation Research Board, National Research Council, 2101 Constitution Avenue, N.W., Washington, D.C. 20418; telephone 202-334-2972. All manuscripts must be submitted in duplicate, typed double-spaced on one side of the page and accompanied by a word-processed diskette in Microsoft Word 6.0 or Word Perfect 6.1. Original artwork must be submitted. Glossy, high-quality black-and-white photographs are preferred; if not available, we will accept color photographs. Slides are our third choice. Digital camera photographs and computer-generated images are not acceptable. A caption must be supplied for each graphic element submitted. Any graphs, tables, and line art submitted on disk must be created in Microsoft PowerPoint (do not use Harvard Graphics software). Required style for units of measurement: The International System of Units (SI), an updated version of the metric system, should be used for the primary units of measurement. In the text, the SI units should be followed, when appropriate, by the U.S. Customary equivalent units in parentheses. For figures and tables, use only the SI units, providing the base unit conversions in a footnote.

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