

# TR NEWS

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## 3 Graduated Driver Licensing: Safety Program Proves Effective in Reducing Crashes

*Daniel R. Mayhew and Herb M. Simpson*

Graduated driver licensing programs, which enable new drivers to gain experience progressively under conditions that minimize exposure to risk, have demonstrated success in reducing collision rates. The authors, key researchers in the subject area, trace the development of the concept, its implementation and acceptance in the United States and abroad, and the studies corroborating the program's safety benefits.

## 8 Transportation Asset Management: New Guide Advances State of the Practice

*Lance A. Neumann, Michael J. Markow, and Louis H. Lambert*

Asset management is a strategic approach to allocating and using available resources cost-effectively. A National Cooperative Highway Research Program project has assembled a comprehensive guide to asset management, defining principles and detailing the applications to transportation agency investments in infrastructure preservation, operations, and capacity expansion.

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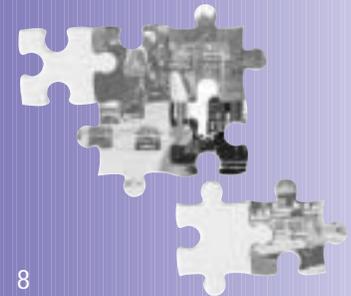
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Cover: Teenagers gain valuable experience behind the wheel in low-risk situations under supervision in graduated driver licensing programs. (Photo courtesy of Traffic Injury Research Foundation.)

# 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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PHOTO: IOWA DOT

The January–February 2004 TR News presents feature articles on the use of market research by state departments of transportation, transit agencies, and other transportation organizations; anti-icing strategies that reduce the amount of salt needed to keep roadways safe; and reports from the field by TRB program officers on the latest developments affecting transportation agencies and research.

Road Weather Information Systems and other technologies help workers apply the minimal amount of salt necessary to keep roads safe and passable after snowfalls.

## LETTERS

### Backtracking into Rail Research History

In delayed response to the letter to the editor in the January–February 2003 TR News, “Getting on Track with High-Speed Dynamic Forces” (page 2), I would like to point out that the first dynamic instrumented rail wheels were developed in Sweden in the late 1950s. When I was appointed Director of Research and Development for the Swedish State Railway (SJ) in 1955, our primary charge was to prevent derailments. A special task force of SJ and Swedish rail industry researchers—working closely with the American Association of Railroads and the Denver and Rio Grande Western Railroad—demonstrated a dynamic instrumented wheel set in 1958. The wheel set allowed continuous measuring, recording, and processing of lateral and vertical forces between the rolling wheels and the rails. The findings were presented at the Technical University of Graz, Austria, and published in 1959 in *Glaser's Annalen* in Germany and in *Österreichische Ingenieur-Zeitschrift*. In 1960 we presented a paper on the topic at the American Society of Mechanical Engineers–Institute of Electrical and Electronics Engineers Joint Rail Conference in Pittsburgh, Pennsylvania.

—Per-Erik Olson, President, Train-Rail Consulting  
Stockholm, Sweden

# Graduated Driver Licensing

## Safety Program Proves Effective in Reducing Crashes

DANIEL R. MAYHEW AND  
HERB M. SIMPSON

*Mayhew, who chairs TRB's Operator Education and Regulation Committee, is Senior Vice President, and Simpson is President and Chief Executive Officer, Traffic Injury Research Foundation, Ottawa, Ontario, Canada.*

**G**raduated driver licensing has gained popularity in North America to address the heightened risk of crashes involving novice drivers. Starting in the 1970s with efforts to introduce elements of the system in Maryland and California, programs recently have gained widespread implementation in Canada and the United States. Graduated driver licensing has won public acceptance by effectively reducing the number of crashes.

### Apprenticeship Approach

Young drivers have a higher risk of collision than older, more experienced drivers (1,2). Age- and experience-related factors contribute to this overrepresentation because risk declines with increased age, as young drivers mature out of risk-taking lifestyles and improve in driving skills (3). Recent research also suggests that increased driving experience is somewhat more important than increased age in reducing collisions among young novices (4).

Recognition of the influence of experience-related and age-related factors on the crash risk of beginning drivers has prompted many states and Canadian provinces and territories to implement graduated driver licensing. A fundamental purpose of graduated licensing is to encourage new drivers to gain driving experience under conditions that minimize exposure to risk.

Warren and Simpson presented this premise more than 25 years ago in a paper, "The Young Driver Paradox," arguing that experience was critical to the development of driving skills (5). Increased experience decreases the risk of collision (6). Beginners therefore need to drive as much as possible; paradoxically, this exposes them to the risk of a collision. What is needed is a means to gain experience with minimized risk. This is a basic tenet of graduated licensing.

Somewhat like an apprenticeship, graduated licensing eases the novice into the full range of traffic conditions. The program provides a protected way for new

drivers to gain experience. Exposure to more demanding situations is phased in as the driver gains experience and competence.

Graduated licensing also addresses age-related or lifestyle factors by minimizing the opportunities for young drivers to engage in risky behavior or to encounter risky situations. For example, provisions for zero blood alcohol content are designed to reduce the incidence of drinking and driving; limits on the number and ages of passengers are intended to reduce opportunities for peer pressure and distraction.

### Program Features

Although the features of the systems implemented in North America vary, each typically has a learner's phase that entails a period of supervised driving, followed by an intermediate phase that imposes certain restrictions on driving.

The learner's period is critical and cannot be bypassed. Most graduated licensing systems stipulate that the learner's license must be held for a minimum period of time—usually several months. During that period, the novice can drive only when supervised by a licensed adult.

In the intermediate stage, graduated licensing





Michigan has designed a vertical driver's license for minors as part of the graduated driver licensing program and to stop underage alcohol and tobacco purchases.

imposes restrictions on when, where, with whom, and how the novice can drive. Restrictions apply, for example, to operating a vehicle on high-speed highways and to driving unsupervised during nighttime hours, as well as to driving with teenage passengers and to drinking alcohol and driving.

The restrictions are removed gradually and systematically—except, of course, for the prohibition on drinking and driving—so that the novice enters the driving task progressively, step-by-step, earning the privilege of full, unrestricted driving.

Graduated licensing programs usually also include a penalty structure, with sanctions imposed at lower thresholds than those that apply to fully licensed drivers. One of the more popular sanctions is to extend the graduated licensing period or to demote the driver within the system, withholding full driving privileges for a longer period. The threat or application of this punishment is intended to deter unsafe driving or other violations of the terms and conditions of the graduated license.

To provide direction on the best practices in graduated driver licensing for the varied programs introduced in the past decade, the Insurance Institute for Highway Safety, together with the Traffic Injury Research Foundation, has issued a report, "Graduated Licensing: A Blueprint for North America" (7). The document presents recommendations for the structure and contents of graduated driver licensing programs.

### Program Evolution

Graduated licensing was first described in the early 1970s in the United States, and the National Highway Traffic Safety Administration (NHTSA) developed a model system in 1977. None of the states, however, adopted the NHTSA model, although Maryland and California introduced elements from it (8,9).

During the next two decades, into the late 1990s, no progress was made on the legislative front in the United States, although many agencies promoted the concept vigorously. New Zealand introduced the first graduated licensing system in August 1987.

### New Zealand Breakthrough

New Zealand's three-stage program applied to all drivers from 15 to 25 years old, inclusively, and to motorcycle operators of all ages. The program was modified in 1999 to apply to drivers of all ages, with several requirements tailored to age. For example, the restricted period for 15- to 24-year olds lasts for 18 months but extends only 6 months for novice drivers over the age of 24 (10).

New Zealand's graduated licensing program was much heralded in North America and was cited extensively as a model legislative initiative. At the same time,

a keen interest in graduated licensing emerged in Australia at the federal level.

### Australian Parallels

In a development similar to what occurred in the United States two decades earlier, the Australian Federal Office of Road Safety designed a model program for discussion, based on the pioneering work of Waller (11) and others (12, 13). Again, like the NHTSA plan, the comprehensive four-stage Australian model was not immediately implemented.

Although several Australian states adopted some of the model components, none—including the most comprehensive system, in the state of Victoria—conformed adequately to the concept of graduated licensing (14). Again, parallel to the slow evolution of graduated licensing in North America, Australian initiatives recently have demonstrated progress. For example, New South Wales introduced a three-stage graduated licensing system in July 2000.

### North American Watershed

In the early 1990s, diverse agencies and individuals actively and aggressively promoted graduated licensing in North America. Some worked from within the government, laying an empirical foundation for the concept and making the case to politicians, while others worked outside the government, creating a receptive public climate. As a result, graduated licensing finally emerged, first in Canada and then in the United States.

In April 1994, the Ministry of Transportation for the province of Ontario introduced the first graduated licensing system in Canada. In October of the same year, the province of Nova Scotia introduced its program. The two programs constituted a watershed in the history of graduated licensing in North America.

During the next 5 years, four more provinces introduced programs, along with 23 states, starting with Florida on July 1, 1996. To date, 47 states and 10 Canadian provinces and territories have enacted one or more elements of graduated licensing.

### Public Support

The level of support for graduated driver licensing is key to the effectiveness of the program. Parents who do not support the program will not enforce the restrictions or will not ensure that their sons and daughters are gaining the necessary driving practice. Teenagers who do not support the program may forgo the required practice time under supervision or simply may proceed to drive unsupervised.

Research in Canada and the United States has shown that the level of support for graduated licensing programs is high. For example, a survey found that 83 percent of 520 parents with teenagers (16 to 18 years old)

in the Ontario graduated licensing program approved of the program (15). Among parents of teenagers in the learner stage, 89 percent agreed with the requirement for supervision. Almost 8 out of 10 parents (78 percent) of both learner and intermediate-stage teenage drivers said that the program was preparing their teenagers adequately for full driving privileges.

A similar level of support was found in Nova Scotia. A survey of 450 teenagers 16 to 18 years old and 500 parents of 16- to 18-year-olds found that parents and many teenagers endorsed the graduated licensing program (16). Among parents of teenagers in the learner stage, 87 percent voiced approval, as did 61 percent of teenagers in the learner stage. Sixty-six percent of learners agreed with the requirement for supervision, as did 97 percent of parents of teenagers in the learner stage.

U.S. studies also have shown that parents strongly support graduated licensing (17,18). For example, in surveys of juniors and seniors from eight Florida high schools before (1996) and after (1998) implementation of graduated driver licensing, the percentage of teenagers who strongly or somewhat supported the program increased from before to after the program (19).

California adopted a relatively strong graduated licensing program in 1998, and a 2002 survey of teenagers and their parents found that 79 percent of parents with children subject to the requirements strongly favored the system (20). Among the teenagers in the system, 84 percent favored the 6-month holding period, and 89 percent favored the requirement that parents certify at least 50 hours of supervised driving.

### Safety Evaluations

Research has demonstrated that graduated licensing is an effective safety measure (21)—all program evaluations published to date have reported safety benefits. Studies of the safety effectiveness of graduated driver licensing in New Zealand, Canada, and the United States have shown overall reductions in crashes of 4 to 60 percent. With the many variations among the programs, this variation in the magnitude of the reported crash reductions is not surprising.

The variability, however, may be attributable in part to different evaluation designs and statistical analyses, ranging from simple before-and-after comparisons, without the control groups necessary to account for other factors or events that may influence collisions, to the use of powerful, interrupted time-series analysis,

TABLE 1 Evaluations of Graduated Driver Licensing Programs in Canada

Province	GDL Date	Target Group(s) Examined	Results		
			Measures	% Reduction	
Nova Scotia	1994	Drivers age 16 <sup>a</sup>	Number of crashes	-37%	
			Number of injury crashes	-31%	
			Per capita crash rate	-24%	
			Per capita casualty crash rate	-34%	
		All novice drivers <sup>a</sup>	Per driver crash rate	-19%	
			Age 16	Per driver crash rate	-22%
			Age 17-24	Per driver crash rate	-21%
			Age 25+	Per driver crash rate	-43%
Ontario	1994	All novice drivers <sup>b</sup>	Per driver crash rate	-31%	
			Per driver crash rate	-31%	
		Age 16-19	Per driver crash rate	-42%	
		Age 20-24	Per driver crash rate	-38%	
		Age 25-34	Per driver crash rate	-37%	
		Age 35-44	Per driver crash rate	-24%	
		Age 45-54	Per driver crash rate	-19%	
		Age 55+	Per driver crash rate	-24%	
Quebec	1997	All novice drivers <sup>c</sup>	Number of fatalities	-5%	
			Number of injuries	-14%	
			Per driver fatality rate	-7%	
			Per driver injury rate	-17%	
			Per driver casualty crash rate	-24%	

<sup>a</sup> Mayhew, D. R., H. M. Simpson, M. Groseillers, and A. F. Williams. Impact of the Graduated Driver Licensing Program in Nova Scotia. *Journal of Crash Prevention and Injury Control*, Vol. 2, No. 3, pp. 179-192 (2001).

<sup>b</sup> Boase, P. and L. Tasca. *Graduated Licensing System Evaluation: Interim Report*. Safety Policy Branch, Ontario Ministry of Transportation, Toronto, Ontario, Canada, 1998.

<sup>c</sup> Bouchard, J., C. Dussault, R. Simard, M. Gendreau, and A. M. Lemire. The Quebec Graduated Licensing System for Novice Drivers: Two-Year Evaluation of the 1997 Reform. In *Proceedings of the 15th International Conference on Alcohol, Drugs, and Traffic Safety*, T-2000, Stockholm, Sweden, 2000.

which seeks to understand the underlying forces and structure that produced the observed changes in the data. In addition, the basic groups under study have differed—for example, the New Zealand program applies to drivers under the age of 25; the Canadian programs apply to all novice drivers, not just young ones; and the U.S. programs primarily apply to drivers under the age of 18.

Initial evaluations of the New Zealand graduated licensing program implemented in 1987 reported substantial reductions of approximately 25 percent in casualty collisions. Longer-term studies, however, have found sustained and significant reductions of 7 percent (22).

In Canada, studies of the effectiveness of the graduated driver licensing programs implemented in Ontario and Nova Scotia in 1994 and in Quebec in 1997 have reported reductions in collisions among novice drivers in all age groups. Table 1 displays a summary of the findings.

In the United States, evaluations have found safety benefits from the programs implemented in Florida in 1996; in North Carolina, Michigan, and Ohio in 1997; and in California in 1998. Table 2 shows the key findings.

Each of these programs includes an intermediate-stage restriction on driving at night—the restrictions

TABLE 2 Evaluations of Graduated Driver Licensing Programs in the United States

Province	GDL Date	Target Group(s) Examined	Results	
			Measures	% Reduction
California	1998	Drivers age 16 <sup>d</sup>	Number of casualty at-fault crashes	-23%
			Number of noninjury at-fault crashes	-17%
			Number of teen pass. deaths or injuries	-40%
Connecticut	1997	Drivers age 16 <sup>e</sup>	Per capita casualty crash rate	-22%
Florida	1996	Drivers age 15-17 <sup>f</sup> Drivers age 15 Drivers age 16 Drivers age 17	Per capita casualty crash rate	-9%
			Per capita casualty crash rate	-19%
			Per capita casualty crash rate	-11%
			Per capita casualty crash rate	-7%
Kentucky	1996	Drivers age 16 <sup>g</sup>	Number of crashes	-33%
			Number of fatal crashes	-34%
			Number of injury crashes	-28%
			Per driver crash rate	-32%
Michigan	1997	Drivers age 16 <sup>h</sup>	Per capita crash rate	-25%
			Per capita injury crash rate	-24%
North Carolina	1997	Drivers age 16 <sup>i</sup>	Per capita crash rate	-23%
			Per capita fatal crash rate	-57%
			Per capita injury crash rate	-28%
			Per capita noninjury crash rate	-23%
			Per driver crash rate	-19%
Ohio	1999	Drivers age 16-17 <sup>j</sup>	Per capita crash rate	-60%
			Per capita fatal crash rate	-69%
			Per capita injury crash rate	-59%
			Per capita noninjury crash rate	-60%
			Per driver crash rate	-23%
			Per driver fatal crash rate	-24%
			Per driver injury crash rate	-21%
Per driver noninjury crash rate	-23%			

<sup>d</sup> California Passenger Deaths and Injuries Drop as Graduated Driver License Law Marks Second Anniversary. News release, Automobile Club of Southern California, 2000

<sup>e</sup> Ulmer, R. G., S. A. Ferguson, A. F. Williams, and D. F. Preusser. Teenage Crash Reduction Associated with Delayed Licensure in Connecticut. *Journal of Safety Research*, Vol. 32, pp. 31-41 (2001).

<sup>f</sup> Ulmer, R. G., D. F. Preusser, A. F. Williams, S. A. Ferguson, and C. M. Farmer. Effect of Florida's Graduated Licensing Program on the Crash Rate of Teenage Drivers. *Accident Analysis and Prevention*, Vol. 32, No. 4, pp. 527-532 (2000).

<sup>g</sup> Agent, K. R., J. G. Pigman, L. C. Steenbergen, S. H. Pollak, P. S. Kidd, and C. McCoy. Evaluation of the Kentucky Graduated Driver Licensing System. *Chronicle of the American Driver and Traffic Safety Education Association*, Vol. 50, No. 1, Winter 2002, pp. 6-7 (2002).

<sup>h</sup> Shope, J. T., L. J. Molnar, M. R. Elliott, and P. F. Waller. Graduated Driver Licensing in Michigan: Early Impact on Motor Vehicle Crashes Among 16-Year-Old Drivers. *Journal of the American Medical Association*, Vol. 286, No. 13, pp. 1599-1598 (2001).

<sup>i</sup> Foss, R., J. R. Feaganes, and E. A. Rodgman. Initial Effects of Graduated Driver Licensing on 16-Year-Old Driver Crashes in North Carolina. *Journal of the American Medical Association*, Vol. 286, No. 13, pp. 1588-1592 (2001).

<sup>j</sup> *An Evaluation of Ohio's Graduated Driver License Law*. Ohio Department of Public Safety, Columbus, 2001.

range from 9:00 p.m. to 5:00 a.m. in North Carolina, to 1 a.m. to 5 a.m. in Ohio. California's program also includes a restriction on teenage passengers—during the first 6 months of the intermediate stage, a driver with a graduated license cannot transport passengers younger than 20 years of age, unless supervised by a driver at least 25 years old.

The partial graduated licensing programs introduced in Kentucky in 1996 and Connecticut in 1997 also have proved effective in reducing the crash involvement of teenage drivers. Neither program has an intermediate stage, but both have an extended learner stage with a mandatory 6-month holding period.

## Improving Programs

The elevated crash risk for beginning drivers—particularly young drivers—has led to the implementation of some version of graduated driver licensing in Canada and the United States. Most parents, as well as many teenagers, support the programs. In addition, scientific evidence continues to confirm the safety benefits of graduated driver licensing. These positive findings are not surprising, because graduated licensing addresses the two critical factors that give rise to the overrepresentation of young drivers in crashes: experience and age or lifestyle.

The crash reductions reported in evaluations, however, are not uniform. The variation in results could reflect differences in the methodologies, in the study sites, or in the program requirements. Research is needed to improve understanding of the mechanisms that reduce crashes; a recent symposium has generated recommendations for research (23).

Jurisdictions should make adjustments to their programs as more is learned about what contributes most to reducing crashes among beginning drivers. Nonetheless, despite the protective features of graduated driver licensing, some novice drivers still will be involved in crashes.

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# Transportation Asset Management

## New Guide Advances State of the Practice

LANCE A. NEUMANN,  
MICHAEL J. MARKOW,  
AND LOUIS H. LAMBERT

Neumann is President, and Markow is Principal, Cambridge Systematics, Inc., Cambridge, Massachusetts. Lambert retired last year as Deputy Director, Transportation Planning Bureau, Michigan Department of Transportation, and is now Senior Associate, Cambridge Systematics.

**T**he recent completion of a National Cooperative Highway Research Program (NCHRP) Project, Asset Management Guidance for Transportation Agencies,<sup>1</sup> marks a milestone in transportation asset management. The *Transportation Asset Management Guide* will help agencies gain new insights into asset management and improve their practices.

The NCHRP project also produced a synthesis of U.S., international, and private-sector practice in asset management, the management framework for the guide, and a prioritized list of research to fill gaps in the knowledge and practice of asset management for transportation infrastructure. These products resulted from tasks outlined in the American Association of State Highway and Transportation Officials' (AASHTO) Strategic Plan for Transportation Asset Management, issued in December 2000.

AASHTO has adopted and will distribute the *Transportation Asset Management Guide*. The final draft is available on NCHRP's website.<sup>2</sup> In addition, the Federal Highway Administration, through the National Highway Institute, has developed a one-day course on transportation asset management for agency executives and senior managers.<sup>3</sup>

Following is a preview of the concepts, principles, and techniques described in the guide, with examples

of the improvements that asset management can introduce in the ways an agency allocates resources and employs different types of investments.

### Defining the Principles

Asset management has many interpretations—for example,

- ◆ A next-generation infrastructure management system,
- ◆ A way to bring private-sector thinking into public-sector decisions,
- ◆ An economics-based approach to investment planning and decision-making,
- ◆ A comprehensive program of facility maintenance or maintenance contracting,
- ◆ A management philosophy to secure the future life of transportation infrastructure, and
- ◆ A way of combining pavement, bridge, safety, and other maintenance management systems to yield more effective information.

All of these descriptions reflect elements of sound asset management, but none captures the concept fully. Asset management is a strategic approach to managing transportation infrastructure. It builds on several principles:

- ◆ **Asset management is policy-driven.** Decisions about managing infrastructure reflect the policy goals and objectives that define the condition of assets, the

<sup>1</sup> NCHRP Project 20-24(11).

<sup>2</sup> [http://www4.trb.org/trb/crp.nsf/All+Projects/NCHRP+20-24\(11\)](http://www4.trb.org/trb/crp.nsf/All+Projects/NCHRP+20-24(11))

<sup>3</sup> [www.nhi.fhwa.dot.gov/coursedesc.asp?coursenum=1130](http://www.nhi.fhwa.dot.gov/coursedesc.asp?coursenum=1130)

levels of performance, and the quality of services to meet customer needs and achieve economic, community, and environmental goals.

◆ **Asset management is performance-based.** Goals and objectives must have clear measures of performance. Targets established for performance measures will guide decisions in analyzing options, setting priorities, establishing budgets, and implementing programs, and must be technically and financially realistic.

◆ **Asset management examines options and tradeoffs at each level of decision making.** Resources are limited. Investment decisions in other areas and about other assets are interrelated and have an effect on transportation assets. Therefore decision makers should consider all options and evaluate the tradeoffs among alternatives.

◆ **Asset management takes the long-term view.** Analyses of program options should incorporate a long-term view of facility condition, performance, and cost. Analysis procedures rooted in engineering and economics are most effective in assessing the tradeoffs among different actions at different times in an asset's life cycle.

◆ **Asset management bases decisions on merit.** Choices among options during program development, project selection, and program and service delivery should be based on comparisons of costs and of the consequences of meeting performance targets. Objective, high-quality information must be applied at each step, using analytic methods and decision criteria consistent with policy goals and objectives and with the agency's business processes.

◆ **Asset management maintains clear accountability.** Performance measures are monitored and reported. This provides feedback on the effectiveness of transportation investments and services, as well as accountability to management for work accomplished and for the effectiveness of program and service delivery.

## Applying the Principles

Applying these principles defines an agency's way of doing business, its procedures for decision making, and its applications of information technology. Asset management is not a separate function or system but a way of improving an agency's procedures for allocating and using available resources to achieve results cost-effectively.

Most agencies already employ aspects of good asset management practice; the principles in the guide therefore suggest ways for agencies to leverage strengths and improve the integration of data, information, and decision making. To be most effective, the asset management principles must be applied com-

prehensively to all of the agency's infrastructure expenditures, including preservation, operations, and system expansion—in capital construction as well as in maintenance and operations programs.

Asset management should be implemented in as many resource allocation and utilization processes as possible—for example, in policy development; long-range planning; project development; program development and priority setting; delivery of projects, programs, and services; and system monitoring and reporting. Agencies, however, may decide to focus at first on high-priority functions, to gain initial results quickly and affordably.

The *Transportation Asset Management Guide* covers asset management in these investment areas and in resource allocation and utilization. Nonetheless, an agency does not need to mount an all-encompassing effort to make headway in asset management. An agency can apply the concepts and principles quickly with current personnel and information technology—taking advantage of good asset management practices already in place.

Because state departments of transportation (DOTs) and other transportation agencies differ substantially in priorities, business practices, and available resources, the guide presents a broad treatment. By enabling agencies to understand the context of asset management, the guide helps agency managers to focus on the specific areas in which asset management improvements can have the strongest early payoff. A self-assessment exercise in the guide helps agencies determine strengths, identify areas for improvement, and develop an implementation strategy for priority areas.

## Investment Categories

Some practical examples can show what asset management involves and how the principles can improve an agency's practices. Because agencies differ in program structure and in management culture, the examples relate to the types of investments common to all agencies. The descriptions are limited to three investment areas: preservation, operations, and system expansion. These investment areas encompass capital as well as maintenance and operations expenditures.

◆ **Preservation** extends the life of an asset or corrects a distress that impedes mobility, safety, serviceability, or engineering integrity. Preservation counters wear-and-tear, providing a cost-effective way to keep a facility functioning at its intended level. Corrective and preventive maintenance, repair, and rehabilitation are examples of preservation.

◆ **Operations** focus on real-time service and operating efficiency. Operations enable facilities to provide



the maximum level of service before expansion becomes necessary. Examples include real-time traffic surveillance, intelligent transportation systems (ITS), real-time signal controllers, various strategies formerly grouped under transportation system management, safety improvements, ramp metering, incident response, road weather information systems, and traveler information systems.

◆ **Capacity expansion** affects a facility's level of service by adding physical capacity, by creating new capacity through a new facility, or by implementing long-term operating strategies. New construction, for example, may include new mainline facilities, interchanges, or intermodal facilities. Expansion also can be achieved through general-purpose or HOV lanes, climbing and passing lanes, bridge widening or construction of a parallel structure, and improvements on interchanges, intersections, and intermodal facilities. Long-term operating strategies could introduce reversible peak-hour lanes, adjustments to speed limits, and new signals and lane controls.

These investment categories provide a framework for the practical implications of transportation asset management. All agencies invest in these areas, but in different measures. Agencies with mature infrastructure in settled urban areas may emphasize preservation and operations improvements, while agencies in regions experiencing population and economic growth may have a relatively higher percentage of expenditures for capacity expansion.

Projects may comprise more than one investment type, creating interactions among preservation, oper-

ations, and capacity expansion. For example, preservation work in construction or maintenance work zones can cause traffic disruptions that require operations remedies. Capacity expansion may include installation of ITS or traffic monitoring hardware to serve operations needs. Operations equipment requires maintenance.

Breaking down an agency's infrastructure management into preservation, operations, and capacity expansion provides a straightforward way of organizing asset management techniques and of considering strategic tradeoffs among the categories of investment.

## Preservation

Asset management has historical roots in preservation. During the significant capacity expansion under the Interstate program in the second half of the 20th century, the need to manage the maintenance, repair, and rehabilitation of the highway inventory increased, as pavements, bridge elements, and other key features of the earliest Interstate-era highways began to approach the end of their design lives.

As more and more portions of the network aged, competition increased for preservation resources. The need for knowledge and tools to preserve the system as cost-effectively as possible stimulated research programs and the development of computerized decision-support systems for pavement, bridge, and maintenance management.

In this way, preservation had a head start in the field of highway management, propelled by its importance and visibility for transportation agencies and motorists, as well as the early recognition by practi-



Transportation management centers regulate travel on streets and freeways and maximize levels of service.



Crack sealing preserves pavement.

tioners that system preservation required ongoing management. Nonetheless, the *Transportation Asset Management Guide* emphasizes that the other areas of investment—that is, operations and capacity expansion—also must be considered within a comprehensive, balanced approach.

The guide encourages continuing improvements in preservation in areas such as the following:

- ◆ **Application of management systems and other analytic tools.** Pavement and bridge management systems are applied routinely to assess condition, identify projects, and track performance. However, use in higher-level management tasks—such as testing scenarios, developing programs and budgets, analyzing program tradeoffs, and supporting executive decisions—should be expanded.

- ◆ **Preventive maintenance strategies.** Capital and routine preventive maintenance offer economic benefits but are politically difficult to sell. Analytical methods and research documenting the benefits, moreover, are not as advanced as those for design and rehabilitation. Better information is needed on the long-term benefits of preventive maintenance strategies.

- ◆ **Continued development of new materials and practices.** Preservation benefits from better materials and remedial practices. New technology should provide cost-effective options for extending the service lives of assets.

- ◆ **More comprehensive analysis of strategies for road occupancy.** Work zone management is a major issue, involving the safety of workers and motorists, and is key in planning major rehabilitation projects. Economic analyses of the effects of work zone configurations and scheduling will become common practice as preservation activities increase, traffic volumes grow, and urbanized areas spread.

- ◆ **Continued enhancement of analytic and decision support tools.** Development and enhancement of decision-support tools for preservation have been ongoing. The focus will be on information for executives, integration with other applications, incorpora-

tion of customer-oriented performance measures and criteria, and analyses of program-level tradeoffs.

- ◆ **Maintenance quality assurance programs.** Maintenance quality assurance takes a performance-based approach, applying customer-oriented definitions of levels of service to budgeting decisions. Maintenance quality assurance embodies the principles of good asset management.

## Operations

Operations always have been a component of highway management and are a logical extension of the asset management concept. Responsibility for operations, however, has been fragmented within and across agency jurisdictions. As a result, operations have not been integrated effectively into an overall system management strategy.

But just as preservation was recognized as critical to sustaining the service life of infrastructure cost-effectively, operations have been gaining recognition for a strategic role in maximizing the system's ability to move passenger and freight traffic. Operations have become a key element of good system management.

An effective operations strategy relies on a range of equipment and software that must perform reliably throughout the network. The physical assets supporting operations must be integrated into agency preservation programs for inspection, periodic maintenance, and repair.

The general principles of asset management apply to operations as much as to preservation, but with a different focus:

- ◆ The goals and objectives must reflect system service and reliability in real time;



PHOTO: GEOPHYSICAL SURVEY SYSTEMS, INC.; NORTH SALEM, NEW HAMPSHIRE

Ground-penetrating radar instrument locates and inspects utilities, part of maintenance quality assurance.

- ◆ The focus is on immediate response to situations and real-time results, not on a program of projects; and

- ◆ Performance measures and monitoring must track real-time service delivery.

The principles of asset management therefore imply the following for operations:

- ◆ **More integrated decision making.** Decision making in operations must coordinate with decision making in other areas of asset management, to support a unified set of system performance measures. Coordination is necessary, for example, in allocating resources to balance investments in physical assets with those in operating programs; in maintaining and preserving operations assets, as well as other physical infrastructure; in long-range planning, project development, and design; in analyses of program tradeoffs; and in dealing with other agencies and jurisdictions that influence operations policies and practices.

- ◆ **Interjurisdictional considerations.** The so-called trip perspective looks at the entire transportation system without regard to jurisdictional boundaries and operating responsibilities. Many traffic management centers and incident response programs follow this principle.

- ◆ **Comprehensive asset inventories, condition databases, and analytic techniques.** An agency's overall preservation strategy should include the operations hardware. This requires database and analytic capabilities for the operations equipment on a par with those for other infrastructure assets. Moreover, other capabilities can be applied to operations—for example, maintenance management and bridge management systems that include such assets as traffic management devices, ITS systems, sign bridges, and tunnel facilities.

- ◆ **Methods to analyze operations strategies.**

Analytic tools comparable to those used in preservation, for example, are needed to integrate operations fully into an agency's decision making about resource allocation and utilization. Developing such systems will require thinking "outside of the box," to analyze performance over time and in real time. Research is needed to understand performance from the perspective of reliability, response time, and the critical threshold values of motorists, as well as from the traditional viewpoints of physical condition and frequency of repairs.

- ◆ **Greater outreach and education.** Transportation agencies and operators may not recognize the relationship between operations and asset management. Clearly defining this relationship and communicating it through training, outreach, research, and deployment will help in advancing the state of the practice in system management and agency coordination.

- ◆ **Communication of the benefits of operations investments.** New analytic tools can improve an agency's ability to demonstrate the benefits of investing in operations, but demonstrating the actual benefits of systems that are already deployed also is valuable. Field tests and rigorous evaluations are critical in addressing agency skepticism about ITS, and particularly in communicating the advantages of strategies that improve system reliability and that benefit freight transportation.

## Capacity Expansion

In contrast with operations, capacity expansion focuses on project development and program composition through a process that can extend for several years. In contrast with preservation, capacity expansion works through discrete—sometimes large and expensive—capital projects, instead of



Bridge widening (above, on VA-199) is an aspect of capacity expansion.

addressing continuing, systemwide needs.

In addition, the substantial federal matching formula for Interstate construction through the Highway Trust Fund has provided a direct and dependable funding mechanism for capacity expansion projects. The major expansion in U.S. highway capacity through the end of the 20th century, therefore, may be regarded as a massive, successful public works effort—but the expansion usually is not thought of in the context of asset management practice.

That has now changed—capacity expansion is part of resource-allocation decision making. Needs for funding have shifted toward preservation and, increasingly, toward operations.

Asset management for allocating and utilizing resources applies as much to capacity expansion projects as to preservation and operations. Translating asset management for more effective decision making in capacity expansion entails improvements in several functions and capabilities:

- ◆ **Performance-based planning.** A performance-based approach to long-range planning focuses on the outcomes of possible investments and the degree to which the outcomes support stated policies. Capacity expansion projects can affect a diverse customer base.

- ◆ **Updated performance measures.** Performance measures for new capacity projects must reflect more than level of service in evaluating operational or multimodal alternatives for expanding transportation capacity. Measures should enable analyses of the tradeoffs among capacity expansion and other types of investments and should reflect the interests of passenger and freight customers.

- ◆ **Procedures to analyze multimodal and intermodal investments and tradeoffs.** Different analytic methods and data requirements apply when assessing projects in different modes or evaluating the effects on passenger versus freight transportation. Methods for comparing cost and performance impacts across modes are under development but must be deployed and tested in agency settings. Data and analytic issues in freight transportation must be addressed.

- ◆ **Accelerated scheduling.** Capacity expansion projects often require several years from conception to completion, increasing costs and delaying benefits. Ways to accelerate this schedule while maintaining the necessary steps in planning, design, right-of-way, and construction include different ways of conceiving projects—for example, as corridor-based or multimodal—as well as streamlining or fast-tracking preconstruction activities and establishing contract incentives for rapid completion of construction.

- ◆ **Bidding and contracting mechanisms.** Agencies are applying contracting mechanisms such as

design-build on projects with demanding schedules or to supplement agency expertise, as well as alternate bidding to base awards on lowest life-cycle cost. In awarding a paving contract for a new freeway, for example, Michigan DOT examined bids for concrete versus asphalt pavement and saved several million dollars in construction costs.

## Agency Self-Assessment

Asset management takes a comprehensive view of resource allocation and utilization. Most agencies, however, will want to focus on particular priorities. To help identify the most promising areas for focus, the *Transportation Asset Management Guide* includes a self-assessment exercise.

Through the self-assessment, executives and senior managers can characterize agency practices, highlight the gains accomplished or under way, and identify opportunities for improvement. The exercise requires responses to a series of statements, organized under the four functional areas of asset management: policy development, planning and programming, program delivery, and information and analysis. Completing the form takes approximately 30 minutes.

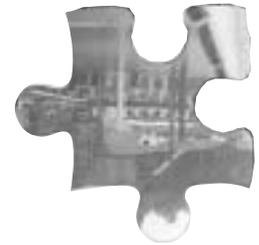
The value of the exercise is in comparing the responses from the agency's executive office with those of managers for such units as planning, engineering, programming, maintenance, finance, operations, and information systems. Bringing together the different perspectives can help identify an agency's strengths and the areas that need improvement in asset management practice. Through this discussion, the agency can develop priorities for immediate and longer-term actions.

The self-assessment is a quick diagnostic tool that yields an overall snapshot of an agency's asset management practices. The information can be used in developing a more comprehensive asset management implementation plan, as described in the *Transportation Asset Management Guide*.

## Implementing Programs

Several agencies have addressed asset management proactively, launching implementation programs and gaining organizational acceptance. The diversity of approaches, however, illustrates not only that asset management draws on a core set of principles, but that application should be customized to an agency's needs, priorities, and situations.

Some state agencies—such as the Colorado, Arizona, Pennsylvania, and Vermont DOTs—have developed plans to identify strengths and priorities for improvements in asset management and information technology. Other agencies have focused on innovations for asset management.





High-occupancy vehicle lanes are tools to manage highway congestion.

### **Michigan's Legislation**

At the direction of the state legislature and administration, Michigan DOT, working with local agencies and other stakeholders, recently played a pivotal role in drafting and securing passage of legislation to institutionalize asset management practice across transportation agencies and jurisdictions. The statute establishes an Asset Management Council charged with developing a statewide asset management process and requires agencies to

- ◆ Collect common data elements for all roads and bridges;
- ◆ Report the true condition of transportation infrastructure, regardless of ownership;
- ◆ Develop multiyear programs from long-range plans; and

Demonstration of system to inspect and evaluate concrete.



GEOGRAPHICAL SURVEY SYSTEMS, INC., NORTH SALEM, NEW HAMPSHIRE

- ◆ Report to the Council annually their roadway and bridge inventories, asset conditions, work activities, expenditures, and activities proposed for the next year.

This process will require local and state agencies to develop a strategic plan within 3 to 5 years to reach an agreed-to level for asset conditions and a recommended level of service. These agencies must cooperate to identify the funding levels and sources to achieve these targets.

### **Colorado's Framework**

Colorado DOT has developed investment categories to organize performance and program expenditure information within a framework useful in asset management. The framework includes

- ◆ Both the capital and the maintenance and operations program dollars, so that Colorado DOT and the Colorado Transportation Commission can see how the programs affect system performance;
- ◆ Performance measures, which provide a basis for analyzing results and, eventually, tradeoffs; and
- ◆ An organizational structure for program information.

The framework does not supplant individual capital and maintenance programs—financial mechanisms and program controls remain in place.

### **Other States' Initiatives**

Several states have adopted programming procedures that focus on a policy-driven, performance-based approach to resource allocation and to analysis of tradeoffs. New York State DOT has had a process in place for

several years. Montana DOT recently instituted a Programming Prioritization Process (or P<sup>3</sup>). Pennsylvania DOT summarizes performance information on a monthly report card, and Washington State DOT issues the quarterly *Gray Notebook* of performance measures and a monthly report card on construction projects.<sup>4</sup>

Asset management principles and techniques also are reflected in maintenance quality assurance programs and the associated levels of service. Several states have undertaken maintenance quality assurance programs, including Arizona, California, Colorado, Florida, Idaho, Iowa, Kansas, Maine, Maryland, North Carolina, Ohio, Texas, Utah, Vermont, and Washington State. A set of the performance measures commonly recognized for maintenance is in development, drawing from workshops, projects, and committee efforts sponsored by AASHTO, FHWA, and NCHRP.

## National-Level Actions

Industry has supported asset management initiatives by individual agencies. At the national level, TRB, AASHTO, and FHWA have been active in supporting conferences, workshops, and TRB Annual Meeting sessions on asset management. The TRB and AASHTO task forces on asset management met jointly in summer 2002 to chart the implementation of asset management from a national perspective.

FHWA has sponsored development of a one-day training course on the *Transportation Asset Management Guide*, and AASHTO and FHWA collaborate in supporting “Transportation Asset Management Today,” a community-of-practice website.<sup>5</sup> Other organizations, such as the American Public Works Association,<sup>6</sup> also have developed materials on asset management. The Midwestern Regional University Transportation Center provides several resources, including a website, research activities, and newsletters.<sup>7</sup>

Research is exploring advances in asset management practice that cut across the investment areas. The NCHRP project produced a prioritized list of research topics in the management, policy, analytic, technological, and academic aspects of asset management. AASHTO selected several of these topics, and studies already are under way through NCHRP.

The projects deal with analytic tools to support asset management, state DOT experience in implementing the Governmental Accounting Standards Board requirements in Statement 34, and identifying and setting targets for performance measures to support asset management. A project nominated for FY 2004 would investigate the effectiveness of asset man-

## Where the Guide Goes

The *Transportation Asset Management Guide* can assist agencies in improving procedures and decisions about allocating and utilizing resources. The book is structured as follows:

- ◆ **Chapter 1: Introduction** defines transportation asset management and outlines past work by AASHTO, FHWA, NCHRP, and international agencies.
- ◆ **Chapter 2: Framework and Principles** explains concepts and tenets of asset management, defines a framework of benchmark practices, and indicates how to customize the management framework to an agency's particular needs.
- ◆ **Chapter 3: Self-Assessment** explains how to use the agency self-assessment test to identify strengths and areas for improvement, provides forms for the exercise, and illustrates how to evaluate results.
- ◆ **Chapter 4: Developing a Strategy** traces how to build a strategy to improve asset management.
- ◆ **Chapters 5 through 8** describe specific applications of asset management to key functions in resource allocation and utilization: policy goals and objectives; planning and programming; program delivery; and information and analysis, including performance monitoring.
- ◆ **Chapter 9: Implementation** presents initial steps to improve asset management and provides a long-term perspective for continuing improvements.

agement implementation. Other research efforts, such as the proposed Future Strategic Highway Research Program, complement the asset management research.

## Questions To Consider

Asset management provides the framework for agencies to assess business practices for infrastructure management, to highlight accomplishments, and to identify opportunities for improvement. When exploring what this framework might do, agency decision makers should consider the following questions:

- ◆ How far has the agency progressed in defining and communicating its strategic direction to all stakeholders?
- ◆ Does the agency comprehensively consider all options in solving problems?
- ◆ Does the agency evaluate tradeoffs in cost and performance?
- ◆ Is the agency concerned about achieving long-term results cost-effectively?
- ◆ Does the agency place value on setting performance goals and on measuring results?
- ◆ What should the agency do to be in the strongest position to justify requests for resources?
- ◆ Even if significant advances in management practices have been implemented, are there better ways to do things?

Asset management addresses these questions by providing an improved way of doing business. The how-tos are presented in the first edition of the *Transportation Asset Management Guide*.

<sup>4</sup> [www.wsdot.wa.gov/accountability/GrayNotebook.pdf](http://www.wsdot.wa.gov/accountability/GrayNotebook.pdf)

<sup>5</sup> <http://assetmanagement.transportation.org>

<sup>6</sup> [www.apwa.net/](http://www.apwa.net/)

<sup>7</sup> [www.mrutc.org/assetmgmt/index.htm](http://www.mrutc.org/assetmgmt/index.htm)



# Costs of Sprawl— 2000

*What Are the  
Impacts?  
What Are the  
Alternatives?*

ROBERT W. BURCHELL  
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Critics of suburban sprawl maintain that this form of growth—predominant in the United States for the past 50 years—has had significantly harmful effects on society. Suburban sprawl, the critics maintain, has thwarted mass transit development, separated rich and poor, caused unnecessary travel, consumed fragile land, and generated excessive public expenditures.

Countering this argument are those who believe that sprawl is as American as apple pie. To them, citizens are getting what they want: single-family homes on large lots, safe communities with good school systems, and metropolitan or nonmetropolitan locations far from the pace and problems of cities.

To provide credible measures for policymakers and citizens to apply in the debate, the Transit Cooperative Research Program (TCRP) undertook a study,<sup>1</sup> sponsored by the Federal Transit Administration. The goal was to assemble useful information, with supporting facts, theory, and analysis, on the positive and negative effects of sprawl on the U.S. economy, environment, and society, with an emphasis on transportation.

The study, published in 2002 as TCRP Report 74: *Costs of Sprawl—2000*, developed measures from methodical assessments of the relative costs and benefits of two forms of metropolitan growth:

◆ Low-density sprawl development at the outer reaches of a metropolitan area, and

◆ More compact, centrally oriented development.

The study analyzed each scenario's demands for land, infrastructure, housing, and public services.

## Defining Sprawl

The TCRP study identified sprawl as rapid and significant population growth in rural and undeveloped counties. A statistical percentage of population growth in the upper quartile indicates significant or at least above-average growth in a particular county. The study defined significant growth as the upper quartile of county growth rates within an Economic Area (EA).<sup>2</sup>

Analyses of growth must consider both a relative (or percentage) dimension and an absolute (or numerical) dimension. If growth in a rural or undeveloped location, therefore, reached a specified level of numerical growth—in this case, 160 percent of the national average numerical growth level—the location was defined as sprawling, regardless of its relative rate of growth within the EA.

In this way, either of two separate measures of growth plus a density factor (a classification of rural or undeveloped) indicated whether or not a county was sprawling. Counties likely to experience sprawl growth between 2000 and 2025 are indicated in Figure 1.

<sup>1</sup> TCRP Project H-10, *The Costs of Sprawl—Revisited*.

<sup>2</sup> An area about twice the physical size of a metropolitan area including nonmetropolitan area (rural) counties.

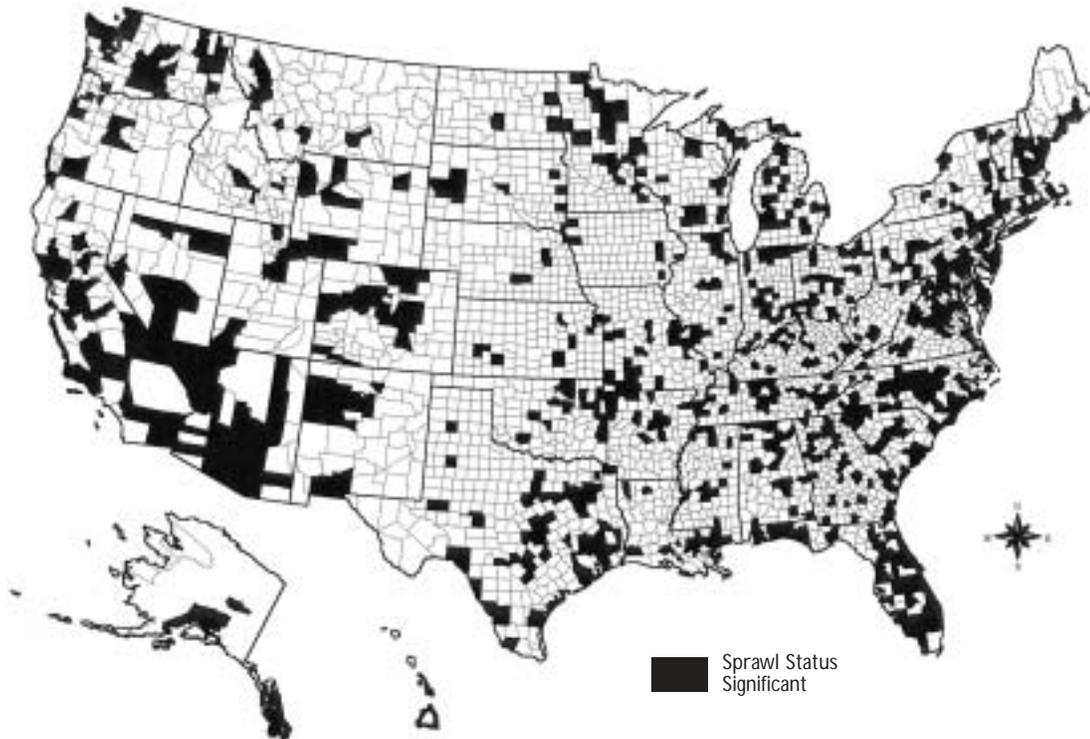


FIGURE 1 Projected sprawl in the United States, 2000–2025.

## Projected Sprawl

Table 1 shows the number of counties in each development classification that will experience sprawl as a result of 25 years of household and employment growth, according to the Woods and Poole projections for 2000 to 2025. Overall, 742 of 3,091 counties, or 24 percent, will experience sprawl during the period.

Of the 742 sprawl counties, 598 are rural and undeveloped; 144 are suburban and rural center counties. Sprawl will occur in 22 percent of rural and undeveloped counties and in 54 percent of suburban and rural center counties.

## Controlling Sprawl

A managed growth scenario redirects household and job growth in sprawl-growth counties to more developed counties within the EA. A variety of monetary and nonmonetary development incentives or restrictions, or both, are required to achieve this redirection.

The objective is to reduce significantly the amount of residential and nonresidential growth in sprawling locations, whether rural, undeveloped, developing suburban, or developing rural center counties. A reduction in growth of one-quarter or more in these locations constitutes a demonstrable change. Controlled sprawl is the classification used for counties in which the purposeful redirection of households and jobs has reduced sprawl growth by at least one-quarter.

Table 2 shows the number of counties experiencing sprawl under the managed growth scenario. Overall, the redirection of households and employment to more-developed counties would reduce sprawl significantly in 420—or 57 percent—of the 742 counties expected to experience sprawl. The projected improvement affects more sprawling rural and undeveloped counties (356) than suburban and rural center counties (64), even though the percentage under control in both groups is about the same, 55 percent to 60 percent.

TABLE 1 Sprawl by County Type Under Sprawl Growth, 2000–2025

County Sprawl Designation	Rural and Undeveloped	Suburban and Rural Center	Urban Center and Urban	Total
Nonsprawl	2,128	121	100	2,349
Uncontrolled Sprawl	598	144	0	742
Total Counties	2,726	265	100	3,091

Source: Center for Urban Policy Research, Rutgers University.

TABLE 2 Sprawl by County Type Under Managed Growth, 2000–2025

County Sprawl Designation	Rural and Undeveloped	Suburban and Rural Center	Urban Center and Urban	Total
Nonsprawl	2,128	121	100	2,349
Remaining Sprawl	242	80	0	322
Controlled Sprawl	356	64	0	420
Total Counties	2,726	265	100	3,091

Source: Center for Urban Policy Research, Rutgers University.

### Land Conversion

In the next 25 years, the United States will convert 18.8 million acres of land to build 26.5 million new units for housing plus 26.5 billion square feet of new nonresidential space for 49.4 million new jobs. Land will be converted at a rate of approximately 0.6 acres per residential unit and 0.2 acres per 1,000 square feet of nonresidential space. This projected level of land conversion per unit is on a par with the rate during 1980 to 2000 (1, p. 195).

Almost one-quarter of this land conversion is not necessary and could be avoided through growth management measures that would neither compromise growth nor alter housing markets. Establishing the equivalent of an urban growth boundary in EAs would direct growth away from rural and undeveloped counties to the more-developed urban and suburban counties and save about 2.4 million acres. Another strategy, creating an urban service area within a county to direct development away from undeveloped areas to more developed areas, could save an additional 1.6 million acres (1, p. 197).

### Water and Sewer Infrastructure

From 2000 to 2025, traditional development or sprawl growth will require developers and local governments to install more than 45 million water and sewer laterals below ground to serve new residential and nonresidential structures. To calculate the infrastructure and associated costs, the study used a model that accounts for increases in water or sewer laterals as the density of housing development increases.

With intercounty and intracounty growth-control measures, the housing patterns would require fewer water and sewer laterals to serve the same number of residential and nonresidential occupants. The cost savings of lower tap-in fees, combined with 4.6 million fewer laterals, would generate an infrastructure savings of \$12.6 billion over the 25-year period (1, p. 222).

This estimate includes adjustments for higher infrastructure development costs per unit in more urbanized areas. Portions of these savings would accrue to local governments, developers, and housing purchasers.

### Local Road Infrastructure

The demand for additional lane-mile capacity of local roads is related to the distribution and density of population. For 2000 to 2025, under traditional or sprawl growth, the United States will spend more than \$927 billion to provide necessary road infrastructure—an additional 2.0 million lane-miles of local roads (Table 3). Managed growth would require 1.9 million lane-miles of local roads, amounting to \$817 billion in local road costs.

Overall, compact growth patterns could trim 188,300 lane-miles of local roads and \$110 billion in expenditures—that is, reductions of 9.2 percent in local lane-miles and 11.8 percent in local road costs—from what would be expected with sprawl development. Again, these savings calculations account for considerably more expensive road development in urban areas.

TABLE 3 Local Road Infrastructure Under Sprawl and Managed Growth Scenarios, for United States and for U.S. Regions, 2000–2025

Region	Total Lane-Miles Required			Total Road Cost		
	Sprawl Growth (lane miles)	Managed Growth (lane miles)	Savings (lane miles)	Sprawl Growth (\$B)	Managed Growth (\$B)	Savings (\$B)
Northeast	288,059	281,251	6,808	\$135.77	\$129.57	\$6.20
Midwest	284,164	266,614	17,550	130.76	122.15	8.61
South	885,944	806,955	78,989	376.99	338.07	38.92
West*	586,011	501,055	84,956	283.49	227.52	55.97
United States	2,044,178	1,855,875	188,303	927.01	817.31	109.70

\* Does not include Alaska.

Source: Center for Urban Policy Research, Rutgers University.

TABLE 4 Additional Daily Travel Miles in Privately Owned Vehicles and Transit Under Sprawl and Managed Growth Scenarios, for United States and for U.S. Regions, 2000–2025 (in Millions of Miles)

Region	Sprawl Growth Scenario			Managed Growth Scenario			Difference—Savings		
	POV	Transit	Total Travel	POV	Transit	Total Travel	POV	Transit	Total Travel
Northeast	87.2	1.4	88.6	81.0	1.7	82.7	6.2	-0.3	5.9
Midwest	178.1	4.6	182.7	171.5	5.2	176.7	6.6	-0.6	6.0
South	541.3	15.7	557.0	517.4	18.2	535.6	23.9	-2.5	21.4
West	386.9	13.2	400.1	367.5	16.4	383.9	19.4	-3.2	16.2
United States	1,193.5	34.9	1,228.4	1,137.4	41.5	1,178.9	56.1	-6.6	49.5

POV = privately owned vehicles.

Sources: Woods and Poole, 1998; Center for Urban Policy Research, Rutgers University.

## Local Public Services

During the period 2000 to 2025, under traditional or sprawl growth development, the nation would expend \$143.2 billion annually for public services while collecting annual revenues of \$99.4 billion. The result is a fiscal deficit of \$43.8 billion by 2025.

Under managed growth, the nation would expend \$139.2 billion annually for local public services—or \$4 billion less. The decrease is possible because managed growth places more development in developed areas—the public services may be more expensive but offer excess capacity that can absorb the increased demand more readily.

Excess capacity is available in public service systems within urban and inner suburban jurisdictions. The \$4 billion annual decrease in costs must be paired with an aggregate annual revenue of approximately \$99.5 billion. This reduces the overall annual fiscal deficit to nearly \$40 billion by 2025 under the managed growth scenario (\$99.5 billion - \$139.2 billion = -\$39.7 billion). In 2025, the managed growth scenario, by reducing negative impacts, would yield savings of \$4.2 billion annually compared with the sprawl growth scenario (1, p. 274).

## Real Estate Development

During 2000 to 2025, under traditional or sprawl growth, individuals and businesses in the United States will spend more than \$6 trillion to develop the residential and nonresidential structures necessary to accommodate household and employment growth. More centralized growth and more compact development patterns can achieve a combined savings of \$420 billion in occupancy costs. This is a savings of more than 6 percent in overall property development investment costs (1, p. 288).

Average residential housing costs would decrease from \$167,038 to \$154,035 under the managed growth scenario, lowering the average housing cost nationwide by \$13,003, or 7.8 percent, for new housing occupants (1, p. 290).

## Travel Miles

The study developed a regression-based travel model to predict person-miles of travel as a function of urban form. The results from the regression model were paired with a population allocation model to estimate miles traveled and costs of travel under the two development alternatives.

The results show a national decrease of 49.6 million miles traveled daily and an associated decrease of \$24.1 million in daily travel costs under the managed growth scenario (Table 4). These figures include increases in the transit component of overall travel costs.

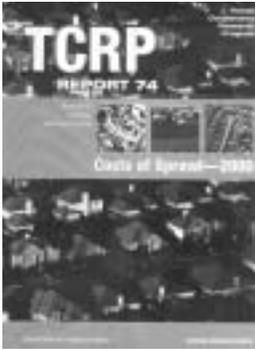
## Quality of Life

The TCRP study employed the so-called places-rated method to measure quality of life. The method involves selecting variables to distinguish places that are recognizable by survey respondents.

The analysis found that the movement of new residents to more-central locations under a managed growth regimen would not appreciably alter experienced quality of life at any level—whether county, EA, state, or region. New residents in counties, EAs, and states would not experience significant variations in quality of life as a result of the closer-in living under a managed growth regimen. Some changes in the quality of life may occur for individuals; on the whole, however, little change would occur (1, p. 364).



Local subdivision roads in a sprawled development.



TCRP Report 74: *Costs of Sprawl—2000* is available from TRB ([www.TRB.org/bookstore/](http://www.TRB.org/bookstore/)).

## Urban Decline

The *Costs of Sprawl—2000* study also explored the relationships between suburban sprawl and urban decline and concluded the following:

Three variables embodying aspects of suburban sprawl have a statistically significant relationship with greater urban decline and distress, as measured by an urban decline-distress index specifically constructed for this study: (1) greater local government fragmentation, (2) greater overall metropolitan-area residential segregation, and (3) higher ratios of the percentage of poor in cities to the percentage of poor in suburbs. These three variables are all indirectly related to the exclusionary behavior of suburban housing markets. (1, p. 438)

## Benefits of Sprawl

Working from a preliminary inventory of 13 possible benefits of sprawl (Table 5), the study examined the effects on society as a whole and on specific groups within society. The benefits were divided into four main categories: housing, transportation, land planning, and social conditions:

- ◆ The housing benefits may be summed up as larger structures and bigger lots for less money—that is, a larger share of the American dream of owning a single-family home.

- ◆ Benefits related to transportation include less congestion farther away, shorter commuting times from suburban area to suburban area, and lower overall transportation costs. Each of these benefits reflects a requirement for unlimited use of the automobile.

- ◆ For land use, a benefit is that skipped-over lands are available for development as the areas become more urbanized.

- ◆ Quality-of-life benefits include better schools and lower crime rates, as well as greater choice of community, more similarity of neighbors, and more opportunities to participate in local government.

An evaluative framework was needed to rate the importance of the 13 potential benefits. Six credibility measures were used to create a hierarchy—for example, whether the benefit was a direct result of sprawl, the overall impact and recognition of the benefit, the benefit's side effects, and whether the benefit made a positive contribution to society as a whole (Table 5).

Results showed that 3 of the 13 benefits appear to be net benefits to society as a whole: (a) making available larger average lot sizes at a distance from the center of a metropolitan area; (b) satisfying consumer preferences for low-density living; and (c) providing households with more choices of tax lev-

els and social services. Two other benefits that may fit into this category are (a) lower land and housing costs farther from a regional center and (b) increased citizen participation and influence in small, fragmented local governments. The eight other benefits included aspects that were not acknowledged by the public, not specifically related to sprawl, or not free from deleterious side effects.

## Developing Policies

To assist in formulating specific policies in response to the negative effects of sprawl, the TCRP study reviewed the literature and found that antisprawl advocates have proposed seven basic strategies (1, p. 494):

- ◆ Encourage spatially compact development.
- ◆ Reduce society's dependence on private automobiles.
- ◆ Reduce the dependence of local governments on revenues based on property values and sales taxes.
- ◆ Provide opportunities for low-income and minority households to move out of concentrated-poverty neighborhoods.
- ◆ Introduce new elements of urban design into land-use planning.
- ◆ Revitalize concentrated-poverty and other neighborhoods in inner-core areas.
- ◆ Create regional agencies to review and coordinate land-use plans drawn up by localities.

These strategies are found in state plans, state growth management acts, local studies, and compilations of best practices.

## Managing Growth

The cost of sprawl in dollars and resources is increasing. The development pattern consumes significant amounts of land and infrastructure.

Sprawl creates two sets of infrastructure, both underutilized:

- ◆ Cities and older developed suburbs, which Americans are running away from; and
- ◆ The new spreading development, which Americans never catch up with.

This dual development results in higher costs for local governments, developers, and housing consumers. Taxes are increasing in older communities because of unused capacity in the infrastructure, and taxes are increasing in sprawl locations because growth requires new systems—for example, for water and sewers.

Growth can be accommodated in another way—through development patterns that are more cen-

TABLE 5 Alleged Benefits of Sprawl as True Benefits to Society as a Whole

Benefits of Sprawl	Perceived as a Benefit by Many People	Actually Caused by Sprawl or its Traits	Appears Widespread in Regions of the U.S.	Has Serious Negative Side Effects	Perceived as a Disadvantage by Many People	Unequivocally a Net Benefit to Society as a Whole
Lower land and housing costs	Yes	Yes	Probably	No	Partly	Probably
Larger average lot size	Yes	Yes	Yes	No	No	Yes
Larger home and room sizes	Yes	Not clear	Not clear	No	No	No, occurrence unclear
Reflects low-density preferences	Yes	Yes	Yes	No	Unclear	Yes
Shorter commuting time	Probably	Not clear	Not clear	No	Yes	Not clear
Less-intensive traffic congestion	Only by a few people	Not clear	Not clear	No	Yes	No, occurrence unclear
Lower overall transport costs	No	No	No	No	Yes	No
More efficient use of infill sites	Only by a few people	Yes	Not clear	No	Yes	No, occurrence unclear
Neighborhoods with lower crime rates	Yes	Partly	Yes	Yes, exclusionary zoning	Yes	No, exclusionary zoning
Better-quality public schools	Yes	Partly	Yes	Yes, exclusionary zoning	Yes	No, exclusionary zoning
Greater consumer lifestyle choices	Yes	Yes	Yes	Yes, exclusionary zoning	Yes	Yes
More homogeneous communities	Yes	Partly	Yes	Yes, exclusionary zoning	Yes	No, exclusionary zoning
Stronger citizen participation and influence in local governments	Yes	Yes	Yes	Yes, exclusionary zoning	No	Probably

trally focused and that consume fewer resources—in other words, through compact development or managed growth. Managed growth allows all the same development that would take place under uncontrolled growth, but managed growth locates the development so that public services can be provided more efficiently. The result is appreciable savings in a short period of time.

Under managed growth, resources are not consumed aggressively, yet the amount of residential and nonresidential development is not altered. The study concludes that more planning or zoning at the regional level, instead of the local, may be required, with a corresponding shift in political power.

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# Livable Cities

## Will Transportation Professionals Answer the Challenge?

VUKAN R. VUCHIC

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This article derives from a presentation at the 2002 TRB Annual Meeting, "Dialogue with Vukan R. Vuchic."

Note: Point of View features opinions of contributing authors on transportation issues. The views expressed are not necessarily those of TRB or TR News. Readers are encouraged to comment in a letter to the editor on the issues and opinions presented.

The development of livable cities is a trend worldwide. In the United States, several requirements in the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and the Transportation Equity Act for the 21st Century (TEA-21) incorporated the goal of livable cities, which offer greater diversity of land use forms and activities, greater equity in travel options, and a more intensive social life.

Despite this trend, professional transportation publications in the United States convey predominantly negative attitudes toward intermodalism. A strong bias against public transportation persists. Instead of opposing the new directions that U.S. laws have introduced, the profession should take a broader view of the public interest and assume a more constructive role in creating more livable cities.

### Recent Experiences

Since the 1930s, the immediate reactions to increases in car ownership and decreases in walking and in use of transit were to widen streets and provide more parking. These responses accelerated the increases in car use and the decreases in the use of other modes, creating a phenomenon termed the "vicious circle of urban transportation" (1, 2). Cities that have followed this pattern—adding facilities to satisfy the demand for car travel—have grown into highway-dominated regions with car-dependent populations.

The need to analyze the impacts of transportation on cities came into focus in the 1960s. Studies of urban transportation were undertaken in Great Britain (3), the United States (4), and Germany (5). The German study was the most sophisticated and became the basis for a German federal law that financed creation of some of the world's highest quality transit and highway systems, as well as livable cities.

Since the 1960s, many innovations have been implemented in urban transportation policies, particularly in industrialized countries. Major points of consensus about these international experiences can be summarized as follows:



Livable cities are characterized by intermodal transportation and pedestrian-oriented central urban areas (here, in Portland, Oregon).

◆ A high density of activities is not compatible with the extensive use of private cars. A car-based city that accommodates unlimited use of private cars is inefficient and undesirable—and in large cities, unlimited car use is physically infeasible (5, 6, 7).

◆ A balanced intermodal transportation system is superior to a cars-only system for economic, social, and environmental reasons (8, 9).

◆ Diverting trips from cars requires two sets of measures: transit incentives and car disincentives (1, 10).

These developments are not theoretical only, but apply in many economically strong, attractive, and livable cities, such as Melbourne, Australia; Munich, Germany; Portland, Oregon; San Francisco, California; and Singapore. Significantly, all of these cities have excellent transit services; ample, attractive pedestrian areas; and limited parking. Cities with coordinated intermodal transportation, therefore, are feasible, achievable, and demonstrably successful.

## Modal Biases

The United States has gone to extremes in accommodating the use of private cars, often sacrificing the quality of urban life. Excessive car dependence has created serious national problems:

- ◆ In most cities, residents and visitors cannot get around—or even get a job—without owning a car. Non-car owners are second-class citizens (TEA-21, Sec. 3037).

- ◆ Downtowns and outlying activity centers have larger areas for parking and for streets than for all other activities.

- ◆ Less than 10 percent of children walk to school because many streets have no sidewalks.

- ◆ Many laws and ordinances favor travel by car instead of by transit or walking.

On the positive side, many steps have been taken toward comprehensive planning and improvements in the urban environment, such as

- ◆ Federally required formation of intermodal, regional metropolitan planning organizations;

- ◆ Ground-breaking legislation in the 1960s to control the negative environmental impacts of transportation;

- ◆ The Federal Transit Administration's major role in modernizing transit systems and promoting livable cities; and

- ◆ ISTEA, a revolutionary departure from highway-dominated policies to coordinated, intermodal transportation policies.

ISTEA and its successor, TEA-21, are generally in line with the thinking of urban transportation professionals and civic leaders in most industrialized countries. However, automobile-dominated thinking remains entrenched and causes animosity toward nonautomobile modes, primarily toward transit and pedestrians.

Supported by special single-mode interests, this opposition to intermodalism has hampered implementation of many TEA-21 requirements. This problem—particularly the obstacles to implementing federal transportation laws—is well documented (11).

A major obstacle to a balanced intermodal distribution of urban travel is the structure of automobile user costs; Figure 1 compares user costs—both fixed and out of pocket—for automobiles and transit. Typically, 85 percent of automobile user costs are fixed, with only 15 percent out-of-pocket. If parking is subsidized, car travel has lower out-of-pocket costs than transit. This cost structure stimulates the overuse of cars and increases vehicle-miles-traveled (VMT).



Light rail transit serves pedestrian and transit mall, then proceeds to high-speed railway lines throughout the city and suburbs in Karlsruhe, Germany.

Moreover, excessive driving has high social and environmental costs, which car users do not pay.

Energy consumption is another example of the dichotomy between laws and actual practices. The CAFE standards and ISTEA set the explicit goal of increasing fuel efficiency in transportation. Yet the transportation system contains many stimuli to boost fuel consumption:

- ◆ Exempt from CAFE standards, SUVs have flouted the laws aimed at decreasing fuel consumption.

- ◆ The pricing of car use defies every rule of the free market—the low marginal cost of driving and the absence of charges for social costs give users the illusion that driving is virtually free.

- ◆ Every cent of a gasoline tax increase receives intense publicity aimed at mustering public opinion against gas taxes.

Increasing the gasoline tax, however, not only generates revenues but also increases the marginal costs of driving. As a result, increasing gasoline taxes is a win-win measure. Tolls for driving into cities—in effect in Singapore; Oslo, Norway; and London—serve the same purposes as gasoline taxes.

Transportation professionals should discuss these issues more openly, to counter the lobbies that consistently work to maximize VMTs and fuel consumption.

## Opposition to Change

TRB and professional associations, such as the Institute of Transportation Engineers, have made great progress in broadening scopes to include intermodal transportation systems. However, many documents published by these organizations are in denial of this policy and oppose the changes. As a result, political leaders and legislation have progressed beyond professional thinking in the subject area of urban transportation. Open debate and a reorientation from negativism to progress are necessary for the transportation profession to regain reputation and authority.



Coordinated land use and transportation: high-rise developments indicate locations of metro stations (Toronto, Ontario, Canada).

In few areas are so many academics and other theoreticians as divorced from reality as in urban transportation. Some are extreme opponents of automobile and highway developments, but a far greater number have developed a passion against urban transit, particularly against rail.

Some have been writing since the 1960s that rail transit has no future because “it is not flexible and is a 19th century technology.” In the past 40 years, however, the number of metro systems in North America has more than doubled. Worldwide, the number of systems grew from 25 to more than 100. Moreover, dozens of cities in North America and around the world have built new light rail transit (LRT) systems.

Why have these rail systems been built? Because they are not flexible, but permanent and reliable, and convey a strong, progressive image. They help shape cities, giving car drivers options that no other mode can give. Light rail and bus semirapid transit are being developed to meet the need for higher quality transit than buses in street traffic can offer. Many new regional rail systems are attracting car drivers in low-density suburbs and serving reverse commuters from central cities.

### **Misguided Reports**

If dozens of cities select rail transit, and the mayors, business associations, and residents evaluate the rail lines as great successes, but a professor theorizes that rail transit is “19th century technology,” who is right?



Large parking garages attract automobiles and damage center city environments (above, in St. Louis, Missouri).

Any professional familiar with urban transportation around the world must be amazed when reviewing the reports published by many transportation-related organizations in the United States. For example,

◆ A 1996 World Bank publication, *Sustainable Transport: Priorities for Policy Reform*, extensively covers planning, financing, equity, and other issues of urban transportation, including cars, transit, and nonmotorized transport, and presents specific recommendations for action (12). TRB’s report on the same topic, *Toward a Sustainable Future* (13), however, discusses transit in layman’s generalities on 2 of its 261 pages, under the heading, “Investments in Transit and *Other Nonmotorized Modes of Transportation*” (emphasis added).

◆ A recent TRB report, *Making Transit Work*, finds that U.S. transit systems are less effective and attractive than European systems because of different urban development conditions (14). The report offers few critical remarks about policies on transit in the United States.

◆ In 1993 Elmer Johnson, former vice president of General Motors, led a team that produced a report, *Avoiding the Collision of Cars and Cars* (6). The report offers an excellent diagnosis of the problems caused by chronic highway congestion in cities. However, the solutions that the report advanced were nearly nonexistent—transit and other modes were hardly mentioned.

Johnson has explained that this glaring deficiency was because the project participants did not allow positive statements on transit. The participants did not include transit experts.

Reports covering major issues in transportation that are noncritical, narcissistic, and void of innovative solutions are a serious problem. The phenomenon reflects the prevailing influence of persons defending the status quo.

### **Conducting Studies**

The problem with the treatment of transit is rooted in the organization and conduct of the studies. Many persons who have extremely negative views about transit, and who lack experience in—and understanding of—transit and intermodal systems, are appointed to study committees as transit experts. In many cases, the appointees have made their negative opinions about intermodal transportation explicit through published writings.

When such a committee discusses issues, statements opposed by some members are eliminated from the report. In this way, the report presents the lowest common denominator or minimum consensus; it is cleaned of self-critical evaluations, loses the focus on major problems, and generally produces ineffective

findings and few constructive recommendations. Two other examples illustrate this pattern:

◆ The report, *In Pursuit of Speed*, was prepared at the request of the U.S. Department of Transportation, to analyze the economic feasibility of high-speed ground transportation plans (15). The sponsor did not include an examination of the national need for efficient high-speed ground transport, so that the study focused on means instead of goals. With this kind of approach, the nation never would have built the Interstate Highway System.

◆ The recent General Accounting Office report on bus rapid transit (BRT) confuses the definition of BRT, classifying bus lines with a few sections of separate lanes as rapid transit (16). Cost data for this kind of BRT are then used to criticize LRT as a more expensive mode. The report treats bus and rail systems as if both offered the same quality of service and had similar impacts—an error commonly made by laymen.

If transportation professionals are to respond to national needs and produce studies to assist political leaders in formulating policies, the studies on topics in urban transportation should be reexamined thoroughly. Consistent opponents of transit should not be considered transit experts and should not be appointed to studies intended to improve urban transportation and to meet national goals. Instead, project participants should demonstrate knowledge, real-world experience, and positive views on the subject matter, as well as the ability to analyze conditions critically and propose new solutions.

Many TRB committees cover the individual technical and planning aspects of urban transportation, but related policies are only covered for major cities. TRB should increase attention to the important area of urban transportation policies.

## Lessons from Amtrak

Interurban travel strongly affects cities—accessibility is key to a city's efficiency and competitiveness. The superiority of ground transportation over air transportation for travel up to several hundred miles has led to intensive modernization of passenger rail services in most industrialized countries.

Cities such as Paris, London, and Tokyo offer easy accessibility via many railway stations and rail links to airports. In contrast, access to New York City via John F Kennedy International Airport or to Los Angeles via Los Angeles International Airport is not efficient.

U.S. national policies have neglected passenger rail. On a per capita basis, investment in Amtrak has been many times lower than investment in national rail by virtually any other country. Congress, which never



Metro Rail greatly contributes to the quality of life in the Washington, D.C., metropolitan area.

has supported intercity passenger rail in ways comparable to those for other modes, diverted attention from the national goal to the inefficiencies of Amtrak.

Solid Amtrak ridership despite this adversity indicates a great latent demand for rail travel in many areas, from the Northeast to Florida, the Midwest, and California, as well as across the country. How have policy makers responded to the need for an efficient rail passenger system?

In 1997, influenced by the British deregulation fad, Congress produced the Amtrak Reform and Accountability Act, which required Amtrak to cover all operating costs by 2002. This self-sufficiency requirement was illogical and contrary to policies for other passenger transportation modes. No such requirement applies to highway, air, or urban transportation systems—nor could these systems meet such a requirement.

The self-sufficiency requirement forces Amtrak to structure fares for maximum revenues, not to attract the maximum number of passengers. Instead of diverting passengers from congested highways and airways, Amtrak's high fares push potential rail travelers back to cars and airplanes.

The Amtrak Reform Council was appointed to oversee the needed reorganization. Holding to the unrealistic self-sufficiency goal despite the bankruptcy of the deregulated Railtrack in Great Britain, the Council produced a report with controversial recommendations.

The council's confusion failed to distinguish two tasks:

1. Defining the goal. What type of modern, efficient intercity passenger rail system does our country need, and of what size?
2. Developing the means to achieve the goal.

The council focused on the means but failed to define the goals.

## Systems View

This evaluation leads to several suggestions for actions concerning livable cities and the role of transit:

- ◆ Focus on goals, then work on means. Define the type of city desired and then determine the required intermodal composition of the city.
  - ◆ Define the goals in terms of a city's livability and sustainability.
  - ◆ Consider the characteristics of livability related to transportation, such as
    - Transportation available to all population groups;
    - Freedom of mode choice—for example, car, transit, or walking;
    - Minimal street congestion to increase economic activity and reduce environmental deterioration; and
    - Reasonable equity in mobility available in all areas.
  - ◆ Provide transportation that allows diversity of land uses and life styles.
  - ◆ Design center city and other major activity areas to be pedestrian-oriented and well served by transit, instead of dominated by freeways and parking garages.
  - ◆ Adopt a policy to provide integrated networks of sidewalks and bikeways in urbanized areas.
  - ◆ Invest in high-quality transit systems that can compete with automobile travel for many kinds of trips.

In general, the car-dependent city offers greater personal privacy—predominantly single family housing and low densities of settlement. The intermodal city offers greater diversity of land use forms and activities, greater equity in travel options, and a more intensive social life.

The two types of cities may be referred to as the *private city* and the *open city* or livable city. By most criteria, the livable city is more efficient and sustainable than the private city.

The livable city requires high-quality transit, reasonable accommodations for cars and bicycles, and good treatment of pedestrians. This is apparent from observations of livable cities in North America (for example, Boston, Massachusetts; Toronto, Ontario; and Portland) and many in Europe (Oslo; Zurich, Switzerland; Paris; and Munich) compared with such car-dependent private cities as Detroit, Michigan; Houston, Texas; and Bangkok, Thailand.

## Contributing to Livable Cities

A major problem in cities is that individuals' choice of modes often negatively affects transportation system efficiency and ultimately the livability of urban areas. Policies and system designs should provide individuals with incentives to select a socially optimal composition of transportation modes.

But could it be too late to make substantial changes? Are disincentives for car-use politically unacceptable because Americans love cars?

This defeatist attitude stems from a gross simplification of a complex problem. Examples of successful intermodal planning and the creation of livable cities clearly show that the measures necessary to balance mode use are feasible and acceptable if well planned and politically well prepared. Livable cities are needed in which people can drive cars, ride transit, and walk comfortably and safely while enjoying an attractive urban environment.

Can professionals and academics make a significant contribution toward this goal? If we broaden our views and assume positive, creative attitudes, we can. We have a moral obligation to make that contribution to society.

TRB, in its venerable tradition as an open professional society encouraging free discussion, should encourage efforts to take a stronger, leading role in planning intermodal transportation systems for the development of livable cities.

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# The Workforce Challenge

## *Recruiting, Training, and Retaining Qualified Workers for Transportation and Transit Agencies*

WALTER DIEWALD

**T**he nation's economy and the lifestyles of its citizens depend on a safe and efficient transportation system. In 2001, surface transportation comprised 8 percent of the gross domestic product and about 18 percent of average U.S. household expenditures, second only to housing.

Yet surface transportation agencies face unprecedented challenges in recruiting and retaining the workforce necessary to deliver transportation infrastructure and services effectively. The responsible and efficient operation of the nation's transportation system depends on a well-trained transportation system workforce. Successfully addressing workforce issues requires a collective effort, involving transportation agencies, the federal government, the private sector, and a range of academic institutions, as well as the transportation workforce.

### Workforce Issues

Under the auspices of the Transportation Research Board, the National Research Council of the National Academies convened the Committee on Future Surface Transportation Agency Human Resources Needs (see sidebar, page 30) to determine how public transportation agencies can reorient human resources efforts to respond to changes in organizational roles

and responsibilities in the next two decades. These agencies include state departments of transportation (DOTs) and transit agencies that deliver transportation infrastructure and services with support from private-sector contractors and consultants.

The study did not measure the shortfalls of labor force supply. Instead, the committee examined strategies and made recommendations for transportation agencies to alter human resources activities—specifically, recruitment, training, retention, and succession management—to meet emerging workforce challenges and to adjust to the labor market. The study also addressed the leadership role of the federal government in this area.

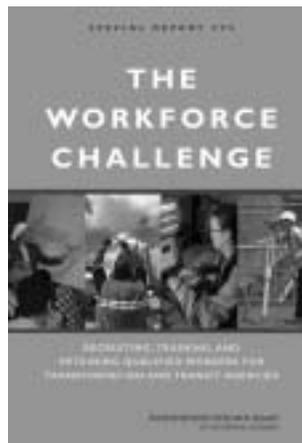
### Complexities and Constraints

Transportation workforce issues are complex. More than 50 state DOTs, nearly 6,000 transit agencies, and many other public agencies share responsibilities for transportation. In addition to unique responsibilities, each agency has its own organizational structure, history, and culture. Each must adapt to internal and external social, political, and institutional working environments, often in different ways.

Agencies vary in size and in the capabilities and resources available to address workforce needs. Few have addressed these needs comprehensively, complicating predictions of how many people will be needed in 5 or 10 years in specific job categories for each type of agency. Most individual agencies do not have the mechanisms to identify the specific skills that will be needed in the future workforce. Therefore, because the data were insufficient, the committee did not estimate specific agency needs—what kinds of workers would be needed for what kinds of jobs.

In recruiting, training, and retaining employees, agencies must adopt and adapt practices from a range of alternatives and combinations to suit circumstances. The endeavor is complex, because each agency competes for qualified staff not only with other agencies but with the private sector.

Special Report 275: *The Workforce Challenge: Recruiting, Training, and Retaining Qualified Workers for Transportation and Transit Agencies* is available from TRB ([www.TRB.org/bookstore/](http://www.TRB.org/bookstore/)).





[PHOTO CREDIT: LAUREL LEWIS]

Washington (D.C.) Metropolitan Area Transit Authority bus drivers receive training on a simulation device.

The committee therefore focused on how agencies can meet workforce needs regardless of specific or cumulative requirements. Transportation agencies—in the public and the private sector—have a history of working together to address common problems systematically and successfully. Resolving workforce needs provides an opportunity for partnering.

#### ***Expansion and Expenditures***

The committee's recommendations aim at avoiding the severe consequences of inaction that already are having an effect. Today's agencies require a workforce with a wider range of technical disciplines. State DOTs were established early in the last century to build highway networks, but some now are responsible also for airports, railroads, public transportation, ports and waterways, intermodal operations, and other ancillary functions, such as motor vehicle registration and enforcement.

The changing mission and expanding responsibilities require a workforce capable of addressing many issues beyond the scope of engineering. Transit agencies, for example, offer a variety of services and must address many community, economic, and customer concerns. All agencies face planning, environmental, and technology issues and are increasing the use of telecommunications, data management, and other information technologies.

Moreover, transportation programs are expanding at the same time that budget restrictions are limiting agency staff or requiring staff reductions. As a result,

more tasks must be contracted out, calling for personnel skilled in contract management and administration.

Another problem common to all public agencies is that senior staff are likely to retire in unprecedented numbers—more than 50 percent of the state transportation agency workforce will be eligible for retirement in the next 10 years. This is more than double the retirement eligibility rate for the nation.

Agencies are facing difficulties recruiting and retaining professional and technical staff because the highly competitive job market has created a disparity between public- and private-sector pay scales. Transit agencies, with bus and train operators comprising approximately 75 percent of the workforce, have additional problems to overcome in recruiting:

- ◆ Attracting workers to a rule-bound, seniority-based environment;
- ◆ The inability to offer the work schedule flexibility sought by job applicants and common in other industries competing for the same employees; and
- ◆ Lower pay scales and fewer opportunities for advancement in comparison with DOTs.

Within the context of greater skill needs and expanding programs, agency expenditures for training are insufficient. Benchmark studies of training investment in the private sector and federal agencies indicate that successful organizations spend an average of 2 percent of salaries on training—at least four times more than transportation agencies are spending.

## **Federal Stakes**

Any one of these issues would be a concern by itself, but taken together these issues suggest a possible crisis. Because it is responsible for strategic national interests, the federal government—Congress, the administration, and U.S. DOT and its modal administrations—has a large stake in the effectiveness of the nation's transportation workforce and has a key role in meeting the challenges.

The federal government relies on the national transportation workforce to deliver the programs and projects necessary to accomplish the economic, mobility, safety, environmental, and defense mobilization goals for transportation. As the primary steward of the nation's transportation system, the federal government is in the best position—in terms of resources, scope of interest, and influence—to take a leadership role in addressing transportation workforce issues. Without federal leadership, attempts to resolve these issues will lack strategic direction and national scope, despite the best efforts and accomplishments of individual transportation agencies and their national associations.

## **Recommendations**

The committee's recommendations aim at a range of skill needs in surface transportation agencies. The federal government, the private sector, educational institutions, unions, and employees, however, also must be involved in the solution. Opportunities abound for partnerships.

Partnering may be difficult at times, however, because of rules and regulations that require distance between public- and private-sector activities. Examples from successful partnerships and collaborations in other industries indicate that these barriers can be overcome.

The consequences of inaction include ineffective agency operations, inefficient use of limited resources, higher future costs to meet needs, and delays in introducing innovation and improvements to the transportation system. Each of the committee's recommendations aims at improving the performance of transportation agencies and, ultimately, the nation's transportation system. The recommendations reflect the goals and benchmarks of successful public- and private-sector organizations and reflect the primary goal of President Bush's 2002 Management Agenda—improving human capital.

### **Training must be a priority.**

All transportation agencies—in partnership with the federal government, the private sector, educational institutions, unions, and employees—should establish training as a priority. Training is an investment,

providing necessary knowledge, skills, and abilities. Training supports alternative paths to transportation agency careers, so that college and community college graduates from programs in business, planning, environmental science, public policy, and other areas can enter the transportation workforce.

Commitment to training is measured by investment and effectiveness. An investment goal of 2 percent of salaries for training—as suggested in benchmarking surveys of successful organizations—is appropriate for transportation agencies. This is equivalent to approximately 40 hours of training annually for each employee. Although the benchmark goal is important, the training must be effective in terms of improved performance, lower costs, and other measures.

### **More federal surface transportation program funds should be eligible for use by state and local transportation agencies for education and training.**

Although spending at all levels for the training and education of the transportation workforce should be increased, federal spending serves as a catalyst. Federal reliance on the nation's transportation workforce points to the need for federal leadership in addressing transportation workforce training.

Federal funding for transportation workforce training has several components. The largest single source of federal training funding to agencies is a discretionary program that permits states to use up to 0.5 percent of a portion of the funds from the Surface Transportation Program for education and training—approximately \$38 million. Similarly, transit agencies can use a portion of federal operating and capital investment funds for training—approximately \$32 million.

The committee supports the administration's reauthorization proposal to make more program funds eligible for use in education and training. If enacted, the proposal would yield a 200 percent increase in available discretionary funds.

Many federal transportation programs encourage the use of new methods and advanced technologies, including planning and environmental models, systems analysis, intelligent transportation systems, community involvement, and alternative-fuel transit vehicles. But these programs—which receive a total of approximately \$36 billion annually—do not support training for the people responsible for implementing, operating, and maintaining the innovations.

This lack of support acts as a barrier to wider implementation of transportation system innovations and to achieving the corresponding safety and performance improvements and cost reductions. The lack of support also hampers federal stewardship in assuring

## Committee on Future Surface Transportation Agency Human Resource Needs: Strategies for Recruiting, Training, and Retaining Personnel

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### *Liaison Representatives*

Joseph Toole, Federal Highway Administration

Timothy Klein, Research and Special Programs Administration

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that state and local governments are using national resources efficiently.

The committee supports reauthorization proposals to increase funding for federal programs that directly support education and training, including the University Transportation Centers (UTC) program; the Federal Highway Administration's National Highway Institute; the Federal Transit Administration's National Transit Institute; and the Local Technical Assistance Program (LTAP). In addition to increasing the funds for agency education and training, Congress should introduce incentives to trigger more federal funding if states and agencies invest their own funds in education and training for the transportation workforce.

Incentives should be added to the UTC program to encourage partnering with community colleges on education and training in areas for which the community colleges are well suited. A systematic evaluation of training outcomes must accompany the increased investment in training.

**U.S. DOT, in partnership with transportation agencies, the private sector, educational institutions, unions, and employees, should undertake an initiative that focuses on innovation in human resources practices, addressing recruitment, training, retention, and succession management for transportation agency personnel.**

This initiative would provide leadership and a focal point for federal, state, and local agency efforts, as

well as a basis for creating partnerships among key parties. The federal government, with its national transportation responsibilities and the human resources capabilities in U.S. DOT and its modal agencies, should take the lead in this initiative as a follow-up to the U.S. DOT-sponsored National Transportation Workforce Summit of 2002.

U.S. DOT should interact with other federal agencies that are pursuing workforce development initiatives and acquire useful information and data. The transportation workforce initiative also can build on efforts such as the Transportation Workforce Development website that the Federal Highway Administration is developing in partnership with the American Association of State Highway and Transportation Officials, documenting exemplary workforce practices at state DOTs. The initiative also can incorporate the ongoing work of the American Public Transportation Association's Workforce Development Task Force.

Including experiences from all types of transportation agencies and private-sector organizations would provide much-needed information and support. All stakeholders in the nation's workforce—agencies, academia, trainers, unions, employees, and the private sector—should participate in setting priorities and directions for the initiative. These partners should work together to compile data and information to examine the national implications of transportation workforce issues.

Transportation agencies should partner with universities, community colleges, training institutes, and LTAP centers for training and workforce development. These institutions are well organized to provide education and training and have the technical expertise to deliver the curricula, courses, and training materials to meet agency needs. Many already are doing this.

**Transportation agency leaders must make human resources management a strategic function.**

The most successful private- and public-sector organizations have raised human resources management to the strategic planning level in their organizations, because human capital is a key to successful and improved performance. Several transportation agencies have made the human resources function a strategic and equal partner with other key agency functions.

Without this organizational change, agencies will continue to fill positions in a piecemeal fashion instead of identifying future workforce needs and addressing gaps in the ability to meet those needs through a strategic human resources program.

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*The author, a Senior Program Officer in the TRB Division of Studies and Information Services, served as study director for this project.*

## TRB Meetings 2004

### January

10 Pavement Performance Data Analysis Forum  
Washington, D.C.  
*A. Robert Raab*

11–15 TRB 83rd Annual Meeting  
Washington, D.C.  
*Mark Norman, Linda Karson*

### April

13–17 5th International Conference on Case Histories in Geotechnical Engineering\*  
New York, New York  
*G. P. Jayaprakash*

14–16 8th International Level Highway–Rail Crossing Symposium\*  
Sheffield, United Kingdom

21–23 Workshop on Abandoned Underground Mines\*  
Tucson, Arizona

### May

5–8 5th International Conference on Cracking in Pavements: Risk Assessment and Prevention\*  
Limoges, France  
*Frank Lisle*

23–26 10th International Conference on Mobility and Transport for Elderly and Disabled People  
Hamamatsu, Japan  
*Claire Felbing*

26–28 8th International Conference on Applications of Advanced Technologies in Transportation\*  
Beijing, China

### June

7–9 6th International Symposium on Snow Removal and Ice Control Technology  
Spokane, Washington

27–30 North American Travel Monitoring Exposition and Conference 2004  
San Diego, California

### July

21–24 Highway Capacity and Quality of Service Committee Midyear Meeting and Conference  
State College, Pennsylvania  
*Richard Cunard*

### August

29–Sept. 1 6th National Meeting on Access Management  
Kansas City, Missouri  
*Kimberly Fisher*

### September

13–17 Structural Materials Technology: Nondestructive Evaluation–Nondestructive Tests for Highways and Bridges\*  
Niagara Falls, New York  
*Stephen Maher*

22–24 9th National Conference on Transportation Planning for Small and Medium-Sized Communities: Tools of the Trade  
Colorado Springs, Colorado  
*Kimberly Fisher*

25–29 2nd International Conference on Accelerated Pavement Testing\*  
Minneapolis, Minnesota  
*Stephen Maher*

### October

14th Equipment Management Workshop  
Minneapolis, Minnesota

19–22 2nd International Conference on Bridge Maintenance, Safety, and Management\*  
Kyoto, Japan

19–24 6th International Conference on Managing Pavements\*  
Brisbane, Queensland, Australia  
*Stephen Maher*

## 2005

### January

9–13 TRB 84th Annual Meeting  
Washington, D.C.  
*Mark Norman, Linda Karson*

### June

3rd International Symposium on Highway Geometric Design  
Chicago, Illinois

20–24 Seventh International Symposium on Utilization of High-Strength/High-Performance Concrete\*  
Washington, D.C.  
*Frederick Hejl*

### July

17–20 6th International Bridge Engineering Conference  
Boston, Massachusetts

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](http://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, or e-mail [lkarson@nas.edu](mailto:lkarson@nas.edu).

\*TRB is cosponsor of the meeting.

## Road Improvements May Not Spark Population Growth

Major road projects completed in North Carolina during the 1990s contributed only marginally to the state's overall increase in population, according to research released September by the John Locke Foundation, a nonpartisan think tank in North Carolina. The findings suggest that other factors such as preexisting density, retail development, zoning, geography, income, demographics, access to schools, and access to sewer and water services have a greater effect on promoting or preventing sprawl in an area than road construction does.

David Hartgen, a Professor of Transportation Studies at the University of North Carolina at Charlotte, conducted the study by comparing population changes in 12 commuting regions of North Carolina with the locations of major road improvements during the 1990s. His research concluded that about half of the state's population growth in the period occurred in areas that had no major road improvements during the decade.

The study notes that the "induced capacity" effect of highway expansion—the number of new drivers due to growth—is only a small percentage of the daily traffic that highway expansion accommodates. According to the research, urban and rural road widenings in several regions of the state raised population at a lower rate than the construction of a single small McDonald's restaurant does—suggesting commercial development causes more growth than road projects.

The study notes that suburban sprawl occurs when high-density urban areas are filled to capacity

and that population tends to increase near desirable locations, such as mountains or the coast. The study suggests that road investments should be made primarily to reduce travel time, operating costs, and accidents in urban areas and to improve transportation access and community mobility in rural areas rather than to spur growth.

"Officials should cautiously consider proposed changes in road funding policy that offer hope of slowing or stopping sprawl or growth since such policies are likely to be unsuccessful," writes Hartgen, a former planner and policy analyst for the New York State Department of Transportation and the Federal Highway Administration. As long as a community is an attractive place to live and generates employment opportunities, growth probably will follow—so failure to build roads to accommodate the resulting traffic only will result in more congestion, the report concludes.

*The full report, an executive summary, and a PowerPoint presentation of the results are posted at [www.johnlocke.org](http://www.johnlocke.org).*

## Nevada DOT Makes Tunnel Cleanings Safer

The Nevada Department of Transportation (DOT) cleaned the twin Carlin Tunnels along I-80 in northeast Nevada this year by shutting down each tunnel for two days instead of keeping one lane of traffic open. Under the new process, workers can complete the annual task of scrubbing the walls and replacing overhead lights without contending with traffic zooming by sometimes just inches away from the crews and the equipment.

Traffic for the closed tunnel is diverted to a bypass route, and traffic in the other tunnel is reduced to one lane to ease the crossover to regular lanes. By separating traffic from maintenance, workers also were able to install new sensors and lines for the Road Weather Information System site and to perform the annual inspection of approach bridges. The results are improved motorist and worker safety and increased efficiency and effectiveness of the maintenance operation, according to Nevada DOT officials.

*Summarized from Nevada DOT's September 2003 issue of Centerline. For further information visit [www.nevadadot.com/](http://www.nevadadot.com/).*

## Economic Downturn Affects Bay Area Commute

For the second straight year, the daily commute has improved for California residents in a nine-county region, according to the 11th survey released in October by RIDES for Bay Area Commuters. Less congestion, faster driving speeds, and shorter commutes to



Nevada DOT worker hoses down the tile walls inside the Carlin Tunnels after rotary brushes scrub off grime.

work were reported by the organization, which operates the Regional Rideshare Program under contract to the Metropolitan Transit Commission.

San Francisco–Oakland area residents who indicated their commute is “better now than it was a year ago” increased slightly to 30 percent, while 18 percent reported their commute is “worse than it was a year ago.” Commuters who indicated worse conditions dropped 7 percent from 2002, continuing a 25-percent decline in the last two years.

Nearly half of residents surveyed said their commute had improved because traffic was lighter. The survey notes that better transit operations and roadways improvements could have contributed to the lighter traffic, but a likelier cause is fewer commuters on the road due to a slower economy and fewer jobs.

The study also suggests that driving speeds increased and travel times decreased in 2003 because of less traffic. Traffic clips along at an average of 33 mph, a 3-mph increase from 2000 when the Bay Area was bustling with jobs. The average commute now takes 29 minutes, down from the 35-minute high of 2000.

Not since 1996 have so few commuters driven to work alone, the study finds. Sixty-four percent of respondents said they drove alone on a regular basis—a 5 percent drop from last year—and an increasing number of commuters said they take mass transit, walk, or telecommute. The study noted, however, that overall mass transit ridership has decreased—again pointing to the slowed economy. Carpooling remained steady at 19 percent.

As in last year’s study, commuters who drove alone said they could not find carpool partners, their work schedules required the flexibility associated with driving alone, and no practical transit options were available for their commute. One reason that moved up the list substantially, however, was that driving is “easiest and fastest,” another indicator of decreased congestion as a result of the slow economy and road improvements, the survey maintains.

For more information view the Commute Profile 2003 report at [www.511.org](http://www.511.org) (click “rideshare,” then “commute research”).

## New Light Rail Line Emphasizes Safety and Security

Last summer’s 13.7-mile expansion to the Los Angeles County metro rail provides Pasadena, California, with a train system for the first time since the 1950s. To ensure public safety, the Metropolitan Transportation Authority (MTA) conducted a proactive public campaign to educate new generations of residents about the importance of adhering to precautionary measures along the new Gold Line light rail.



The Los Angeles Metropolitan Transportation Authority is taking a proactive, innovative approach to ensure safety and security on its new Gold Line light rail.

MTA officials visited 71 area schools to teach students to be aware of approaching trains and the required stopping distances, to stay away from tracks and idle trains, and not to breach train crossing gates. MTA relied on high tech presentations to promote the rail safety message in a more effective, hands-on manner.

Interactive DVD presentations were created to help the community to recognize rail warning devices and how they function. MTA also unveiled a “Metro Experience” mobile theater, a Disneyland-style thrill ride that simulates actual train rides and demonstrates consequences of unsafe behavior. The mobile theater employs 3-D projection, wind, seat movement, and strobe lights in the 5-minute presentation.

MTA utilizes safety and security measures along the Gold Line and in transit stations. Four quadrant gates seal off key intersections when trains are crossing; vehicle detection loops embedded in the pavement automatically lift the nearest gate to allow trapped vehicles to escape; and pedestrian and swing gates close off foot traffic at most at-grade crossings.

Fiber optic signs installed on traffic signal cantilevers for the street-running portions of the line provide drivers advance warning of approaching trains. Meanwhile, Sheriff’s Department security assistants inspect fares at transit stations, providing assistance and resolving issues.



**BRIDGE OF ACHIEVEMENT**—New Jersey DOT received the 2003 National Achievement Award from the National Partnership for Highway Quality for work on a 500-ft., fixed-span bridge along US-9 over the Nacote Creek in Atlantic County. The bridge replaced a deteriorating draw-bridge built in 1922. For the first time in any project, New Jersey DOT employed such innovations as load and resistance factor design; high-performance concrete for beams and for prestressed cylinder piles to support the pier caps; nontoxic, manmade

materials for the fender system; and Vibro concrete columns that support the approach embankment walls. The construction also resolved environmental issues involving historic property, coastal wetlands, and threatened and endangered species, including the bald eagle and osprey.

### National Survey Identifies Household Travel Trends

For the first time a typical American household now has more vehicles than drivers, U.S. DOT reported in August. An average of 1.9 personal vehicles is owned or available to 1.8 drivers per household, according to the department's National Household Travel Survey (NHTS).

The survey contacted a national sample of 26,000 households in 2001 and 2002 and interviewed 60,000 individuals about the amount and purpose of their travel, the use of different travel modes, time and miles spent traveling, and the ownership of vehicles. NHTS, which expands and replaces the Nationwide Personal Transportation Survey and the American Travel Survey released in 1995, examines both daily travel and longer-distance trips. Among the findings were that

- ◆ Americans travel an average of 40 miles a day, including 35 of those miles by personal vehicle,
- ◆ About 90 percent of daily and long-distance trips are by a personal vehicle,
- ◆ 9 percent of daily trips are by walking and 2 percent by transit or school bus,
- ◆ 13 percent of long-distance trips of more than 50 miles from home are for commuting to and from work,
- ◆ 97 percent of trips of less than 300 roundtrip miles are by personal vehicle;
- ◆ Nearly 75 percent of trips of more than 2,000 roundtrip miles are by airplane,
- ◆ 57 percent of long-distance trips are taken by people who have a total household income of \$50,000 or more,
- ◆ 8 percent of U.S. households do not have a vehicle, and

◆ 17 percent of adults report that they have used public transit in the last two months.

*For further information, go to the Bureau of Transportation Statistics (BTS) website at [www.bts.gov](http://www.bts.gov).*

### B&O Railroad Museum Rebuilding

Restoration continues at B&O Railroad Museum's National Historic Landmark Roundhouse in Baltimore, Maryland, after a February 2003 snowstorm caused the lower roof to collapse. Falling debris damaged historic locomotives and railcars on display, and the museum has been closed since.

Architects, engineers, and contractors have replaced historic structural components with materials that replicate the finishes of the interior and exterior. Museum management recently learned that the remaining portions of the upper roof, including the clerestory, lantern, and cupola, do not meet the International Building Code standards and must be replaced, at a cost of an additional \$2.2 million. The projected reopening date for the museum will be announced in early 2004, according to Museum Director Courtney B. Wilson.

Plans, drawings, and permits are being finalized for a state-of-the-art facility that will enable museum staff to begin repairing historic locomotives and rolling stock severely damaged by the fallen roof. The total cost of the repairs and expansion is estimated at more than \$30 million, with approximately \$20 million covered by insurance. The board of directors and staff are raising \$10 million through support from federal, state, and city government grants; private and corporate foundation funds; and a grass-roots appeal to regional and national businesses and the general public.

*For more information visit the B&O Railroad Museum's website at [www.borail.org](http://www.borail.org).*



After February 2003 snowstorm, rubble from fallen roof surrounds Track 15 and covers historic locomotives at B&O Railroad Museum's Roadhouse. By November 2003, much of lower roof was rebuilt and interior scaffolding was put in place in preparation for clerestory reconstruction.

## INTERNATIONAL NEWS

### Canada Uses Compost To Vegetate Highway Areas

The Ontario Ministry of Transportation (MTO) in Canada is evaluating pilot projects that are using compost, rather than topsoil, to replenish subsoil and establish vegetation cover after highway construction projects. The preliminary results indicate that compost is a highly effective and environmentally friendly alternative to traditional methods of growing vegetation cover and controlling erosion.

The revegetation process normally consists of setting down over the exposed earth a new topsoil layer and hydraulically seeding the area with perennial grasses. A field trial along Highway 404 in December 2001 spread a compost and seed mix, and MTO observations indicate good initial growth of perennial grasses, quick germination and cover, moderate erosion control, and reduced weed and competitive grass growth.

A truck-mounted, computer-controlled and -calibrated pneumatic blower unit propelled the mixed compost directly and uniformly onto the soil

surface. The ministry now is monitoring approximately 30 applications of the compost technique at various road and facility sites.

The compost is formed by a high temperature bio-oxidation process converting wood, leaves, grass clippings, and other natural waste materials into a stable, nutrient-rich organic matter. The compost processing involves heating the waste up to 60°C for at least 15 days, which destroys weed seeds and pathogens that may be present in other soil additives, reducing the need for herbicides and pesticides. The compost also contains significantly more organic material than topsoil. Compost is known to improve the structural, nutrient, and biological properties of soil to which it is applied, and the density helps prevent sediment runoff and erosion. MTO also notes a key benefit to using compost is it recycles natural waste.

*Summarized from MTO's June 2003 issue of Road Talk. For further information visit <http://www.mto.gov.on.ca/english/>.*



PHOTO: NICK CLOSE, ROAD TALK, JUNE 2003

Compost seeding is pneumatically applied on median areas on Highway 404. (Published and reprinted with permission of the Ontario Ministry of Transportation.)

## PEOPLE IN TRANSPORTATION

### Researcher Honored for Efforts To Prevent Teen Alcohol Use

Mothers Against Drunk Driving (MADD) has named a new National President's Award in honor of Ralph W. Hingson, Professor of Social and Behavioral Sciences and Associate Dean for Research at the Boston University School of Public Health. The award recognizes Hingson's work to prevent alcohol-impaired driving. A member of the TRB Committee for Alcohol, Other Drugs, and Transportation, Hingson has published more than 100 articles in peer-reviewed



Ralph W. Hingson

journals. MADD credits his papers with providing scientific evidence for legislation that raised the legal drinking age to 21, lowered the illegal drunk driving limit to .08 percent blood alcohol concentration, and made it illegal for youth under 21 to drive a vehicle after consuming any measurable amount of alcohol.

The Ralph W. Hingson Research in Practice Award will be given annually to a researcher whose work supports MADD's mission. Hingson, a past MADD National Board member, received the inaugural award at the organization's 2003 national conference. Hingson provided background for a September 2003 National Academies report about effective strategies for combating underage drinking in America.

### Traffic Flow Expert Receives Research Award

Adolf May, Jr., Professor Emeritus at the University of California-Berkeley, has received the American Road and Transportation Builders Association's (ARTBA) 2003 S.S. Steinberg Award for his contributions to transportation research.

In his 45-year career as an educator and researcher, May has been a recognized leader in the design, operation, and simulation of freeways, rural highways, urban streets, and intersections. He has published more than 300 papers and reports, and is author of the textbook, *Traffic Flow Fundamentals*.



Adolf May Jr.

May has been active in TRB since the early 1950s. He has served on many committees and panels, as well as the TRB Executive Committee and the Technical Activities Council. He is an emeritus member of the Highway Capacity and Quality of Service Committee.

May served as the first director of the Chicago Area Freeway Surveillance and Control Project, a forerunner of current activities in intelligent transportation systems. In 1990, he was elected to the National Academy of Engineering in recognition of his work in traffic engineering and traffic flow. He received the Theodore M. Matson Memorial Award in 1992 and the TRB Distinguished Lectureship in 1994.

The award was named after S.S. Steinberg, the founding president of ARTBA's Research and Education Division.

## Annual Meeting Abounds in Sessions and Themes

More than 9,000 transportation professionals from around the world are expected to converge on Washington, D.C., in January for 5 days of sessions, specialty workshops, and committee meetings at the TRB 83rd Annual Meeting. In addition to the three spotlight themes of transportation infrastructure, security measures, and funding reauthorization, one-third of the 500 sessions, on January 11–15, 2004, will focus on one of the following major issues:

- ◆ Transportation safety options for the future (36 sessions);
- ◆ Balancing environmental and transportation goals (24 sessions);
- ◆ Matching transportation systems with communities—including context sensitivity, land use and sprawl, demographics, and environmental and economic impacts (23 sessions);
- ◆ Freight transportation (20 sessions);
- ◆ Future capacity—or congestion—of the transportation system (18 sessions);

- ◆ Integrating modes and institutions for a more seamless transportation system (18 sessions);
- ◆ Transportation investment decisions: art or science? (15 sessions);
- ◆ Transportation personnel shortage: outlook, implications, experiences, and actions (6 sessions); and
- ◆ Long-term options for transportation and energy (5 sessions).

Sessions are located at three hotels: Marriott Wardman Park, Omni Shoreham, and Washington Hilton. The Hilton will play host to mega sessions on Monday, January 12, when high-ranking officials from the U.S. Department of Transportation will give their perspectives on the upcoming reauthorization and future outlook for federal transportation programs. The future role of state DOTs also will be discussed.

For session details and program information, visit [www.TRB.org/meeting](http://www.TRB.org/meeting). An Interactive Preliminary Program on

## COOPERATIVE RESEARCH PROGRAMS NEWS

### From the Top Down: Fatigue Cracking in Hot-Mix Asphalt Layers

Load-associated fatigue cracking had been thought to originate in the bottom layer of hot-mix asphalt (HMA) in concrete-surfaced pavements and then spread to the surface. Recent studies have determined, however, that fatigue cracks in the wheel path also can originate on the pavement surface and then descend through the HMA layer. Penetration of water and other foreign debris can accelerate this cracking. Studies have identified some of the factors that cause top-down cracking, have provided hypotheses for cracking mechanisms, have proposed test methods for evaluating an HMA mixture's susceptibility to cracking, and have developed preliminary models for predicting the initiation and propagation of cracks. Additional research is needed, however, to evaluate and validate the hypotheses, test methods, and models and to guide pavement engineers in selecting HMA mixtures and in designing flexible pavements.

Advanced Asphalt Technologies, LLC of Sterling, Virginia, has received a \$39,556, 7-month contract [National Cooperative Highway Research Program (NCHRP) Project 1-42, FY 2003] to conduct Phase I and develop a research plan to determine

- ◆ Mechanisms that govern the initiation and propagation of top-down fatigue cracking in HMA layers,
- ◆ Methods for laboratory testing of HMA mixtures to identify the susceptibility of the surface layer to cracking,
- ◆ Significant factors associated with top-down fatigue cracking, and
- ◆ Models for predicting the initiation and propagation of top-down cracking.

Investigations will be pursued in a subsequent phase to develop guidance for dealing with top-down cracking.

For further information contact Amir N. Hanna, TRB (telephone 202-334-1892, e-mail [ahanna@nas.edu](mailto:ahanna@nas.edu)).

### Mainstreaming Riprap Design Criteria, Specifications, and Quality Control

The Federal Highway Administration, the U.S. Army Corps of Engineers, and state departments of transportation have developed or used methods for sizing riprap (rock cover) to protect bridge abutments, piers, channels, guidebanks, dams, embankments, and other structures vulnerable to erosion. Most of the methods are based on, or derive from, procedures originally presented in the 1930s. Other methods for sizing riprap are the result of empirical studies designed to protect specific structures, such as piers and abutments.

Current techniques and procedures for the design of riprap protection can be confusing and difficult to apply. A review of the literature indicates that many different techniques are used to determine the size and extent of a riprap installation. Depending on the technique used to measure riprap, the required size of stone can vary widely, because there is no consistent classification system or set of specifications. Most states have their own specifications for classifying riprap size and gradation. A consistent specification that could be used from location to location, therefore, is needed. Moreover, many of the construction practices for installing riprap are not effective, so that projects historically have suffered from poor quality control. Standard construction practices and techniques are needed to ensure proper placement and performance of riprap countermeasures.

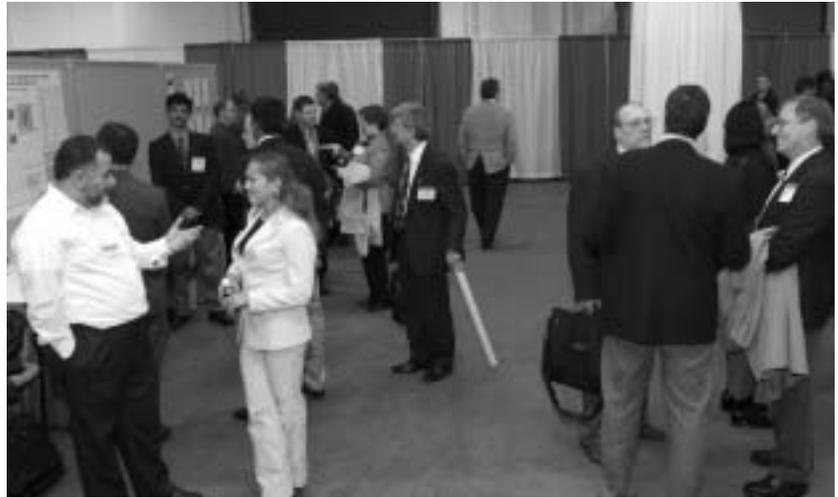
Ayres Consultants, Inc., of Fort Collins, Colorado, has been awarded a \$350,000, 30-month contract (NCHRP Project 24-23, FY 2003) to develop recommended design guidelines, material specifications, and construction inspection and quality control guidelines for riprap. Ayres anticipates that the guidelines and specifications will be used for the design and construction of riprap revetment at riverbanks, bridge piers, bridge abutments, guidebanks, and other locations requiring scour countermeasures.

For further information contact Tim Hess, TRB (telephone 202-334-2049, e-mail [timhess@nas.edu](mailto:timhess@nas.edu)).

the website allows searches of program sessions and meetings so that participants can plan a meeting itinerary. Preregistrants can view session room assignments.

## Transportation Giants Celebrate Centennials

Ford Motor Company, the American Automobile Association (AAA), motorcycle manufacturer Harley-Davidson, and the first of the state DOTs all are passing the 100-year milestone in 2004. Special events at the TRB Annual Meeting will honor the historic achievements of these groups. Consult the online Interactive Preliminary Program for more information, [www.TRB.org/meeting](http://www.TRB.org/meeting).



The TRB Annual Meeting offers opportunities for professional interaction and idea exchange; (above) a poster session at the 2003 meeting.

## Audible Signals for Pedestrian Safety Near Light Rail

Safety issues associated with motor vehicle–light rail vehicle crossings traditionally have received more attention than issues involving pedestrian–light rail vehicle conflicts, such as collisions, near misses, evasive actions, and illegal pedestrian movements. Although light rail vehicle collisions with pedestrians are fewer in number, the results are generally more severe because of pedestrian vulnerability. Compounding the problem are new generations of light rail vehicles that are quieter than previous designs. Conflicts may increase for pedestrians—particularly for those with disabilities—who are unaware of quieter oncoming light rail vehicles.



Korve Engineering, Inc., of Oakland, California, is developing a guidebook for train operators on the use of audible signals near pedestrian crossways.

Light rail systems use audible signals to alert vehicles and pedestrians to oncoming trains, but operating procedures for these signals differ from system to system. For example, some rail systems require the train operator to sound a horn or bell at each grade crossing, while other systems require the sounding of the horn or bell only if there is an immediate hazard.

Operating procedures also differ for sounding the bell on automatic warning devices at grade crossings. Some agencies sound the bell only when the warning devices are active and the gates are lowering, and then extinguish the bell when the gate reaches the horizontal position. Other agencies sound the bells at the grade crossing for the entire time that the warning devices are active, until the train has passed and the gates have fully ascended. In addition, some agencies have installed supplemental audible devices at crossings.

The use of loud and frequent audible signals, however, can lead to community pressure to reduce noise at crossings. In some instances, quiet zones have been established, increasing the concern for vehicle and pedestrian safety at crossings.

Research is needed to improve understanding of the effectiveness of various audible signals and associated operating procedures, and to provide guidance for light rail systems.

Korve Engineering, Inc., of Oakland, California, has been awarded a \$400,000, 24-month contract [Transit Cooperative Research Program (TCRP) Project D-10, FY 2003] to develop a guidebook on the use of audible signals and related operating procedures for pedestrian-crossing safety in a light rail transit environment. The research will address

- ◆ Integration of audible devices with other crossing measures—such as signage, channelization, warning and control devices—to maximize safety;
- ◆ Pedestrian crossings in various environments—for example, low-speed street running, at highway–rail grade crossings in semi-exclusive rights-of-way, and at stations;
- ◆ On-vehicle and wayside audible signals; and
- ◆ The needs of disabled individuals.

For further information contact Christopher Jenks, TRB (telephone 202-334-3089, e-mail [cjenks@nas.edu](mailto:cjenks@nas.edu)).

## Transit IDEA Expands Panel for Security Projects

The Transportation Security Administration (TSA) has joined the panel of TRB's Transit IDEA (Innovations Deserving Exploratory Analysis) program to guide projects that focus on measures to enhance transit security—a high priority since September 11, 2001. Subject matter experts, transit agency representatives, and leaders from the American Public Transportation Association and the Federal Transit Administration also collaborate on the Transit IDEA panel, which has the following three investigations under way:

- ◆ Innovative Bioterrorism Detection for Transit Security,
- ◆ Bandwidth Expansion and Real-Time Surveillance for Security on Transit Buses, and
- ◆ Counter-Terrorism Chemical Detector for Rail Transit Systems.

For more information about the project or to propose transit security or bus rapid transit projects go to [http://www4.trb.org/trb/dive.nsf/web/transit\\_idea](http://www4.trb.org/trb/dive.nsf/web/transit_idea).

## IDEA Project Helps Win Award

A past recipient of a TRB IDEA program research grant, TransTech Systems, Inc., of Schenectady, New York, received the 2003 NOVA Award for the Pavement Quality Indicator. The indicator provides quality readings during a paving job without the limitations of nuclear devices or destructive testing. The density gauge employs electrical impedance

technology originally tested through the National Cooperative Highway Research Program IDEA program. The Construction Innovation Forum presents the NOVA Award to honor innovations that improve the quality and reduce the costs of construction.

For further information read the Fall 2003 issue of *Ignition*, [http://gulliver.trb.org/publications/ignition/ignition\\_4.pdf](http://gulliver.trb.org/publications/ignition/ignition_4.pdf).



The 16-pound TransTech Systems Pavement Quality Indicator measuring density.

## COOPERATIVE RESEARCH PROGRAMS NEWS (continued)

### Developing and Sharing Transit Bus Maintenance Practices

Transit bus maintenance managers must problem-solve issues not covered by internal written procedures. Whether addressing an equipment problem, an inspection procedure, a campaign replacement, a climatological adaptation, or a routine cleaning, many managers proceed by gathering information from other transit systems and vendors to develop a maintenance practice that meets the needs of the local system. That practice then becomes the de facto norm until a better method is identified.

The results of their efforts, however, often are not shared with the rest of the transit industry. Consequently, many transit systems face the same issues and expend valuable time and resources seeking information from other transit systems or “reinventing the wheel.” Improved methods for sharing maintenance practices would greatly improve bus maintenance efficiency.

The Internet has made new tools and information sources available for developing and sharing of bus maintenance practices; yet, many transit systems are not aware of these resources. TRB and the American Public Transportation Association publish transit maintenance web boards that allow managers to compare notes and share information. Use has been increasing steadily. In addition, product manufacturers and suppliers maintain websites that provide guidance

on maintenance issues.

Potential pitfalls to some of these tools include inconsistency in the quality of information, the need to adapt the information to local conditions, warranty issues, proper citing of references, use of copyrighted materials, and legal and liability implications associated with sharing maintenance practices.

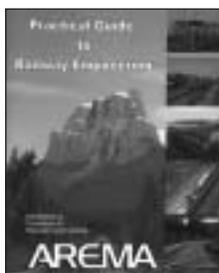
Transit Resource Center of Sacramento, California, has been awarded a \$300,000, 18-month contract (TCRP Project E-5, FY 2003) to create recommended guidelines for transit systems on how to develop and share bus maintenance practices with the rest of the transit industry. The research would not develop universal best maintenance practices, but instead provide methods to assist maintenance managers in obtaining relevant information, validating it, filling in the gaps where necessary, developing a practice most applicable to local conditions, and appropriately sharing maintenance practices with the rest of the transit industry.

The guidebook will include case studies that use the methodology to develop practices for at least six specific maintenance problem areas. The research also will include recommendations on how to improve tools for developing and sharing bus maintenance practices.

For further information contact Christopher Jenks, TRB (telephone 202-334-3089, e-mail [cjenks@nas.edu](mailto:cjenks@nas.edu)).

**Practical Guide to Railway Engineering**

Committee 24, Education and Training, American Railway Engineering and Maintenance of Way Association; Landover, Maryland: 2003; \$124.95, including a full-text CD-ROM; 572 pp.



In the United States, formal education in railway engineering is limited to a handful of universities; some of these also offer short courses for practitioners. Members of the American Railway Engineering and Maintenance of Way Association (AREMA) Committee on Education and Training have responded to the need for educational materials about railway operations and practices for individuals who are entering the specialized field of railway engineering without the formal education. This comprehensive guide was assembled by 50 volunteer railway practitioners, members of the committee, each of whom tapped extensive experience and knowledge for the task.

As the introduction states, the guide constitutes a course, "Railroad 101." The text provides detailed coverage of railroad operations, rolling stock, right-of-way

and roadbed, track design and maintenance, communications and signals, railway structures, electrification, passenger and high-speed rail, and railway environmental conditions and permitting, among other topics. The guide is intended to enhance the understanding and use of the more detailed and technical AREMA *Manual for Railway Engineering*, the definitive work in the field.

**Practice Problems for the Civil Engineering PE Exam: A Companion to the Civil Engineering Reference Manual, Ninth Edition**

Michael R. Lindeburg, Professional Publications, Inc. Belmont, California: 2003; \$164; 1-888577-96-7.



This book presents 439 problems divided among chapters that cover PE exam topics involving water resources, environmental, geotechnical, structural, and transportation. Most problems are in the same multiple choice format as the exam. Solutions assist the reader step by step through the process, providing a clear, complete explanation of how to reach the correct answers most efficiently.

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

## TRB PUBLICATIONS

**Pavement Management, Monitoring, and Accelerated Testing 2002**

**Transportation Research Record 1816**

This three-part report contains papers about pavement management, including state highway networking projects, infrastructure maintenance, and cost analysis; pavement monitoring, including trucking trends, fiber-optic traffic sensors, and long-term pavement performance models; and accelerated pavement testing, including compressive stress pulse measurements, adapting for wet base conditions, and failure mechanisms in FHWA's ultrathin whitetopping project.

2002; 155 pp.; TRB affiliates, \$36; nonaffiliates, \$48. Subscriber category: *pavement design, management, and performance (IIB)*.

**Transportation Planning and Analysis 2002**

**Transportation Research Record 1817**

This volume presents diverse transportation planning issues, from the development of the highway system in California to transportation planning for

air quality management in Delhi, India; from Internet outreach in New Jersey statewide planning and the viability of online grocers to transportation policies in Bogotá, Colombia, and highway improvement in central Kentucky.

2002; 187 pp.; TRB affiliates, \$37.50; nonaffiliates, \$50. Subscriber category: *planning and administration (IA)*.

**Highway Safety: Work Zones, Law Enforcement, Motorcycles, Trucks, Older Drivers, and Pedestrians**

**Transportation Research Record 1818**  
Under the rubric of highway safety, papers offer findings on road use behavior in Estonia, the typology of motorcycle crashes, truck crashes, the relationship between injury and fatality in aging road users, pedestrian collision prediction, and sidewalk design and accessibility for persons with disabilities.

2002; 142 pp.; TRB affiliates, \$31.50; nonaffiliates, \$42. Subscriber category: *safety and human performance (IVB)*.





***Eighth International Conference on Low-Volume Roads 2003***

**Transportation Research Record 1819, Volume 1 and 2**

This two-volume set compiles the 94 papers presented at the 8th International Conference on Low-Volume Roads in Reno, Nevada, on June 22–25, 2003. Volume 1 includes research findings on the following topics: management and planning for rural roadways in the western United States, Sweden, Scotland, Nicaragua, Botswana, and Nepal; technology transfer for innovative solutions for roads with difficult terrain and for improved erosion control; environmental effects, including fish passage, biodiversity conservation, and native vegetation; safety for low-volume rural roads and detection of unsealed surfaces; traffic and design; and maintenance for distressed pavement and gravel road management systems. Volume 2 includes papers on soil stabilization, such as testing of cement kiln dust asphalt, magnesium chloride, and calcium chloride; and studies of materials, pavements, structures, and drainage.

2002; 328 pp.; TRB affiliates, \$71.25; nonaffiliates, \$95; CD-ROM only, TRB affiliates, \$52.50; nonaffiliates, \$70; printed volumes plus CD-ROM, TRB affiliates, \$97.50; nonaffiliates, \$130. Subscriber categories: *planning and administration (IA), energy and environment (IB), design (II), materials, construction, maintenance (III), operations and safety (IV).*

***Water Transportation, Ports, and International Trade***  
**Transportation Research Record 1820**

These studies present diverse developments in water transportation and international trade at seaports in Los Angeles, California; Florida; Rotterdam, Netherlands; South America; and the three Baltic states of Estonia, Latvia, and Lithuania. Included are an evaluation of the design and operational costs of intermodal rail systems; methods to improve cost-and-quality features of barge transport; an analysis of transportation system access to port areas; the feasibility of linking routes and services between the Great Lakes, Minnesota, and Ontario, Canada; and the economic impacts of port capacity investments.

2003; 81 pp.; TRB affiliates, \$30; nonaffiliates, \$40. Subscriber category: *marine transportation (IX).*

***Additional Investigations on Driver Information Overload***

**NCHRP Report 488**

Driver information overload occurs when too much information—from either devices or conditions—

prevents proper perception and response. Drivers with information overload may make erratic maneuvers or engage in other behaviors that compromise safety. This report investigates and develops a model for predicting driver information overload from freeway signs. CRP-CD-36 incorporates the model into a software tool that identifies conditions that create information overload and that evaluates alternatives for sign locations.

2003; 107 pp.; TRB affiliates, \$16.50; nonaffiliates, \$22. Subscriber category: *safety and human performance (IVB).*

***Public Transportation Security, Volume 4: Intrusion Detection for Public Transportation Facilities Handbook***

**TCRP Report 86, Volume 4**

Volume 4 addresses the need for evaluating and upgrading intrusion detection systems applicable to a wide range of transit facilities (including tunnels, bridges, and rail yards) and transit vehicles (such as buses, trains, support vehicles, and special-purpose vehicles). The handbook guides in assessing system needs; developing system designs; and estimating system costs, benefits, and risks. Systems discussed range from low-tech to high-tech and directly support the deterrence and detection of intrusions into secure areas.

2003; 162 pp.; TRB affiliates: \$18; nonaffiliates: \$24. Subscriber categories: *public transit (VIA); planning and administration (IA).*

***Facilitating Partnerships in Transportation Research***  
**NCHRP Synthesis 312**

In today's transportation research community, no single research unit possesses every required resource in sufficient measure to operate independently or meet all of its strategic goals. Partnerships can contribute significantly by making resources more broadly available, allowing more flexibility in research performance, and providing greater opportunities for the parent organization to maximize the value of its research.

This synthesis examines current partnerships within transportation research to identify the key factors that facilitate partnerships and to present methods and approaches for producing synergies that can benefit the research programs and the participating organizations. Materials in this synthesis are designed to assist state and provincial research units to form, manage, and sustain more effective research partnerships.

2003; 76 pp.; TRB affiliates, \$12; nonaffiliates, \$16. Subscriber categories: *Planning and Administration (IA); Highway Operations, Capacity, and Traffic Control (IVA).*

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## INFORMATION FOR CONTRIBUTORS TO

# TR NEWS

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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.

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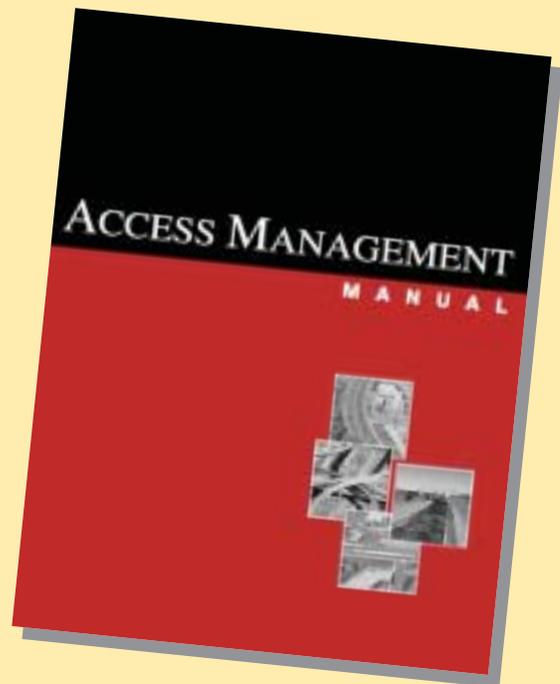
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# Safer Connections

Access management is the systematic control of the location, spacing, design, and operation of driveways, median openings, interchanges, and street connections, as well as roadway design treatments—such as medians and auxiliary lanes—and the appropriate spacing of traffic signals.

The Transportation Research Board (TRB) has examined regulations and techniques associated with access management, producing a portfolio of practical know-how to help transportation professionals, planners, decision makers, and members of the general public examine ways to improve public safety, extend the life of major roadways, reduce traffic congestion and delays, support alternative transportation modes, and improve the appearance and quality of the built environment.

Here are some of the access management titles TRB has published:



## Access Management Manual

ISBN 0-309-07747-8, 388 pages, 8.5 x 11, paperback (2003);  
also available separately in CD-ROM

New

## Impact Calculator CD-ROM: Impacts of Access Management Techniques

CRP-CD-24, Version 2.0.4 (2003)

## Driveway Regulation Practices

Synthesis of Highway Practice 304, ISBN 0-309-06921-1,  
77 pages, 8.5 x 11, paperback (2002)

## Impacts of Access Management Techniques

NCHRP Report 420, ISBN 0-309-06312-4,  
157 pages, 8.5 x 11, paperback (1999)

## Land Development Regulations That Promote Access Management

Synthesis of Highway Practice 233,  
ISBN 0-309-06003-6, 45 pages, 8.5 x 11,  
paperback (1996)

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