Trends and Issues in Transportation

TRB's 1997 Field Visit Program

Specialists in the Transportation Research Board Technical Activities Division are in a unique position to identify the current concerns and learn about the activities of the transportation community. The TRB Annual Meeting, Board-sponsored conferences and workshops, standing committees, publications, and contact with thousands of organizations and individuals provide TRB staff with information on all modes of transportation from both the public and private sectors.

A major source of such information is the annual field visit program, through which TRB staff meet on site with each state transportation department, many universities, transit and other modal agencies, and industry representatives. The objectives of the program are to (1) learn of problems facing these organizations and transmit information from state, industry, or educational institutions that can help solve those problems; (2) learn of research activities that are in progress or contemplated, and exchange information on similar research being carried out elsewhere, thus preventing duplication of efforts; (3) identify new methods and procedures that may be applicable elsewhere; (4) identify innovative or experimental work that may not be widely published, but is worthy of broader attention; (5) describe the Board's range of services to new staff at transportation agencies that support TRB; and (6) identify potential candidates for TRB committees.

Presented here are the issues, concerns, and recent program changes in transportation identified by the TRB Technical Activities Division staff as a result of this year's field visits. The time period covered is July 1, 1996–June 30, 1997, unless otherwise noted.

Last year's hopes that reauthorization of the Intermodal Surface Transportation Efficiency Act would be enacted by September 30, 1997, the end of the federal fiscal year, were just that—hopes. Despite the hard work of the administration and Congress, as well as the many affected parties, multiyear surface transportation legislation was still pending at fiscal year's end. Passage was delayed, perhaps not surprisingly, by conflicts with the balanced budget requirement, debate over allocation formulas, and a host of "special considerations."

Although the trend has been evident for the past several years, the 1997 field visits revealed increased activity within the state DOTs related to new ways of conducting business. Regardless of the term used—quality initiatives, strategic plans, business plans, partnering, or customer orientation—many states are introducing new initiatives aimed at reorienting their departments to better address current needs and demands, partly in response to the need to shift from a construction to an operations mode. The use of performance measures is a critical part of most of these initiatives, and the first section of this summary provides an overview of the states' experience with these measures to date.

Environmental issues, railroad mergers, airport funding, freight planning, demonstration of automated highway systems, transit initiatives, state DOT

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staff reductions and outsourcing, and safety concerns are among the many other subjects addressed in this summary. A central concern in all of these areas is the data required to conduct the various analyses and decision-making processes involved. With the recent sponsorship of the U.S. DOT Bureau of Transportation Statistics, TRB has been able to strengthen its data-related activities. In accordance with this new emphasis, a section addressing the data needs of state and local transportation agencies has been added to this annual summary.

Performance Measures

At the request of TRB's state representatives, a special effort was made during the 1997 field visits to determine the current status of the use of performance measures within the state DOT programs. The following is a summary based on interviews with individuals involved in the use of performance measures within the various DOT offices. More information can be found in National Cooperative Highway Research Program Synthesis 238, *Performance Measurement in State Departments of Transportation,* which includes detailed descriptions of current practice in Florida, Minnesota, Oregon, and Pennsylvania. Two other related TRB reports are NCHRP Report 357, *Measuring State Transportation Program Performance,* and Transit Cooperative Research Program Synthesis 6, *The Role of Performance-Based Measures in Allocating Funding for Transit Operations.* Ongoing research includes NCHRP Project 8-32(2), Multimodal Transportation Planning—Development of a Performance Based Planning Process.

Overview

A mix of cautious optimism and reasoned skepticism describes the general attitude of states regarding the usefulness of performance measures in improving their programs and activities. On the one hand, many states see the potential value of monitoring performance in different program areas across the state, as well as among subdivisions within the state, such as DOT districts. On the other hand, there is considerable concern regarding the use of performance measures to rank states against each other, as well as the potential use of these rankings by federal agencies to determine federal funding for individual states.

This concern is not without basis. Direct and meaningful comparisons among states are unlikely because of the inability to account for such factors as differences in climate and urbanization. Further, there remains considerable uncertainty over which factors are most relevant and whether the data needed to measure those factors are available. While these concerns also apply within a given state, expanding the comparison to a national level increases the uncertainty by an order of magnitude.

Nevertheless, nearly all states are moving toward greater use of performance measures. Yet even among the states that are fully committed to these measures as a central aspect of their management approach, most are in the early developmental phase. Perhaps the greatest current need is for sharing of information among the states, as well as from other organizations, regarding different approaches and lessons learned. This information exchange is taking place through various activities of the American Association of State Highway and Transportation Officials, TRB, U.S. DOT, and others, but a great deal remains to be done in this regard as additional states expand their performance measurement efforts. One state suggested cooperative efforts among groups of states having similar characteristics.

Why Do State DOTs Use Performance Measures?

Some state DOTs have no choice. The state legislature or the governor, often in response to or as part of a demand for greater external accountability, mandates the use of performance measures for performance-based budgeting and oversight. One state legislature requires a formal report when progress falls 5 percent or more below a target level. Often the requirements are placed on all state agencies, not just the DOT. In fact, in one state the DOT-initiated approach was used as a model for extending the use of performance measures to other state agencies. As an aside, it is worth noting that the U.S. Army Corps of Engineers based its performance measurement approach on that of the Oregon DOT. Clearly, some states are playing a leadership role in this area.

Some state DOTs started using performance measures in support of ISTEA-mandated management systems, and continue to maintain these systems—though no longer mandated—for their own purposes. The most cogent reason for using

performance measures was found among state DOTs that have implemented a comprehensive and aggressive management approach—termed a strategic plan, business plan, quality initiative, or the like—aimed at improving the department's efficiency, productivity, and image with a strong customer focus. Indeed, such efforts appear to be the driving force behind the increased attention being given to performance measures. There is often an emphasis on greater public involvement in DOT programs, as well as on partnering with other agencies and organizations. With leadership from top DOT officials, these initiatives permeate the organization, resulting in a new outlook on doing business. Some high-level managers have direct on-line access to the information systems used for these initiatives so they can personally monitor progress.

What is most impressive in these states is that performance measures are being used not so much to identify poor performance as to encourage improved performance in a nonthreatening, positive way. To illustrate, one state uses the term "critical success factor indicators" instead of "performance measures." These new initiatives are not totally successful in the states that are trying them, nor are they fully supported by all levels within the organization, nor should all states adopt the same approach. Yet these initiatives are moving the DOTs in the right direction.

What Is Needed?

To facilitate increased sharing of information on performance measures among the states, TRB staff collected the names of contact people in each state in the performance measurement area and distributed this list to all the states. Much remains to be done, however.

First, there is a need to define what items are to be measured and how. The measures need to serve multiple users, including (1) program unit staff in their monitoring of progress, (2) top-level management in their decision making and monitoring of goal attainment, (3) legislators and governors in the budgeting process, and (4) the public. Program units use the more traditional measures of physical condition, such as miles of resurfaced highway. For the other users, greater attention is being given to outcome measures that can be directly related to goals and to transportation system performance, such as aircraft on-time arrivals and departures, improved mobility, and reduced air pollution. Measures currently in use are well documented (see TRB Synthesis 238 and NCHRP Report 357, for example), but more experience in their application is needed before agreement can be reached on what is most useful in supporting state programs.

Perhaps even more important, there is a need to establish benchmarks against which performance can be measured. These benchmarks must be realistic, that is, achievable, and they must be meaningful, that is, related to decision points. Given the need for continuing reassessment and revision as experience is gained, this task of establishing benchmarks will never be completed, yet it probably represents the greatest current need with regard to advancing the process.

Who Needs To Be Involved?

The individual states and AASHTO are obviously the key players. Federal agencies, along with organizations such as TRB and the research community, also have a role in information dissemination, as well as in the conduct of research to support such needs as the identification of best-practice benchmarks and the development of process and procedural guidelines. Institutional concerns related to the use of performance measures are addressed in the next section.

Institutional Concerns

Planning

Most states and metropolitan planning organizations consider the planning elements of ISTEA a good foundation for their transportation planning activities. One of the important characteristics of planning during the past 5 years has been partnership—not only the typical public/private partnerships, but also arrangements that involve partnerships among and within governmental agencies.

A general trend among agencies is a closer linkage between planning/programming and financial strategies for plan implementation. An element of ISTEA not universally endorsed is the requirement for a plan to be financially constrained, a requirement that may reduce the plan's visionary characteristics.

Another trend to be noted is a closer link between planning and operations, such as intelligent

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transportation system activities, traffic engineering options, and demand management. This trend is a result of shifts in investment to system preservation, enhanced operational efficiency, and safety.

Still another area receiving increased attention is the incorporation of freight transportation into planning. Key elements of this increased attention include forecasting, economics, data requirements, and globalization of markets. Another important development resulting from ISTEA is the private sector's increased emphasis on activities related to intermodal and freight-oriented activities.

Environment

There are two noteworthy trends in the transportation environmental area: (1) streamlining of the environmental review process to remove redundancy and speed up decisions on approval of permits, projects, and programs, and (2) more stringent rules and enforcement by environmental agencies in the regulation of non-point-source pollution.

Streamlining of Environmental Review. In recent years, many members of the transportation community have agreed that the form and administration of some environmental rules could be simplified without causing any environmental degradation. The U.S. Environmental Protection Agency took one major step in response to these concerns with its revision of the Transportation Conformity Rule, effective September 1997. The Conformity Rule ensures that federally funded or approved transportation plans, programs, and projects do not contribute to violations of air quality standards or delay attainment of those standards. The revised rule replaces the "build/ no-build" test with a much simpler test that requires comparison of the build alternative with a previously adopted emissions budget. Many transportation planning agencies expect this action to reduce substantially the time and effort expended in modeling for the conformity requirement. Other changes include limiting of the requirement for network modeling to large urban areas, more discretion to advance previously planned nonfederal transportation projects, and more options for rural areas in demonstrating conformity.

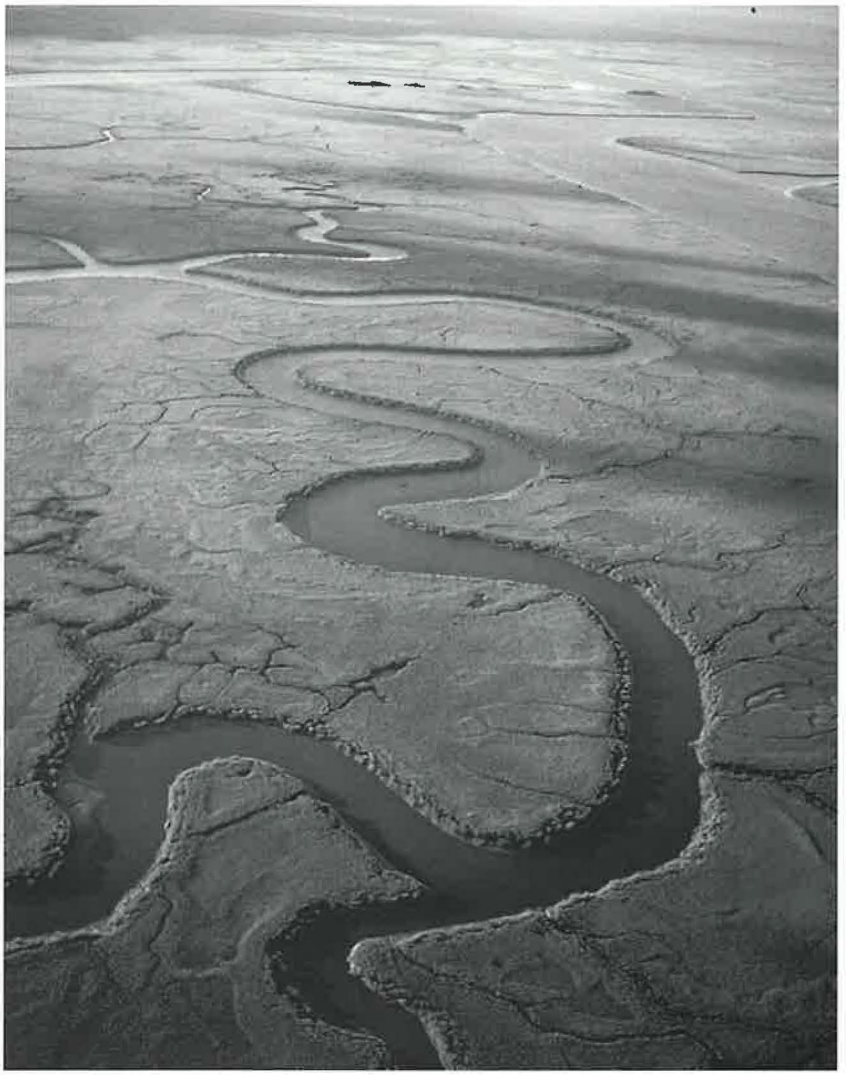
Additional simplifying actions have been taken for transportation project development. The requirements for Section 404 of the Clean Water Act have been integrated into the National Environmental Policy Act (NEPA) process. Section 404 regulates the discharge of dredged and fill material into U.S. waters, including wetlands. The federal government has developed guidance on satisfying Section 404 and NEPA requirements through an integrated process for transportation agencies seeking to implement projects. Another action is the streamlining of Section 106 of the National Historic Preservation Act for transportation enhancement projects. For many of these low-impact projects, a National Programmatic Memorandum of Agreement is increasingly being used by the states to sat-

isfy Section 106 requirements; this approach can shorten the review process considerably.

Another emerging strategy for streamlining is based on making better use of environmental data. States are increasingly developing geographic information system (GIS) databases with overlays for such environmental features as wetlands, cultural resources, and endangered species. Such tools can greatly improve and expedite project planning and development by providing detailed and graphical information on where projects can best be sited to avoid environmentally sensitive areas.

More Stringent Rules and Enforcement. This trend has emerged as the more easily achieved means of pollution prevention have been exhausted. One case of great interest to transportation operating agencies concerns the National Pollutant Discharge Elimination System (NPDES) of the Clean Water Act. In the past, with respect to stormwater, transportation agencies have been concerned with attenuating the flow to prevent flooding and damage. Increasingly, however, EPA is holding transportation agencies accountable for the *quality* of stormwater runoff. Eventually, this could lead to the costly retrofitting of mitigation structures and equipment.

As regards air quality, EPA, in response to its statutory requirement for periodic review of air quality standards, has revised the standards for ozone and particulate matter in accordance with new scientific evidence. Although the implications of the new standards are not yet fully understood, it is clear that the number of local jurisdictions in nonattainment of air quality standards will increase. To soften this impact, EPA has extended the dates by which areas are expected to achieve attainment of clean air standards. Moreover, to assist state transportation agencies, NCHRP has embarked on a study of the transportation implications of the new standards. This study is expected to be completed by September 1998.



Marshes of Glen, Georgia. Wetlands are among the environmental features that states must consider in transportation project planning and development.

Finance

The ISTEA reauthorization process highlights an ongoing debate on how to provide adequate funding for maintenance and improvement of the national transportation system while at the same time balancing the federal budget. Although these needs may not be fully reconcilable, a budgetary compromise will no doubt be achieved.

The national debate over federal funding levels obscures two major transportation funding issues. First, federal funding is a declining, minority share of total public-sector transportation funding. The large and increasing balance of public funds is provided by state and local governments. Second, current total levels of public funding for transportation do not appear to be adequate. U.S. DOT's *1995 Status of the Nation's Surface Transportation System* reports that funding from all levels of government was 25 percent below the minimum needed to maintain the current condition of the highway system. The Bureau of Transportation Statistics' *1996 Transportation Statistics Annual Report* states that in 1994, 27 percent of all highways had poor or mediocre pavement condition, 27 percent of all bridges were deficient, 20 percent of urban transit buses were overage, and 22 percent of airport runways were in fair or poor condition.

Since funding is not keeping pace even with system preservation needs, it is critical that new funding sources and mechanisms be explored. In April 1997, TRB, in cooperation with the Federal Highway Administration, the Federal Transit Administration, and the Federal Railroad Administration, sponsored a conference on Transportation Finance

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for the 21st Century to address these issues. The conference, which was attended by more than 450 representatives of government, academia, and the private sector, explored the use of financing mechanisms common to other industries, but not often applied to transportation. Topics included means of accelerating transportation projects by leveraging available federal dollars, public/private partnerships, bonding, use of advanced technology to generate new revenues, federal credit assistance, road pricing, innovative procurement strategies such as turnkey and design–build, and the federal State Infrastructure Bank (SIB) program.

The U.S. DOT SIB program allows states to use federal dollars in a bank that can make loans and employ other mechanisms to provide fiscal leverage and attract substantial private-sector investment. The original program was limited to the participation of 10 states. The program proved very popular, and in June 1997 Vice President Gore announced its expansion to include 29 additional states and pledged almost $1 billion in new funds during the next 6 years. It may be noted that one of the issues raised at the TRB finance conference was how to ensure consideration of labor and environmental interests as transportation funding is increasingly defederalized by initiatives such as the SIB program.

Human Resources and Management

There are three root causes of recent changes in transportation agency management and organization. First, organizational reinvention has been a continuing theme for most local, state, and federal governments as executives and legislators have responded to public demands for government to become more efficient and service oriented. At the same time, as suggested earlier, many transportation agencies have undergone a change in mission—from building extensive infrastructures to operating and improving increasingly congested transportation networks. Finally, funding for transportation programs has begun to shift from a simple basis of assured annual grants and fuel taxes or fare-box revenues to a more complex and less certain mix of grants, appropriated funds, user fees, debt financing, and private-sector participation.

In light of these challenges, a consensus is emerging that effective change requires the adoption of multiple strategies under the guidance of a strategic plan or vision. It is not enough to downsize by 20 percent or adopt a set of performance measures. Mission, staffing, culture, and structure all need to change in a manner that will result in a new kind of transportation organization for the 21st century.

The strategic vision being adopted by many transportation agencies, reflected in the earlier discussion of performance measures, is to become performance based: flexible, efficient, and oriented to results instead of bureaucratic and bound by rules. The approaches used to achieve performance-based change in a transportation agency are likely to include strategic planning to chart a new course and the adoption of performance measures and new budgeting systems to track progress. Staffing levels may be reduced and the workforce reshaped through training, quality initiatives, and new hiring to be top performers in a rapidly changing, high-tech environment. Market competition is introduced through outsourcing to the private sector such functions as operation of motor vehicle registration offices and design–build of rail transit lines, airport terminals, and highways. The focus of the agency is reoriented to serving the needs of customers.

As noted in the previous section, state transportation agencies are increasingly becoming performance based. At the federal level, U.S. DOT has adopted a multipronged approach for itself and each of its modal administrations: new strategic plans, performance measures and benchmarks, customer service plans, an ongoing quality initiative, and reduced staffing levels. In the overseas arena, a recent "scanning tour" sponsored by FHWA, AASHTO, and TRB introduced American transportation officials to performance-based initiatives adopted by national highway agencies in New Zealand, Australia, Sweden, and the United Kingdom. It remains to be seen whether the high levels of outsourcing of agency activities achieved in these countries will be attempted in the United States.

Transportation Data Trends and Issues

Key transportation data trends and issues were identified this year during the field visits and at a TRB Conference on Information Needs To Support State and Local Transportation Decision Making into the 21st Century, attended by 150 data experts from

state DOTs, MPOs, and federal agencies. The trends and issues thus identified include the following.

Revolution in Methodology. A technological revolution in data collection methodologies is occurring that will produce needed data more quickly, less expensively, and with less intrusion on respondents. The advent of the Internet and the increasing ease of data transfer call for greater attention to new tools such as data sharing. These tools offer opportunities in terms of speed and efficiency. At the same time, they raise new issues, such as privacy concerns.

World Trends. International economic forces have led to a new and expanded role for statistical agencies. State and local agencies need to monitor world trends in economics, demography, and technology that have implications for local policy and planning.

New Relationships. A new relationship between federal and state and local agencies is evolving. The traditional model in which the federal government establishes rules and mandates for required data collection is being replaced by relationships based on agreements about goals and shared effort. Increasingly, MPOs and state DOTs hold the same views regarding data needs, problems, and opportunities.

Interdependence. Greater definitional compatibility, statistical standards, and adequate descriptors of data quality among data sets are critical needs as data sharing increases. While state DOTs and MPOs will take advantage of technology that allows them to access one another's data, the coordination of such standardization efforts should be a centralized, nationwide effort.

Future Needs. Much work remains to be done in identifying research needs and data policy in the areas of content, methodology, and institutional responsibilities and relationships. Important areas for data policy discussion identified to date include Census 2000, highway performance monitoring systems, metropolitan air quality, ITS data, and cross-border freight statistics.

Intermodal and Modal Concerns

Intermodalism

Intermodalism, coupled with the global marketplace, continues to challenge carriers, shippers, policy makers, and planners in determining how best to realize the opportunities and meet the challenges involved. The debate over how to define intermodalism continues within the transportation industry, as well as among planners and policy makers. Efforts to evaluate whether and to what extent ISTEA has achieved its purpose are hampered not only by the issue of how to define intermodalism, but also by the lack of data with which to measure the impact of the legislation. While information systems have been developed to manage integrated logistics systems, relatively little progress has been made on developing systems to support public-sector transportation planning. Although states are no longer required to develop intermodal management systems, it may be hoped that efforts to define and establish a means of collecting the data needed to assess the level and impact of intermodalism and associated planning will continue.

Improved connectivity between modes, for both freight and passengers, is being promoted through initiatives such as joint terminal planning and operations, and coordinated information systems. Another arena in which joint or shared use of services and facilities has become increasingly important is the military, which continues to rely increasingly on commercial services and nonmilitary facilities for the movement of both personnel and supplies.

To achieve even higher levels of intermodal efficiency will require that both the public and private sectors redouble their efforts to define, fund, and share intermodal research and data needs; to make effective use of emerging technologies; and to explore opportunities for mutually beneficial partnerships. Partnership efforts must extend to the area of education and training. Intermodalism requires skills and knowledge in engineering and technology, advanced logistics and information systems, and planning and management. In November 1997, TRB, at the request of FHWA, hosted the National Conference on Intermodal Transportation Education and Training, which brought together representatives from the carrier, shipper, logistics, military, planning, and education sectors to examine education and training needs and assess current programs. Recommendations were developed on how industry and academia can work together to

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Transportation Technology Center Test Track, which is used to support Federal Railroad Administration's high-speed rail research and development program.

develop or modify education and training programs that will better meet the needs and demands of the intermodal transportation industry. In the words of Secretary of Transportation Rodney E. Slater, the goal is "...to ensure we have the transportation professionals of the 21st century...."

Rail

The health of the rail freight industry is evidenced by the fact that 1996 was the industry's tenth consecutive record-breaking year, with total traffic of more than 1.3 trillion ton-miles. Intermodal traffic volume (trailers and containers carried by rail) grew to more than 8 million units, exceeding the previous annual record set in 1994.

The Union Pacific Railroad's purchase of Southern Pacific in September 1996, closely following the Burlington Northern-Santa Fe merger, reduced the number of Class 1 railroads in the United States to five. The industry will see additional consolidation in 1998 if the joint proposal from Norfolk Southern and CSX to purchase and divide the Conrail system is approved by the Surface Transportation Board. Continuing concerns about adequate competition, quality of rail service, and safety have followed UP and BNSF since their mergers, and the critical safety and service problems that have developed at UP may impact some of the conditions of the NS/CSX purchase of Conrail.

Collaborative research among the freight railroads (working through the Association of American Railroads), FRA, and the rail supply industry has contributed to remarkable improvements in rail safety in recent years. Ongoing programs include the Heavy Axle Load Program, which aims to quantify through full-scale testing the safety and economic impacts of operating increased axle loads of up to 35 metric tons. Nearly a decade of research is demonstrating that heavier axle loads can be accommodated safely and economically with improved rail suspension-truck design.

In the face of continuing financial constraints, Amtrak's funding—and future—depend on congressional action this year. Creation of a $2.3 billion fund for Amtrak's capital needs has been tied to "reforms" that include changes in some labor provisions. A centerpiece of Amtrak's future plans is providing higher-speed service in the Northeast Corridor. Electrification of the portion of the corridor from New Haven to Boston is under way, and Amtrak has ordered new high-speed train sets for use on the portion of the corridor from Washington to Boston.

A number of state initiatives for incremental high-speed rail services are under way, for example in North Carolina, New York, California, and the Pacific Northwest (Washington, Oregon, and British Columbia). California has also established a High-Speed Rail Authority to explore funding possibilities for a true (i.e., 125 mph or higher) high-speed rail system. Florida has made a long-term financial commitment to develop a high-speed rail system and selected a franchisee to carry out the development, but additional funding is needed for this project to proceed. A number of other midwestern and southern states are analyzing and developing plans for improvements to existing intercity rail passenger services and for new services. Along with increased state interest in passenger rail as an alternative form of public investment, many of the same rail corridors are being used by freight railroads, which, as noted above, are handling record volumes of traffic. Conflicts between the schedules for freight and passenger trains are complicated by a number of factors, including liability issues, compensation for the freight railroads that own the rail lines, and capacity constraints.

Several aspects of FRA's high-speed rail research and development program are related to the safe and efficient operation of high-speed rail technology being implemented by various states and Amtrak. Major areas of focus are positive train control, new types of grade-crossing protection, and the development of higher-speed nonelectric locomotives. As part of this program, a portion of the test track at the Transportation Technology Center is being upgraded for electrification and higher speeds; initially it will be used to test Amtrak's high-speed trains before they are put into service on the Northeast Corridor.

Many states report that they are reaping economic benefits from investments in continuing rail

To accommodate projected changes in ship size and design, some ports may be required to make significant changes to the layout and equipment capabilities of existing intermodal transfer facilities.

freight services on branch lines that could not be sustained by Class 1 railroads. Nearly half of the states have invested their own funds in rail freight preservation projects in recent years. Some states are using loan programs to maximize the use of existing funds, including federal funds granted in prior years. The Class 1 railroad mergers will continue to impact regional and shortline railroads—some adversely through the loss of competitive access to more than one Class 1 carrier. Opportunities for new shortlines may occur in other areas.

Marine Transportation

While there has been some progress in integrating the marine mode into the overall transportation planning process at the federal, state, and local levels, there is still a need to increase awareness of and appreciation for the important role played by water transport in the nation's transportation system and its impact on the nation's economy. This need becomes increasingly important as ports and marine transportation face challenges on many different yet connected fronts, including technology, landside access, and the environment. Many of these issues will be discussed in greater detail in a future issue of *TR News* (scheduled for May/June 1998), which will focus on ports and waterways. These are challenges that cannot be met by the ports and waterways sector alone; they demand the attention and cooperation of other sectors as well.

Changes in ship size and design will require that some coastal ports make major physical improvements to accommodate the so-called "megaships," which are longer and wider and require a deeper draft than previous generations of vessels. Other ports may require facility improvements to accommodate so-called "fast ship" designs. Depending on the port, the next generation of vessels is likely to require changes in ship loading/unloading, cargo handling and processing, rail connections, and truck highway access. The new vessels could also have implications for the size and structure of the nation's coastal port system. New ship technology and the challenges it poses for ports and landside infrastructure were the focus of a series of

Blue Line LRT, Los Angeles. Transit operations continue to realize increasing benefits from managerial, capital equipment and facilities, and technological advances that have occurred since the 1980s.

FWHA-sponsored focus group seminars conducted throughout the United States during the past year.

The inland waterway system continues to face challenges associated with increased traffic on a system that requires major investments to improve lock capacity, as well as continued maintenance. Research initiatives are under way to assess and forecast freight capacity and demand, to examine innovative designs for lock and dam structures, to explore uses of high-performance materials, and to complete a systemwide environmental impact statement. Work is also being done to address issues associated with remediation and reuse of land along the nation's inland waterways that may have been contaminated by previous industrial uses (so-called "brownfield sites").

Contaminated sediments and the technologies for cleanup, beneficial reuse, and disposal of dredge materials remain a critical issue for all sectors of the industry. TRB will be hosting a national symposium on this topic in the spring of 1998 as a follow-on to a March 1997 National Research Council study entitled *Contaminated Sediments in Ports and Waterways: Cleanup Strategies and Technologies.*

There continue to be growth and change in the marine passenger sector, particularly in commuter and high-speed ferry operations. As fast-ferry technology evolves, there appears to be increased interest in assessing the level of demand for such service in North American markets. In the past year, there have also been efforts to establish combination passenger–freight ferry services. At the same time, conflicts regarding ferry regulation and classification remain.

As with other modes, it has become imperative within the marine sector to formulate and consider new methods of financing a broad range of capital improvements and new construction. The ports and waterways industry is seeking innovative financing methods and partnerships to ensure its future long-term viability, as well as to increase the efficiency of the entire transportation network.

Transit

There is a growing sense of revitalization this year as local transit providers attempt to solve local problems, despite the continuation of basic economic and social forces that make it difficult for transit to sustain its share of the travel market. Funding is as much a concern as ever. Existing ridership is steady, but some areas experience high turnover. Cogent, documented arguments have been developed to support the economic case for transit. Without transit, traffic congestion in major metropolitan areas would increase by as much as 47 percent (New York City metropolitan area), with a range of 16 to 20 percent in other locations. Most of the highways in these cities are already at or near high levels of congestion; thus even a slight percentage increase in

traffic could overload the system. The timing of such arguments is not accidental. ISTEA is up for renewal, and how transit will fare in this critical federal legislation is not at all certain.

Changes may also result from parallel activities—the American Public Transit Association's Mobility 21 program, TCRP New Paradigms studies, FTA's strategic plan and emphasis on access to employment—that look forward to identify future needs and opportunities. These efforts help sketch desirable future directions, including such themes as a focus on the customer, mobility management, and information technology.

Actual transit operations are benefiting increasingly from previous changes in practice and additional investments. Payoff is now accruing from managerial, capital equipment and facilities, and technological changes that have occurred since the 1980s. Management has been focusing on the customer, recognizing that in many service areas, customers do have modal choices. Fare collection is more customer oriented. In New York City, the Metropolitan Transportation Authority has announced that intermodal transfers (e.g., bus–rail) will be free. Existing rail systems (commuter and light rail) are experiencing expanded and increased ridership; other such systems are in the planning stages across the nation (Baltimore, Dallas, Denver, Portland, St. Louis, Salt Lake City, San Diego, Santa Cruz, and others). Bus systems have improved ITS capabilities, customer services, and maintenance systems. Nonfixed route services such as ridesharing, taxis, vanpools, and paratransit are increasingly viewed as essential to mobility in difficult-to-serve, low-density locations.

From an international perspective, two new (to the United States) transit approaches are being closely followed. In Curitiba, Brazil, a regional/local busway system has been created that is almost a "subway" running above ground. The system has three levels of service, modernistic "station tubes," and high ridership. The second new approach is tracksharing. In Karlsruhe, Germany (and other European cities), heavy and light rail vehicles share the same tracks. If suburban and city rail systems are interconnected, more through-train service is possible without transfers. There are also cost savings from dual-use rights of way instead of the building and operation of two separate systems. Both ideas represent attractive approaches to improving service.

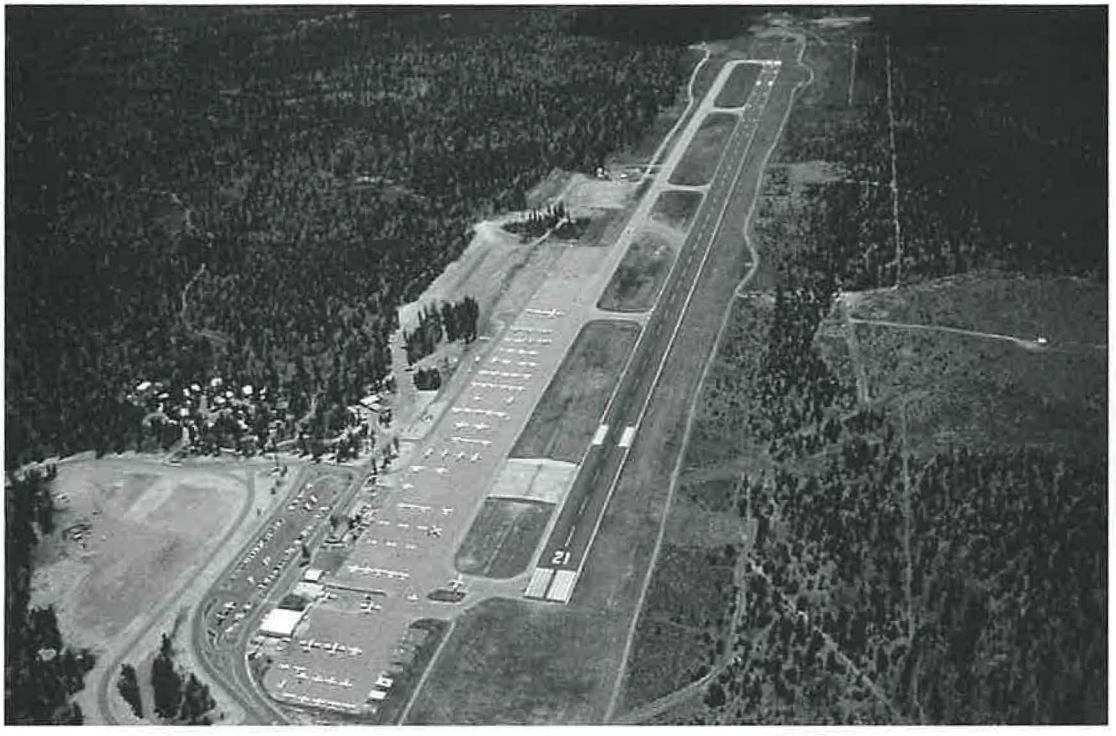
Aviation

For most of the past year, there has been considerable anxiety among state aviation planners and budgeters over federal plans proposing a 31 percent cut in Airport Improvement Program (AIP) funding—from $1.45 billion in 1997 to approximately $1 billion in 1998. Last-minute congressional action increasing the AIP to about $1.7 billion was most welcome. This addition is significant given the many examples of serious deficits. For example, one state aviation administrator exceeded his airport assistance budget by 400 percent because of critical requirements combined with recent reductions in AIP funding. There is some optimism that the increased funding will be matched by greater flexibility, such as new options for investing in preventive maintenance.

Another major concern is locating funds for what states consider to be essential but marginally self-supporting airports. It is comparatively easy for large commercial airports to attract market financing that covers their costs for maintenance and improvements. The real challenge is for the greater number of smaller airports that meet valid transportation, business, and recreational needs and serve as relievers for the larger commercial airports. Illustrating the true significance of these small airports, one state aviation official pointed out how the closing of 10 apparently marginal reliever airports would divert about 1,500 aircraft into already crowded commercial airports. It was also noted that 65 percent of general aviation operations in this state are business related, even though general aviation is not an especially popular topic among municipal and state officials.

There have been some misgivings over seemingly positive federal actions, such as the findings of the White House Commission on Aviation Safety and Security (the "Gore Commission"). In this case, recommendations were made to accelerate the advent of the new National Airspace System. Some believe that this will mean a diversion of funds, with fewer dollars remaining for state requirements. The end result could be to increase the states' aviation-related burdens as they struggle to meet rising costs for maintaining navigational aids; repairing deteriorating facilities; and complying with federal mandates on security, safety, planning, and the environment.

Without significant improvements, forecast growth during the next 12 years could be capacity constrained both at airports and within the National Airspace System. Air cargo is quickly becoming a major economic consideration, putting even more pressure on existing facilities for space and service. New large aircraft will place increased stress on both runways and support services, such as passenger holding facilities, customs, and baggage handling. The new large aircraft currently envisioned are in the 500–700 passenger category (e.g., Airbus



Grand Canyon Airport, S. Rim, Arizona. Funding for small airports that meet essential needs is a major concern for many states.

A3XX, Boeing 747-500X/600X). The infrastructure demands imposed by these new aircraft necessitate extensive coordination, planning, and investment if the required facilities are to be operational by the time these aircraft enter into service.

Looking beyond federally directed research for major programs such as the National Airspace System, there is a definite requirement for lower-cost, higher-payoff improvements in both materials and processes. Such improvements are especially important for repairing and resurfacing runways and taxiways, as well as deicing aircraft and runways, while simultaneously meeting increasingly strict environmental requirements. Research is clearly needed to identify alternative deicing and anti-icing materials that are more environmentally benign and less expensive. These needs are becoming even more apparent as both prices and problems associated with current procedures and materials increase.

Among major airlines, business continues to boom, along with extreme competition and concurrent efforts to cut costs. In contrast with earlier booms, this cycle has seen a much more disciplined response to the need for increased capacity. Regional and commuter airlines are also thriving, even after mandated safety and systemic improvement efforts designed to put them on a procedural par with the majors. Load factors and trip lengths are increasing as major airline partners transfer short/medium-haul routes to their regional affiliates. A current trend toward jets should improve service and further increase demand, continuing the drive for higher standards of service and reliability. Local communities are competing aggressively for such services.

General aviation is showing some positive signs after a long decline. The renewal began with the General Aviation Revitalization Act of 1996. However, general aviation still faces an uphill struggle, as illustrated by the fact that new flying-lesson starts have been at their lowest level since the early 1950s. Government and industry are cooperating in a broad-based effort to reinvigorate general aviation through engine, airframe, and avionics improvements; new training techniques and technologies; and lowered costs for the general aviation community. The National Aeronautics and Space Administration/Federal Aviation Administration/industry Advanced General Aviation Transport Experiment (AGATE) Program and the General Aviation Manufacturers Association's Team 2000 are two such initiatives.

Business aviation has entered its third year of modest growth in a high-pressure environment that reflects both the economy and the intensely competitive pace of business in general. Sales and operational tempos are high, with fractional ownership becoming a popular response to conflicting needs to cut costs while remaining flexible and responsive to rapidly changing customer demands. Business aviation is extremely sensitive to the allocation of user fees if that much-discussed method of revenue generation should become a reality.

TRB has actively assisted FAA and the aviation community in the search for new and better ways of meeting aviation needs. Virtually all major aviation associations, state aviation and regional planning officials, FAA, the General Accounting Office, congressional staff, financial markets, and other interested parties participated in an April TRB workshop on Airport System Capital Requirements. The workshop went beyond rationalizing the various assessments of capital needs and was a first step in trying to identify new and innovative sources of funding to meet the needs of the aviation community. The challenge is to identify realistic options for the many smaller airports that are considered vital to their communities, but cannot compete for capital market funding.

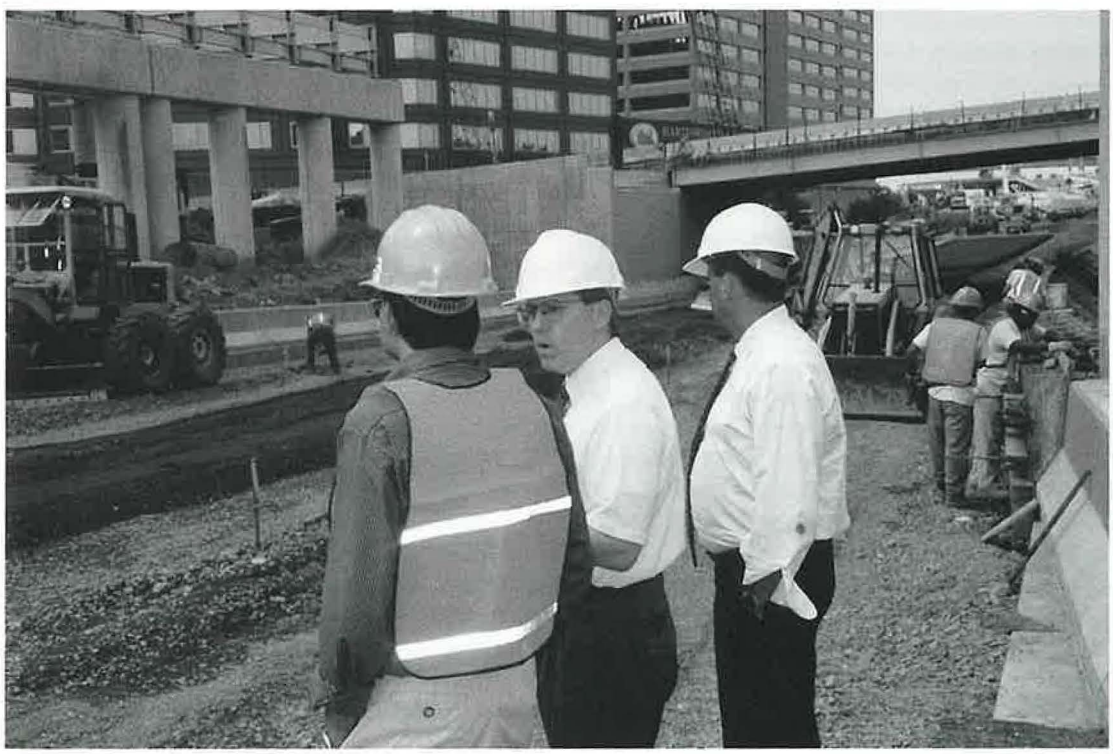
Highway Transportation

Design

An increasing percentage of design work in many highway agencies is being contracted to the private sector as a result of agency reductions in staff. In addition, regional or district offices are being given more authority and responsibility for design. Agencies are looking at organizational realignment and the use of performance measures (as discussed earlier) to better serve their clients. Information provided by management systems, such as pavement management systems and bridge management systems, has been valuable in supporting the implementation of such changes. The challenge is to integrate these systems to provide improved information for the decision-making process.

Pavement designers are moving toward the use of mechanistic principles, calibrated with empirical data from local pavements. Mechanistic design is based on the mechanical properties of the paving materials themselves, in contrast with empirical design based on formulas reflecting past performance of similar pavements. The Strategic Highway Research Program Long-Term Pavement Performance (LTPP) database and state pavement management systems provide these empirical data, not only for calibration of mechanistic formulas, but also for improved prediction of pavement performance. Emphasis remains on design for rehabilitation instead of new pavements on new alignments. There is considerable interest in NCHRP Project 1-37, Development of the 2002 Guide for the Design of New and Rehabilitated Pavement Structures, which has the objective of producing a revised AASHTO guide for pavement design by the year 2002. An area of research receiving particular attention is the rapid, automated, nondestructive testing of pavement surface condition, structural support, and thickness.

Bridge designers are using the Load and Resistance Factor Design (LRFD) Specifications developed under an NCHRP project and adopted by AASHTO's Highway Subcommittee on Bridges and Structures.



State transportation departments are seeking ways to accelerate project construction without compromising quality, and are experimenting with more durable, longer-lived materials.

Superpave® shear tester *(left)* and test specimens. State agencies are increasingly implementing the Superpave asphalt binder and mix specifications developed under the former Strategic Highway Research Program.

Computer programs facilitating the designs are becoming available and continue to be improved. Susceptibility to scour and mitigation techniques at bridge piers and foundations are other aspects of structures receiving considerable attention.

Most states are adopting metric (SI) units for plans and specifications. Efforts in this direction have been thwarted in a few states by local laws directing the agencies to continue to use English units. The metric clearinghouse at Texas Transportation Institute continues to assist and share information in this area.

Materials and Construction

Most construction projects are now focused on the rehabilitation and reconstruction of the aging infrastructure. This new focus brings challenges that did not exist in the past, when most construction projects involved new rights-of-way with minimal effect on the traveling public, construction funds were (relatively) adequate, the state construction and materials workforce was larger and more experienced, and environmental sensitivity was less evident than is the case today. These challenges are creating opportunities for innovation in materials and construction engineering. To minimize the impact on the traveling public, state transportation agencies are seeking ways of accelerating the construction of a project without compromising the quality of the work, and are experimenting with more durable materials that promise a longer life. Agencies are also continuing to address environmental issues and evaluate the use of nontraditional materials in construction.

Warranties, design–build contracts, and "A plus B" (cost plus time) bidding are contracting practices being used by some state agencies as they look for ways of dealing with the decrease in experienced personnel. Training and certification is a major issue for most materials and construction engineers as they strive to replace the experience lost as a result of retirements and layoffs. The implementation of quality control/quality assurance specifications is gaining acceptance by state highway agencies as they look for ways to use their reduced workforces more effectively.

The Superpave® asphalt binder and mix design specifications developed under SHRP are being implemented by state agencies. The asphalt binder specifications are scheduled for nationwide implementation in 1997 and the mix design specifications by 2000. High-performance concrete, another product of SHRP, is being used experimentally in bridges by a few states.

State agencies have found an environmentally safe alternative to using chlorinated solvents, banned in 1996, to determine asphalt content in asphalt pavements. In addition to the use of biodegradable solvents and a nuclear asphalt content gauge, a few states have adopted the ignition oven as their specified procedure. State transportation agencies continue to evaluate waste materials and by-products as engineering materials on their own initiative or pursuant to local concerns or legislation. Reclaimed asphalt pavement has been allowed in asphalt mixes by most states, in varying percentages, for several years. An NCHRP project is currently evaluating the incorporation of reclaimed asphalt pavement in the Superpave system.

Soils, Geology, and Foundations

Unusually wet winter and spring months in 1996–1997 caused major problems for transportation agencies in several regions of the country, including landslides and rockfalls, flooding, scour of bridge foundations, and erosion of slopes along the transportation corridors. Road closures and efforts related to investigation of affected sites and implementation of mitigative measures have cost states significant amounts of money.

The number of states developing an inventory of

Flood conditions in South Dakota, April 1997. The unusually wet spring and winter months of 1996–1997 resulted in major problems for transportation agencies in several regions of the country.

rockfall and landslide areas has increased. Such an inventory aids in the prioritization of problem sites so that limited resources can be used in the most cost-effective way. Monitoring of problem sites includes on-site visual observation and laboratory investigation of soil and rock samples for appropriate physical properties, as well as use of inclinometers and experimental installation of time-domain reflectometry to detect slope movements. A wide range of mitigative measures is being taken or considered by states, including the use of some type of drainage; pile walls; lightweight fill, such as waste tire chips and expanded polystyrene; soil or rock berm; tieback walls; soil nailing; various types of rockfall fences; and shot-in-place rock buttress.

With regard to bridge foundation scour, states are looking for help in the prediction of scour when the streambed material is cohesive or transitional between rock and soil. They also need assistance with instrumentation for measuring scour, particularly during flood stages, and with the selection and implementation of appropriate scour countermeasures.

Some states are conducting research on erosion control methods for use in highway construction areas and in routine maintenance activities, and a few states have an established approach for evaluating new products. The research addresses surface erosion, sediment transport, slope failures, and innovative mitigation measures.

Another problem is related to transportation facilities that are located over abandoned underground mines and in sinkhole-prone regions. Some states have had to close roadways that have collapsed at such locations. To address this problem, some states have taken the lead in developing a concept for an inventory that would ultimately lead to prioritization of such sites based on risk assessment. States are interested in reconnaissance methods for identifying abandoned mines and potential sinkholes and developing appropriate mitigation measures.

The reconstruction of I-15 through Salt Lake City is an intriguing project from many perspectives, including the geotechnical. During the next 4 years, about 130 bridges will be replaced under this project, providing the opportunity to use these bridges as field sites in order to (1) conduct destructive as well as nondestructive tests of foundation elements, (2) study pile behavior during seismic events, and (3) investigate settlement of embankments. Researchers interested in making use of this opportunity should contact UDOT.

Maintenance

Training of public and private employees in work zone safety requirements and procedures continues to be a high priority of transportation agencies. Increased use of truck-mounted attenuators and variable message signs was noted, along with use of public service announcements on television, stricter enforcement of doubled fines for speeding, and use of traffic-calming techniques. States are increasing their efforts to train non-DOT employees as more contract employees are exposed to work operations and traffic hazards.

As the number of DOT employees continues to

States are seeking means of sustaining traffic flow during highway maintenance and repair.

decline, agencies are increasing their use of contractors to complete needed maintenance work. Several agencies view contract maintenance as a relief valve that can free DOT employees to perform other critical maintenance functions. Some agencies are moving toward managed competition to prepare staff for competing with the private sector. Several states contract all maintenance functions on certain sections of roads, using outcome-based specifications with penalty provisions to ensure contract performance. There is an increased awareness that agencies must view privatization as a tool to assist in preserving the public's investment in the roadway infrastructure. With reductions in staff levels, there has also been increased concern regarding the ability of transportation agencies to respond adequately to emergency situations involving public safety.

Most transportation agencies have replaced underground fuel storage tanks with instrumented double-wall underground and aboveground tanks, and several are exploring the use of private fuel providers. Lead paint removal from bridge structures, worker health and safety, and waste disposal continue to be primary environmental maintenance issues. While lead paint removal remains an expensive process, lower prices have been noted with increased contractor experience. The state of the practice, along with new, innovative procedures, is summarized in NCHRP Synthesis of Highway Practice 251, *Lead-Based Paint Removal for Steel Highway Bridges* (1997).

Several organizations are developing new maintenance management systems that offer field-level data entry; field retrieval of management information; and sharing of data with other management systems, such as pavement, bridge, sign, and budget. Field-level inputs include labor, equipment, and materials, along with the physical condition of the infrastructure. The sharing of information with other management systems provides field-level managers with access to other management system databases. Several states are using pavement management system data collection procedures to gather information on such items as signs, guardrails, pavement markings, and other roadway appurtenances for use in their maintenance management systems.

A number of states noted increased emphasis on preventive maintenance programs for pavement, bridges, and culverts and pipes. Preventive maintenance remains the most cost-effective approach to maintaining the roadway infrastructure.

Quality initiatives continue to be important in maintenance operations, as elsewhere (see the earlier discussion of performance measures). Successful implementation of quality initiatives requires top management involvement and support, a clear direction for the organization, a customer focus, changes to the organizational structure and culture, a comprehensive organizationwide information system, measures to support individuals and work teams, and benchmarking of maintenance activities.

Maintenance units are continuing their efforts to introduce anti-icing technologies and procedures to reduce the use of deicing chemicals while main-

taining an acceptable level of safety. Agencies are finding that information on roadway weather conditions from roadway weather information systems and forecasts of anticipated changes in weather conditions are essential to support an effective anti-icing program. Lack of knowledge and experience in the use of these new techniques appears to contribute to the poor performance of anti-icing procedures.

Traffic Operations

The many issues facing transportation professionals today are manifested in the traffic operations arena. Increasing traffic congestion, changing driver behavior, ITS deployment, the development of automated highway systems—all of these and more continue to make traffic operations a focal point in transportation.

Many drivers, apparently frustrated with increasing traffic congestion, are becoming more aggressive in their driving behavior. The term "road rage" has emerged in the media to describe this driver attitude, which has been linked to a number of traffic fatalities. In an attempt to remedy the situation, public agencies are implementing a number of countermeasures, including enforcement targeted at the aggressive driver and roadway design modifications to calm traffic. Long used in Europe and Australia, traffic calming has recently received increased attention in the United States. Traffic calming typically refers to a variety of physical features placed on the roadway to slow drivers down and encourage safe driving behavior. Such features include speed bumps, chicanes, chokers, and small traffic circles, among others. Advocates of traffic-calming measures frequently cite the benefits of improving the safety and quality of life in nearby residential areas, while opponents are concerned about increased emergency vehicle response times, impediments to snow removal, and the potential for liability exposure.

Roundabouts are another approach used extensively elsewhere in the world that has recently generated considerable interest in the United States. Modern roundabouts have been used successfully in a number of areas around the nation as replacements for signalized intersections and diamond interchanges. When selected and designed properly, they have proven to be effective in reducing delay and improving safety.

The ITS program continues to be the major research effort in traffic operations. U.S. DOT's Intelligent Transportation Infrastructure initiative provides the foundation for the deployment and integration of the various ITS systems. For example, those ITS technologies that address traffic operations are called advanced traffic management systems. These systems integrate traffic management and control systems to facilitate dynamic traffic responsiveness. Their key feature is the integration of subsystems with real-time control adjustments to respond to traffic fluctuations. Thus, the focus of research in traffic operations is in such areas as detection technologies, traffic models, dynamic traffic assignment, real-time traffic simulation, corridor optimization techniques, rapid incident detection, congestion anticipation, and control strategy selection.

In the aftermath of the 1995 Fox River Grove, Illinois, collision involving a school bus and a train, U.S. DOT established a technical working group to review existing standards and guidelines for preemption and warning time at rail–highway grade crossings and to make recommendations for modification as appropriate. The major issues of concern were interconnection between highway and rail signals, signal preemption, vehicle storage between rail track and highway intersections, and provision of adequate clearance. The group developed 35 recommendations for improving rail–highway grade-crossing safety. The recommendations related to traffic operations included the development of (1) consistent terminology and definitions to be used by the rail and highway industry, (2) a new traffic signal warrant based on railroad preemption, and (3) guidelines for evaluating and designing safe preemption and interconnection of railroad–highway warning devices and signals.

High-occupancy toll (HOT) facilities are a new approach being considered and implemented in a number of areas. There are currently two HOT lane concepts in use. The first, which has been implemented on Route 91 in Orange County, California,

Traffic Control Center, Orange County, California, is an example of the application of intelligent transportation systems to improve traffic operations.

Many states that have developed safety management systems are reporting a variety of benefits from these systems. The most evident of those benefits is greatly improved communication and coordination among agencies at both the state and local levels.

is to allow carpools and vanpools free access to the toll facility. The other concept, which has been implemented for the I-15 HOV lanes in San Diego, California, lets drivers purchase a monthly permit that allows them to buy their way into the dedicated HOV facilities when they do not meet the HOV requirements.

TRB's *Special Report 209: Highway Capacity Manual* (HCM) is one of the most widely used documents in the transportation community. Translated into several languages, the HCM is the standard reference on which transportation analysts around the world rely for state-of-the-art methods of highway capacity and level-of-service estimation. A major update of the HCM that incorporates six revised chapters will be published in 1998. Developed through research activities funded by FHWA and AASHTO under NCHRP, these chapters contain changes in analysis procedures for signalized and unsignalized intersections, freeways, ramps, and arterial streets.

Safety

Many states that have developed safety management systems are reporting a variety of benefits from these systems. The most evident of those benefits is greatly improved communication and coordination among agencies at both the state and local levels. Elimination of redundant or overlapping activities results in both cost and workload benefits. Sharing of experiences and program results helps focus efforts on the most effective safety treatments. In some states the flow of technical and crash information has been greatly improved, so that safety decisions and efforts are more data driven. Safety management system committees in a few states are being used as expert resources by state agencies and legislatures; a good example is a report to the Iowa legislature on speed limits. Many safety professionals believe the potential value of safety management systems is just beginning to be explored and realized.

One of the concerns of state agencies and legislators with regard to using administrative license revocation (ALR) to combat crashes due to driving under the influence (DUI) is the economic impact on those who lose driving privileges. Data from several states and a National Highway Traffic Safety Administration study show that ALR does not have a major impact on DUI offenders' jobs and income. Also, there is no strong evidence favoring one form or duration of ALR over another from the point of view of minimizing economic consequences.

More and more states are finding that driving without a license and/or insurance is a growing trend, especially among motorcycle riders. This trend includes both individuals who never obtained a license and those with suspended or revoked licenses. While the numbers apparently vary considerably by state, in some cases riders/drivers with revoked or suspended licenses account for 20 percent or more of the driving population.

While alcohol-related crashes and fatalities are slowly decreasing over time as a result of various countermeasures, one group appears resistant: adult drivers aged 21–34. During the last decade there has been no reduction in the proportion of drivers in this age group with blood alcohol content higher than 0.05 or 0.10. Attention needs to be given to countermeasures for this age group, particularly repeat offenders. A review of techniques for dealing with repeat offenders is provided in TRB Circular 437, *Strategies for Dealing with the Persistent Drinking Driver.* This past year two alternative programs for repeat DUI offenders were evaluated and showed promise for reducing recidivism. A pretrial intensive-supervision probation program used in Milwaukee, Wisconsin, reduced reconviction to half the rate found in a comparison group. This program can be made self-sufficient by having offenders pay for the costs of services on a sliding scale. In a Los Angeles evaluation of an electronic monitoring program begun in 1992, reconvictions decreased by about one-third relative to a comparison group. In addition to potential crash reduction, real savings of $1 million to $2 million in jail costs were realized in Los Angeles.

The National Highway System Designation Act of 1995 rescinded the national maximum speed limit (NMSL). The NMSL was originally enacted by Congress in 1974 as an attempt to reduce fuel consumption and lessen U.S. dependency on foreign oil in response to the oil embargo of the early 1970s. As energy conservation issues faded over the years, the NMSL was retained because of its perceived safety benefits. Much has changed since 1974. Traffic congestion is greater, the driving population is older, vehicles have better safety features, use of seatbelts and child restraints is commonplace, emer-

gency medical services are much improved, and pavements are smoother and of better quality. Early data on the impacts of recision of the NMSL on traffic operations and safety have been mixed. Most states have seen slight increases in vehicle operating speeds. Some states have seen increases in traffic fatalities, while others have seen little impact on safety. However, the recision has reintroduced the need to examine speed-related issues, as well as conflicts among design speed, operating speed, speed laws, accidents, and enforcement.

State DOTs are increasing the number of highway miles with rumble strips. DOT evaluations, both published and unpublished, suggest this technique is cost-effective in reducing run-off-the-road crashes due to inattention or fatigue. In some states certain categories of roads are rumble grooved or striped as repaving (thin layer or otherwise) is performed. In response, FHWA and NHTSA are funding a TRB policy study to comprehensively review policies for establishing and enforcing speed limits.

Pedestrian and bicycle accommodation and safety are increasingly of concern during roadway planning and design. In efforts to develop sustainable highways and transportation, bicycle routes (on and off road) designed for commuting as well as for recreational use are being built. Successes in such states as Florida, Oregon, and Virginia suggest that bicycling is a viable transportation alternative for other than recreational purposes. However, traffic generators (shopping, business, recreation) must be linked to residential areas, with access perceived as secure and convenient. With the advent of ultralight hybrid bicycles (bicycles with electric generators and motors that supplement pedaling, for example on upgrades), potential commuter and other nonrecreational uses can expand.

To accommodate higher levels of average daily traffic without sacrificing safety and without the cost of going from a two- to full-four-lane facility, Minnesota DOT has developed design options for a supertwo, which includes a 10-foot shoulder that can be used as a slow-vehicle lane to allow passing, thus eliminating the need to cross the centerline into opposing traffic. Warrants for left-turn bays and use of two-way left-turn lanes in towns are included. These design options are currently being tested on the University of Minnesota Human Factors Laboratory Driving Simulator. A supertwo design is presently in operation in Sweden, and a revised supertwo design is being introduced.

Results of a TRB conference on 3D Visualization in Transportation, held in May 1997, show clearly that the cost of 3D is coming down, while the ease of use and power of the technology are increasing. At least four state DOTs are actively using 3D visualization for communications related to major projects, such as public hearings, environmental reviews, and legislative briefings. Design options can be portrayed and changed relatively easily in the 3D environment. Use of 4D (e.g., driver perspective drive-through, flyover) will allow safety analysis (e.g., sign placement, sight distances) to be performed more completely. With this technology, safety problems can be identified and eliminated before final design. The latest state transportation agency experience with 3-D and 4-D visualization technology is described in NCHRP Synthesis of Practice 229, *Applications of 3D and 4D Visualization Technology in Transportation* (1996).

Another technique being introduced in the United States to reduce safety problems before construction or reconstruction is safety audits. Safety audits are used extensively in Australia and several European countries. The current technique employs a series of checklists used by staff trained in the safety audit process. Foreign experience indicates that investing in safety audits before pouring concrete saves money by allowing design changes to be made early, instead of having to retrofit. These savings are over and above the potential savings from crashes that do not occur because design changes have been made before construction. Safety audits are equally applicable for existing roadways. Pennsylvania DOT currently has districts using safety audits on a volunteer basis. FHWA will be establishing safety audit demonstration projects in several states in the coming months.

Pedestrian and bicycle accommodation and safety are increasingly of concern during roadway planning and design.

A future development could be a marriage of 3D technology and safety audits that would allow the safety audit process to be performed on a fully visualized design. This development will be one of many features of the Interactive Highway Safety Design Model currently being developed by FHWA. This model will also have modules for design consistency, vehicle dynamics, driver performance, traffic, crash analysis (prediction), and policy review. These modules will be applied to design alternatives in a computer-aided design environment. This process clearly represents an improvement over current procedures, which usually involve a wait of 2 to 3 years while crash data accumulate before safety problems can be identified.