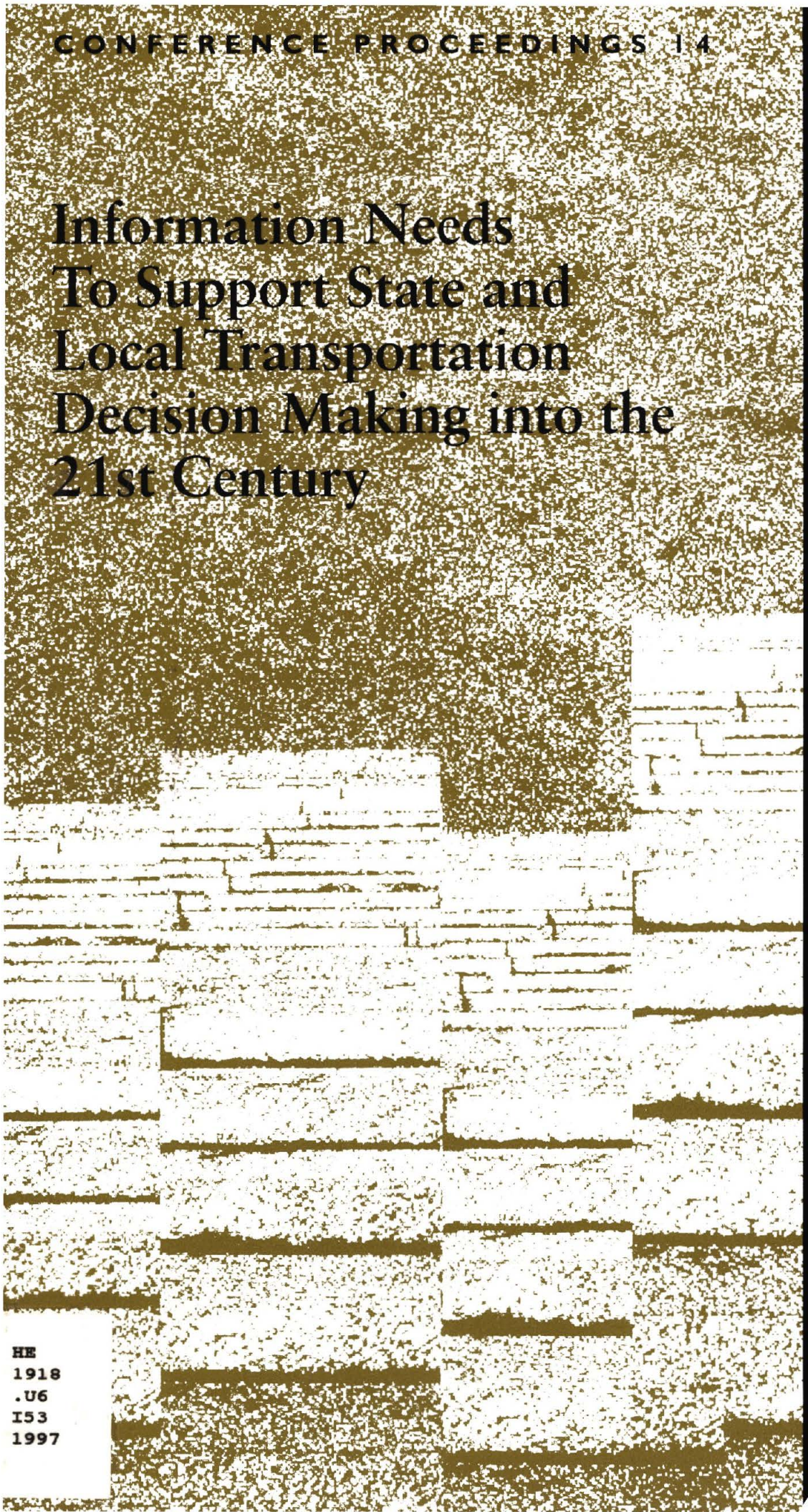
CONFERENCE PROCEEDINGS 14

Information Needs To Support State and Local Transportation Decision Making into the 21st Century



TRANSPORTATION RESEARCH BOARD

NATIONAL RESEARCH COUNCIL

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Information Needs To Support State and Local Transportation Decision Making into the 21st Century

Proceedings of a Conference
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This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

The views expressed in the presentations contained in this report are those of the authors and do not necessarily reflect the views of the committee, the Transportation Research Board, the National Research Council, or the sponsors of the conference.

The conference was sponsored by the Transportation Research Board; the Bureau of Transportation Statistics, Federal Highway Administration, and Federal Transit Administration of the U.S. Department of Transportation; the American Association of State Highway and Transportation Officials; and the Association of Metropolitan Planning Organizations.

Foreword

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) established new requirements for data development and dissemination that have had an impact on federal, state, and local transportation planning processes across the United States. As transportation professionals look ahead to the 21st century and the reauthorization of ISTEA, broadscale and rapid changes will surely challenge transportation decision making and affect future needs for data to support sound transportation planning.

The conference provided an opportunity for participants to (*a*) identify the types of data that are critical for planning and policy analysis; (*b*) identify data-collection requirements; (*c*) discuss the appropriate roles of and relationships among federal, state, and local agencies in the context of data collection and dissemination; and (*d*) review the impact of technological advances on data collection and dissemination.

Objective and Product

Participants developed recommendations regarding the data needed to improve state and local transportation decision making in the future. Among the critical information-related challenges are how to (*a*) take advantage of new data-collection and dissemination technologies; (*b*) improve data-collection efficiency with no new net burden; (*c*) produce and deliver the right information to decision makers; (*d*) effectively measure system performance; and (*e*) respond to new demands for information from the public and other organizations. A major focus of the conference was the development of findings to assist the U.S. Department of Transportation and other federal agencies in their development of new data-related activities aimed at improving transportation planning at all levels of government.

The invitation-only conference included participants from state departments of transportation (DOTs), metropolitan planning organizations (MPOs), and federal agencies providing broad representation of the transportation planning and policy communities. Significant effort was made to include a full spectrum of policy, management, and front-line

analysts who have extensive experience in answering policy questions, supporting the planning process, and responding to federal reporting requirements.

Conference Format

Working Groups

Each of the conference participants was assigned to one of six working groups. The assignments ensured that each group was geographically and institutionally diverse. Each of the six groups addressed the same set of six data issues during each of three different breakout sessions, applying a different context during each session. The groups were each led by the following moderator-facilitator teams made up of an MPO representative and a state DOT representative:

Group	*MPO*	*DOT*
A	Charles L. Purvis Metropolitan Transportation Commission	Mary Lynn Tischer Virginia
B	Ed J. Christopher Chicago Area Transportation Study	Susan Mortel Michigan
C	Ronald F. Kirby Metropolitan Washington Council of Governments	Sandy Straehl Montana
D	Howard Glassman Florida MPO Advisory Council	Jay Klagge Arizona
E	Linda Koenig Association of Central Oklahoma Governments	Larry King Pennsylvania
F	Robert Parrot San Diego Association of Governments	James Hall Illinois

Data Issues

The data issues covered and the reporters for each are as follows:

- Socioeconomic data: Michael S. Bronzini, Oak Ridge National Laboratory;
- Financial data: David L. Lewis, Hickling Corporation;
- Supply and system characteristics data: James L. Covil, Wilbur Smith Associates;
- Demand and use data: G. Bruce Douglas III, Parsons, Brinckerhoff, Quade, and Douglas, Inc.;
- System operations data: Marsha Dale Anderson, Street Smarts; and
- Impact and performance data: Timothy J. Lomax, Texas Transportation Institute.

Data Issue Contexts

- *Data content*: What information is needed to support decision making?
- *Data-collection and analytical methods*: How can the data that are needed be most effectively and efficiently collected and analyzed?
- *Institutions*: What institutional issues need to be addressed regarding the identified data needs?

Contents

Overview and Executive Summary

Alan E. Pisarski

More is expected of transportation today than ever before. Its roles and functions are directed at multitudes of social and economic goals. Local and state officials need access to increasingly diverse and complex information for transportation decisions. Yet there is greater focus on economy in current data-collection practice than ever before, and many traditional sources of transportation data, such as the decennial census and the Highway Performance Monitoring System (HPMS), are coming under close scrutiny. An immensely talented and disciplined group of transportation professionals was assembled for the Conference on Information Needs To Support State and Local Decision Making into the 21st Century to address the conundrum of how to obtain the right data for state and local decision making without adding to the data-collection burden on states and metropolitan planning organizations (MPOs). The challenge was to maintain focus on a topic that is almost unlimited in its scale and scope.

The conference was in fact the first of what will clearly need to be a series of many meetings to deal with state and MPO data needs. Many of these will be specialty conferences at which the expertise is made available to address specific subjects in great detail. Many specialty events, such as the Census 2000 conferences, the HPMS review process, the metropolitan environmental data needs conferences, and the discussions on the North American Free Trade Agreement (NAFTA) cross-border freight statistics, have already occurred and will continue in the future. This conference on state and local information needs provides a framework, a context, for those other activities. The observations and proposed directions that have resulted will provide broad guidance for priority setting at future conferences and for demarcating the boundaries of research efforts to come, establishing the agenda for state and metropolitan transportation data collection far into the next century.

First, a note is in order about the nature of "findings." Participants at this conference represented a diversity of views from data users across the transportation community. Given this broad range of perspectives, the observations and suggestions voiced at the conference were varied and sometimes even at odds. Accordingly, the findings reported in these proceedings represent a selection of the large number of observations that were aired and discussed at the event. This selection represents the conference steering committee's view of concerns and

findings that were widely held and characterized by many participants as critical. The findings are not, however, "consensus" findings or recommendations of all the participants and should not be construed as such.

The role of technology in changing how data are collected, manipulated, displayed, and disseminated will become increasingly important and dramatic in transportation data collection. Conference participants conveyed a strong sense that the transportation industry is on the cusp of a revolution in data-collection methodologies that will produce needed data faster, more inexpensively, and with less intrusion on respondents. Old methods, such as mail-out paper questionnaires, although not made completely obsolete by current technology, are thought to be largely replaceable by digital means that use electronic surveillance technologies, administrative records, and computerized instrumentation. Intelligent transportation systems (ITS) are foreseen as playing a strong role in these developments. These new tools will create new opportunities in terms of speed and efficiency and also create new issues, such as concerns about privacy and the loss of special data because of changes in technological methods. Several of these issues are treated in detail in the section on findings.

One of the key terms today in most discussions about transportation is *globalization*, which refers to the international economic forces that affect even the most local of issues and decisions. This aspect of transportation today has spawned a new or expanded role for central statistical agencies: state and local agencies need the input of an agency or agencies that monitor world trends in economics, demography, and technology and that can interpret these trends and describe their implications for local policy and planning. Groups such as the American Association of State Highway and Transportation Officials (AASHTO) and the Association of Metropolitan Planning Organizations (AMPO) will also have a role in interpreting and disseminating these trends from the perspective of their members.

Not surprisingly, the call for "more data" was heard again and again. Although this clamor can be interpreted simply as evidence of the insatiability of "data junkies," conference participants repeatedly spelled out the increasing pressure on the transportation community to support a host of societal goals while minimizing unintended consequences. Evidence of new goals—such as welfare reform and new environmental standards for particulates—arose at the conference. Each of these goals and prospective outcomes needs to be anticipated, described, forecast, measured, monitored, and reported either to meet federal, state, or local requirements or to inform constituencies, stakeholders, and investors.

Participants were nearly unanimous in their views on their relationships to the federal government. The word "partnership" was often used to describe the nature of the new role in data collection and other statistical relationships between levels of government. The traditional model, in which the federal government sets rules and mandates for required data-collection processes, was widely agreed to be outdated and no longer workable. A new future was foreseen, built on collegial agreements about goals and shared effort based on a "bottom-up" process rather than a "top-down" system. Participants recognized that achieving this vision of a new professional structure for transportation data collection will require significant effort on the part of all involved and will not be accomplished without dedication and cooperation.

Unanticipated Outcomes

The nearly uniform views among state and metropolitan officials regarding data needs, problems, and opportunities were, perhaps, a surprising outcome of the conference. The conference steering committee went to considerable pains to ensure that the separate needs of MPO and state representatives would be represented independently and that the conference would not be a zero-sum game, one in which one group could only gain at another's expense. In conference preparations the steering committee even considered an option in which state and local officials would caucus separately to consider shared issues and problems. This option was presented to the assembly, but because compelling separate needs did not exist among the participants, no interest in individualized sessions materialized.

Arguments for ending certain kinds of data collection brought forth the point that legislatively based requirements, which drive the work programs of states and metropolitan areas, specifically or implicitly mandate much of current data collection. Data are seldom collected experimentally or because the information is of the "nice to know" variety. There was much research-based data collection in the early development of the modern transportation planning process, but such data collection today is rare compared with that for operational or planning needs. Current data collection is also more limited because of the high costs of collection and the stringencies of data-collection budgets. It would be necessary to terminate the legislated mandates before the data requirements could be abolished.

Many participants voiced concerns about data budgets. Data collection takes a large share of planning and policy budgets in both states and metropolitan areas. These costs place pressure on data analysis resources as well as on other planning activities. The focus for future collection methods will be on reducing the costs and improving the speed of collection rather than on reducing the quantities of data collected. Increased efficiency in collection was recognized as the best mechanism for reducing the share of agency budgets going to data collection.

An important factor in the ability to control the scale and costs of data collection, as cited by a number of participants in different contexts, is that public policy concerns today and in the future will frequently target the needs of smaller target populations rather than the broad needs of the total population. Such groups as households without vehicles, transit or bicycle users, racial and ethnic minorities, or those on welfare will be the focus of policy and planning response. These groups are often limited in number in the population and may be difficult to access, measure, and describe with statistical quality. For example, in a survey population of 1,000 work-trip respondents, there would be about 50 transit users and about 5 bicycle users.

The advent of the Internet and the increasing ease of data transfer gave rise to much closer treatment of subjects such as data sharing. The sense of the group was that economy of effort comes about by using all sources as effectively as possible. This means ensuring, by the most effective means possible, that newly developed data are made broadly available, that others with whom data might be shared are aware of new sources, and that access to information is pervasive and effective. Coordination of data sharing was seen as a strong federal or nationally centralized responsibility.

The interest in other sources of data also emphasized more strongly than in the past the need for greater definitional compatibility among data sets and the greater need for statistical standards and adequate descriptors of data quality. Discussions and suggestions related to mechanisms for standardization of definitions, procedures, and documentation were forthcoming in several sectors. In particular, agreed-upon definitions were believed to be critical for the early development stages of ITS technologies. The upcoming era of greater data interdependence will generate new responsibility for coordination and compatibility, again identified as a centralized, nationwide role.

This quality of interdependence affected the organization of the conference findings. The findings on data content do not always concisely differentiate among the areas. Socioeconomic areas overlap those on demand and use, system operations areas overlap those on supply and system characteristics, and several categories overlap the impact and performance category. These demarcations are not critical to understanding the overall set of findings. There is a further potential for overlap between the findings on data methods and those on institutions, and the boundaries here are often unclear as well. Many of the methodological issues will require institutional innovation as well as technological innovation. As a general guide, if a problem is of a substantive nature and could be resolved by research, it is considered methodological in character; if it requires government agencies or private players to work out new arrangements for joint efforts, it is deemed to be institutional. Grey areas abound; for example, working out ways to use ITS data capabilities to meet the need for planning data will almost certainly involve a combination of methodological and institutional changes.

A welcome surprise, recognized only in retrospect after several days of serious work, was that the whole conference period was characterized by a certain buoyancy. There was a

wealth of optimism and excitement about the future and about the abilities of the transportation profession to respond to the needs that the future will bring.

Major Findings

In the following sections, the major findings of the conference, reflecting a selection of the observations presented at the event and the steering committee's ordering of major concerns expressed by participants, are presented in italics and followed in some cases by explanatory material. These findings transcend specific subject areas and have broader impacts or applications. The classification of these items may differ slightly from that in the detailed Findings section of these proceedings, which was organized for ease of reading. The findings appear in three categories based on the conference process: content, methods, and institutions.

Although overlap was inevitable, the three categories indicate a greater degree of emphasis on, respectively, the what, the how, and the who of a specific data need. Proposed approaches to methods and institutional arrangements often converged.

This overview is followed by the detailed Findings section, which contains observations from among those aired during the working sessions. Several presentations from the conference conclude these proceedings.

Content

Questions of data needs are always difficult to classify and summarize. There was an outpouring of data needs at the conference, much of which reaffirmed past needs in sometimes modified form. Those for improved collection and use of traditional data are identified as *baseline needs*. Many of the needs expressed were new and associated with developing trends or new policy concerns; these needs for collection and use of new data items are classified here as *emerging needs*.

Socioeconomic Data: Baseline Needs

Basic federal socioeconomic data continue to be necessary, including basic data-collection programs (such as the decennial census in its complete form, the Consumer Expenditure Survey, and the Commodity Flow Survey); federally sponsored state-level data collections such as employment statistics; key indicator estimation programs such as the Consumer Price Index; and compilations such as County Business Patterns.

Census data remain critical as a tool in transportation decision making. The long-form survey should be continued for 2000, and the Bureau of the Census was encouraged to solicit the input of its federal, state, and local transportation customers on instituting continuous measurement of census data elements.

The Nationwide Personal Transportation Survey (NPTS) should be structured to allow MPOs to assist in increasing sample size and adding questions for their areas. Currently, NPTS data are not available in sufficient geographic detail.

The federal government and the states could help make employment records more readily available to MPOs and, if necessary, obtain any additional data required to make site-level information available.

Socioeconomic Data: Emerging Needs

Welfare reform is expected to affect travel demand significantly, and the success of welfare reform depends in part on transportation. Data that could serve to forecast this effect are lacking. Variables such as race, income, and education should be incorporated into travel demand models and other analytical components of the transportation planning process.

Better data are needed to identify relationships between economic productivity and transportation investment.

Data on trade and tourism, including transportation characteristics such as modes used, are needed to examine the impact of international activity on states and localities. Especially needed are data on trade among the North American Free Trade Agreement (NAFTA) partners. Data on supporting infrastructure, such as international port and airport facilities and warehousing, are also needed.

Better data should be obtained on the relationship between land use and both transportation demand and investment.

Financial Data: Baseline Needs

Credible estimates of income and clear, accurate information on revenue sources should be determined for states and metropolitan areas. Forecast horizons, risk assessments, and project cost estimates should be more realistic. Past revenue forecasting problems should be documented and the investment community should be engaged in investigating how to better meet the needs of the federal, state, and local transportation agencies in this area.

Among the key inputs suggested to improve state and MPO forecasts are earlier provision of forecasts of expected financial aid from the federal government.

Financial Data: Emerging Needs

Research was suggested on the economic value of the transportation system, described as a capital stock measure at present and potential capacity and including the lease or sale value of rights-of-way.

Financial forecasting would greatly benefit from better fleet data, including the value and number of privately owned vehicles and the size and capital value of state, local, and transit authority vehicle fleets.

Unneeded Data

The area of financial data was one of the rare ones in which unneeded data were identified. The sense of those who felt burdened by reporting requirements was that data requirements on federal project forms should be streamlined. It was believed that much of what is currently called for is not needed.

Supply and System Characteristics Data: Baseline Needs

States and MPOs need a variety of data on the extent, capacity, condition, and other physical characteristics of all components of the transportation system, including links, terminals, and other supporting facilities for all modes.

The HPMS program review is a useful exercise and should be continued. The Section 15 reporting requirements for transit systems should be reviewed. On the basis of these reviews conducted in cooperation with data providers, the federal government should revise these requirements to be more responsive to state and local needs and input.

HPMS and Section 15 data have value at the local and state levels. Greater involvement of the states and MPOs, as both collectors and users of the data, would help ensure quality. The U.S. Department of Transportation (DOT) was urged to revise HPMS requirements with state, MPO, and local input and to ensure that the revisions allow use of existing state and MPO data. The MPO preference is for a bottom-up, consistent, and standardized scheme for compiling HPMS data. Privatization of HPMS and Section 15 reporting might also be feasible, and it was suggested that this possibility be researched.

Standard methods should be facilitated for flexible collection of data on pavement and intermodal system deterioration. A partnership between AMPO and AASHTO is essential to

developing a needs-based, multiuser inventory that is useful to states and MPOs, not just to the federal government.

Several data needs were placed in the context of a desired, readily available, nationwide transportation facility and service data base with a geographic accuracy typical of maps of 1:100,000 scale or more detailed, covering all urban and rural areas of the country.

Supply and System Characteristics Data: Emerging Needs

A substantial array of data needs were identified with regard to linking system data with data on system use and surroundings, including such information as commodity and passenger flows linked to individual transportation facilities.

The data refer to obtaining information on the condition of the facility itself, the character of transit and private-vehicle service conditions on the facility, and information about the characteristics of the surrounding area.

Demand and Use Data: Baseline Needs

Data on the demand for and use of transportation should support multimodal planning and cross-modal comparisons. Such data should provide information about the scale and character of passenger and freight demand by socioeconomic population categories and economic establishments. These data should also permit assessment of demand at national, regional, and local levels and should provide for the calculation of corridor-level throughput.

Much of the demand and use data traditionally collected is still needed. However, origin-destination data should be of higher quality and should be collected at a greater level of geographic and temporal detail. Specific data needs relating to general system use were identified in detail, including origin-destination patterns of travel and goods movement by type of facility and mode.

Demand and Use Data: Emerging Needs

Data should be gathered on the effects of strategies to influence system use. Such strategies include traveler information, transportation system management (TSM), and transportation demand management (TDM).

More and better data should be collected on "special generators," including hospitals, sports events, airports, and tourist attractions, to identify effects on traffic of special events by type and size of event.

Freight demand data have been neglected in transportation planning. Increased just-in-time freight deliveries and the impact of international trade on all sectors of the economy demand greater focus on freight data needs.

System Operations Data: Baseline Needs

System use and performance measures should be based wherever possible on data obtained efficiently and unobtrusively from traffic operations systems. In particular, operations data should be used to measure system reliability and congestion.

All levels of government should cooperate to develop a definition of highway reliability, and the states, MPOs, AMPO, and AASHTO were widely viewed as the logical leaders to collect data on reliability.

A pilot study should be conducted to collect and analyze data on system downtime, which are needed to make investment decisions and evaluate economic development plans, and data that describe the impact of downtime (e.g., winter snowstorm recovery in the Northeast) on economic activity, particularly because just-in-time freight delivery is becoming more prevalent. DOT is the logical agency to spearhead this effort.

Currently there is no single agreed-on measure for congestion. Better data should be collected to promote the understanding of congestion and develop common measures and definitions.

System Operations Data: Emerging Needs

Data are needed to evaluate responses to scheduled disruptions (such as construction) or unanticipated incidents (such as accidents). Information is needed on traffic impacts and other characteristics during construction periods or catastrophes such as bridge failures, as well as information on the effectiveness of other operational responses.

Just-in-time freight activities create new operations issues and data demands. Questions need to be answered concerning typical turnaround time at marine and air terminals and factors affecting choice of routing for commercial shipments.

Impact and Performance Data: Baseline Needs

MPOs and state departments of transportation should collect performance and impact data to be fed back into the system design and transportation improvement process. The system should be measured in terms of overall performance and system performance for the user (i.e., user perception of performance). Political leaders should be asked what performance indicators most interest them as well as how data on performance can be presented to them in understandable ways and integrated into their decision-making process.

Measures of customer satisfaction should be developed and integrated into system performance evaluation, particularly user perceptions of the reliability of the system and reactions to variability in travel times and quality of trips. Data on speed, safety, and cost across roads and modes are consistently needed to provide a basis for evaluating the transportation system's success in serving the user.

A lexicon of definitions of accessibility and mobility should be compiled, taking into consideration what definitions are likely to be easily understood and used by decision makers.

Better data should be obtained to evaluate the extent to which the transportation system provides access to employment, services, and recreation, as well as the connection between access to all transportation modes and neighborhood character (i.e., aesthetics, noise levels, safety).

More data should be collected to determine the effects on the economy at the national, state, and regional levels of all decisions affecting the transportation system, including investment, lack of investment, system changes, and service changes.

Better data on the security and safety of the transportation system should be collected.

More and better data should be gathered to evaluate the effect of the transportation system and decisions affecting it on the environment, particularly accurate emissions data for all relevant modes. Data also are needed that measure the transportation system's energy use and energy consumption by type of user.

More and better data should be obtained that describe the effects of the transportation system on communities, urban form, and populations.

Methods

Customer focus should be strengthened.

Customer focus involves interaction among transportation data providers, users, and decision makers. Data providers must improve their understanding of (and responsiveness to) the needs of data users. Data users must become smarter customers, understanding better what data providers can do and helping providers design and defend their data programs. Data users must also better understand the needs of their customers, the transportation decision makers, to better define what data to collect, what models to develop, and how to show results in the most effective forms.

To the extent that agencies seeking or requiring information understand the importance of involving data producers in discussions of what type of data should be collected and how, the end-use data will be strengthened. The criterion for successful data activity is its relevance in the context of a broad canvas of community desires. The Transportation Research Board

(TRB) was often named as the lead agent for convening research and discussion on information pertaining directly to transportation agencies' mission in serving the customer, such as travel comfort, system damage, safety, and delay data.

Data professionals were urged to learn about, use, and improve on recognized methods for discovering and measuring customers' needs and attitudes. Focus groups and surveys were often mentioned as valuable means for collecting the views of system users. Demonstrating the value and relevance of data was considered crucial to continued success with this audience, particularly at the local level, as concerns for individual privacy become more prevalent and as funds for data activities become more scarce.

States and MPOs should pay closer attention to how information is presented to the public and to officials.

Many problems faced by transportation data professionals are rooted in the inability to display data in clear, concise, and compelling ways to decision makers, rather than in the data issues themselves. Geographic information systems (GIS), graphics, and other communications tools are important assets.

Profiles of innovative state and local practices should be synthesized.

Throughout the conference, participants cited the Cooperative Research Programs of TRB as the natural mechanisms for compiling national profiles of methods that work for data collection, analysis, and dissemination and for identifying current innovative practices. A special effort within the National Cooperative Highway Research Program (NCHRP) and the Transit Cooperative Research Program (TCRP) focused on data and data development would be desirable.

The Bureau of Transportation Statistics (BTS) and its partners on the Federal Geographic Data Committee should continue to work with other DOT officers, states, MPOs, and industry groups to implement and maintain the nationwide geographic data base for transportation. Federal agencies should work with state and local partners to develop common formats and definitions for geographic data, to sponsor research on improved methods of geographic data integration, and to support state and MPO efforts to build and update the national picture with local data.

Fiscal constraints on data budgets prompted participants to turn their attention to the economies that new technologies can yield for data activity, including faster exchange and the ability to relate and more easily synthesize or compare different types of information. The costs and challenges of these still-new approaches were also weighed: one suggestion was that NCHRP study the costs of creating a GIS data base of transportation systems that would include both state and metropolitan data; it was also suggested that NCHRP produce a synthesis of successes and failures to date.

The role of the federal agencies would be to coordinate with state and local governments to maintain and update the system, to explore an ITS connection, and to look into funding for state and local transitions from their current GIS systems to a national version. All levels of government should cooperate with the private sector (especially freight organizations) with regard to data that are needed for the national GIS transportation data base. For example, it was suggested that all levels of government coordinate with public and private rail agencies to develop a data base of railroad crossings and add it to the GIS data base.

Public and private agencies at all levels of government should participate in ensuring that ITS and other information-intensive technologies contribute high-quality, usable data for transportation planning.

Almost all advanced information technologies pose both opportunities and significant challenges for data producers and users. Much attention is being devoted to the potential of ITS for improving the efficiency and performance of state and metropolitan transportation systems. These emerging technologies also have profound implications for data collection, storage, and distribution to meet their own needs as well as for other applications. Capturing and sifting the vast amount of data produced through ITS to obtain those data sets of value to public policy and planning will be a significant challenge.

Research on methods used by states and local governments to forecast or estimate transportation revenue from all sources (federal, state, local) for planning, programming, and

cash flow management should be enhanced, including how states handle risk and uncertainty.

Reliable revenue forecasts are critical to compliance with financial constraint requirements on state and metropolitan planning under ISTEA. An important aspect of such forecasting is credible risk analysis of uncertainties. "Cost creep"—the expansion of project scope to incorporate ancillary elements—is a part of risk assessment that needs to be addressed.

TRB was named as a possible facilitator of research into this issue. It was suggested that NCHRP conduct a research project on revenue forecasting methods used by states and local governments, including the handling of risk and uncertainty. The TRB Committee on Finance was encouraged to compile sources and methods for revenue source forecasting, building on existing work.

MPO and state efforts to develop methods for substate financial forecasts derived from higher-level forecasts (i.e., "step-down forecasts") should be coordinated, perhaps by AMPO and AASHTO.

The continuation of the decennial census short and long forms in 2000 is important to transportation planning and should be supported.

Federal funding limitations for census activities were recognized to be barriers to obtaining extremely detailed data. However, much is at stake for all organizations interested in sound data.

The BTS-sponsored study by TRB on changes needed to transportation models and other analytical methods should be expanded, perhaps as part of the Travel Model Improvement Program. A major goal of the new joint effort would be adapting these methods to use continuous measurement of census data instead of a single estimate each decade.

Research should support the development of analytical tools for state and metropolitan transportation planners to use and evaluate data from a continuous-measurement program produced by the Bureau of the Census (i.e., the American Community Survey), instead of a single decennial cross-sectional census. Potential research into such tools could be conducted as part of NCHRP or by university researchers.

AASHTO and AMPO are in a position to foster improvements to Census 2000, such as faster results, more detail, and better-quality data.

States and MPOs should work with DOT to develop methodologies, performance measures, analytic tools, and techniques to help assess the contributions to and impacts of transportation on quality of life (both personal mobility and other important goals of community life).

Cross-modal system performance measures that address societal, economic, and other broad goals are critically needed to take transportation decision making beyond costs to real choices. Access and mobility are particular areas of interest. Because social equity is of increasing concern in transportation, measures to address this issue are critical.

Federal support is needed to study the comparability of system performance data across modes, with periodic updates to suggest ways of improving comparability. Research and assembly of profiles on state and local practices should focus on which measures of performance make sense. Measures of reliability, delay, system performance by time of day, and the impacts of maintenance and construction are also neglected areas. Research is also needed on methods and data collected to develop performance measures that are better oriented toward customer needs.

One aspect of research on performance measures could be cognitive research on their comprehensibility to decision makers and the public. The question arose, Is the level-of-service measure easily understood, or are the more esoteric measures equally valuable and understandable? Are performance measures at too broad a geographic level (areawide measures) to be sensitive to changes in transportation improvements?

Research or a pilot project should be conducted on the creation of subarea employment data sets, methods, federal data enhancement, and private source acquisition and use. A collaborative effort could be launched by BTS, TRB, DOT, and the U.S. Department of Labor. Market research models, institutional data sharing, and "piggybacking" on existing survey instruments should be encouraged to increase the availability of detailed employment data without adding significantly to the collection burden.

The implications of disaggregated data for transportation could be evaluated by state departments of labor and the Bureau of Labor Statistics (BLS). Trade-offs between the need for detailed data on employment at small-area detail and the need for protection against disclosure of sensitive data should be addressed in a way that permits more effective public data sources to be created.

Federal, state, and local transportation agencies should develop a consensus on the principles of full accounting for transportation costs. A peer review of current methods of full-cost analysis should be conducted as well as of the principles and information on full-cost accounting approaches to include social, economic, and environmental considerations and the needs of both system users and nonusers. Information on how to measure and quantify quality of life and the transportation system's impact on it could be monitored, synthesized, and disseminated by DOT.

This issue is of particular concern with regard to existing facilities, which should be evaluated as part of congestion management system analysis. Proposed projects are generally evaluated through an environmental impact study or major investment analysis. Environmental analysis should take a long-term view, and relevant data are not now collected.

Institutions

Partnerships are needed to create win-win relationships between data gatherers and data users, both among jurisdictions and between the public and private sectors.

Data need ownership, care, and feeding, but convincing various jurisdictions to accept responsibility is a problem. Each level of government needs to define its role as a stakeholder in data management. The Texas Department of Transportation recently issued a statement of policy in this regard, which can be considered a model.

Data needs for the general good are especially vulnerable to becoming "orphaned" when private providers do not perceive the profitability of collecting and providing the data, and when no agency perceives the usefulness of the data for its specific jurisdiction.

The states and MPOs do not have the resources to investigate the full range of transportation data available. Although BTS does produce a data catalogue, the agency's efforts in this area could be expanded and a compendium of secondary data sources added. Information on how to fuse secondary data and transportation data should be included.

The public sector in transportation spends considerably less per professional on providing access to data resources than many other sectors, including medicine and agriculture. Given the high value of data to the field, this situation ought to be remedied. A comprehensive catalogue of data sources is needed, but the sector's need goes beyond that, perhaps even to a clearinghouse that would store and disseminate all publicly available transportation data, as well as provide technical assistance to its customers. Any such effort should include points of contact for data sources to assist potential users in determining data quality.

BTS's National Transportation Library could assign staff to be responsible for clearinghouse functions such as providing assistance in locating alternative data sources and distributing responsibility for acquiring, storing, and providing access to data. AASHTO and AMPO could provide clearinghouse functions with regard to information on institutional processes at state DOTs and MPOs, for example, detailing the procedures used to develop performance measures.

A consortium of federal modal agencies and state, regional, and local transportation agencies should be convened to determine key data elements, conventions, and protocols.

Differences in data-collection and analysis methods among transportation agencies at all governmental levels hinder the exchange of valuable information. It is necessary that an effective coordination process for data exchange be created, one that relies on common formats, flexibility, aggregation, sampling, and methods. For example, it would be helpful if all DOT surface transportation agencies had mutually consistent financial data bases that incorporated standard items and accounting practices.

DOT is the logical agent to provide guidelines for standardizing a variety of data and data-collection methodologies, such as those pertaining to causal relationships for safety, but the department should not itself establish standards.

BTS should relate local data over time by using compatible formatting and measurements for data sets collected at different times. The agency might also develop a data dictionary for critical transportation inventory elements to enable bottom-up distribution of data elements for creation and maintenance of a base inventory.

Federal agencies that collect and use data related to household and population data (e.g., census data and labor statistics) should be more responsive to state and local priorities and input.

BTS was encouraged to represent state and MPO needs to the federal agency producers of population, household, and labor data during design. Although collection of basic census data is a federal responsibility, many participants believed that it was extremely important for AASHTO and AMPO to have the opportunity to include state and local add-ons. State and local governments should support census programs designed to obtain local input.

Public agencies and private entities should increase coordination regarding data access. Collaborative agreements with trade organizations could be useful to this effort, and cost sharing or purchase of data should be considered. Public-private partnerships and new institutional relationships should be explored for development and distribution of data.

The scarcity of resources for data led to numerous proposals for increased attention to public-private partnerships, data sharing, and "piggybacking" of data collection among public agencies.

It was suggested that BTS take the lead facilitating access to and use of private data through "win-win" arrangements such as buying or sharing data, partnering, and privatizing collection, analysis, and storage.

Democratic access to data was discussed as an important federal enforcement issue. For example, several MPOs and states are frustrated at being unable to gain access to ES202 employment data. The federal government, which funds collection of these data through the U.S. Department of Labor, should also take a hand in ensuring access for states and MPOs. Federal guidelines and principles were suggested for balanced public-private partnerships for data collection and dissemination. Several participants believed that agencies should be more willing to purchase or trade better public and private data. It was noted that many MPOs already purchase or barter data.

Partnerships with private data holders were considered by most participants to be crucial to getting better data, particularly with regard to freight. However, the competitive environment among freight companies, and the attendant proprietary nature of their data, poses a significant obstacle to realizing this goal.

In the area of financial data, federally guided methods or institutional arrangements were called for to provide specific information from the federal government to states and from states to MPOs. It was urged that financial and supply and system characteristics data be integrated and made available to decision makers who participate in financially constrained planning.

To assist all data-collection efforts undertaken by state and local agencies, it was suggested that these agencies develop partnerships with universities and private companies, which might assist specifically in improving collection methodologies.

The Truck Inventory and Use Survey (TIUS) and the Commodity Flow Survey (CFS) should be used more widely. It would be helpful if BTS and the Bureau of the Census could adapt the surveys to better meet needs at the state and MPO levels. A working group with national freight stakeholders could be coordinated by TRB, BTS, AMPO, and AASHTO, with the goal of sharing data and protecting confidentiality.

Urban freight movement is a neglected area of study, although it has become increasingly important as the scope of long-range metropolitan planning has expanded to include private transportation operations. More attention is needed to this topic. Among the subjects in need of research are estimation methods of expected levels of freight activity (by tonnage and other measures) at intermodal facilities.

International trade flow data are available, but are not being used efficiently. The national commodity flow survey is a recent effort that contributed to filling in the knowledge base about domestic trade. Methods to improve the use of global trade flow data are still needed. Also needed is national monitoring of freight technologies affecting port capacities.

A national freight working group could encourage better relationships between the public and private sectors and open discussion of such key elements as how to get freight flow information without jeopardizing the privacy of companies. National associations and federal agencies could work with national private-sector businesses (i.e., freight shippers and carriers) to determine their data needs from transportation agencies and what data sharing could be realized. Likewise, DOT should review existing data sets to ensure accurate and usable freight data that are appropriately aggregated to support transportation planning and decision making at state and local levels while maintaining private-sector confidentiality.

Agencies at all levels of government should step up efforts to address the link between transportation and land use. Research into land use models should be improved, and DOT is the logical agency to lead this effort.

The effect of transportation improvements on land use development and the linkage between land use and transportation are long-standing concerns. Improved land use models and performance measures may require data not collected today.

However, funding is scarce for land use modeling integration, which hampers MPO efforts to interface land use and transportation models. The traditional support by the Department of Housing and Urban Development for land use modeling has been long gone and was never replaced. DOT should continue to emphasize the relationship between transportation and land use through its research and funding priorities.

Findings

During the working group process, a three-part framework was used to address the separate but overlapping and interdependent contexts for data users: content, methods, and institutions. Each of these three categories shared the goal of improving data activities to support state and local decision making. However, each category had distinct characteristics that called for it to be addressed somewhat differently than the other two.

Discussions of data content were characterized by brainstorming and development of wish lists for data-collection efforts, for which subsequent discussions of methods and institutions clarified the priorities. Action items for methods and institutions that relate most directly to specific data topics are presented in the Content section.

Proposed approaches to methods and institutional arrangements often converged. Both categories led workshop participants to devise solutions that cut across several topic areas, with the potential to address numerous transportation data needs at the same time. Recommendations regarding methods involved significant changes to collection, storage, analysis, and interpretation techniques. Also eligible for consideration in this category were general proposals for synthesizing information, documenting state and local practices, and using technologies in new ways to generate, evaluate, or display data. Institutional recommendations highlighted the need for significant leadership on a specific issue, a major shift in an institution's role or function, or creation of a new relationship between or among institutions.

As noted in the Overview and Executive Summary, the findings reported here are a selection of the numerous observations and suggestions generated at the conference. The selection reflects the conference steering committee's ordering of critically important concerns and recommendations that were expressed by conference attendees.

Content

Socioeconomic Data

Conference participants generally agreed that most federal data efforts should continue and that states and metropolitan planning organizations (MPOs) should be more closely involved

in tailoring data activities to their tasks. Programs singled out as especially important to transportation decision making include the following:

- Compilations such as County Business Patterns, produced by the Bureau of the Census;
- Basic data-collection programs such as the decennial census in its complete form, the Consumer Expenditure Survey (produced by the Bureau of Labor Statistics), and the Commodity Flow Survey (produced by the Bureau of Transportation Statistics);
- Federally sponsored state-level data collections such as employment statistics; and
- Key indicator estimation programs such as the Consumer Price Index.

Demographics

The census and its companion, the Nationwide Personal Transportation Survey (NPTS), sponsored by the Federal Highway Administration and other U.S. Department of Transportation (DOT) modal administrations, were recognized as core programs among federal data efforts. The impending shift from an extensive decennial census to annual surveys (i.e., continuous measurement, also called the American Community Survey) could affect the characteristics of data collected to document changes in households, a category of data on which demands have grown as the goals of transportation planning processes have broadened to include consideration of individual behavior, community character, economic effects of transportation investment, and environmental enhancement as well as mitigation. Demographic data identified as particularly crucial to transportation decision making are the following:

- Data on emerging and critical population subgroups, including the disabled, the elderly, those affected by welfare reform, immigrants, low-income households, and zero-vehicle households;
- Household characteristics of nonpermanent-resident households ("snowbirds," who move to warm climates in the winter; migrant workers; and students); and
- Vehicle ownership and availability as household characteristics.

The increasing complexity of the state and local decision-making processes, coupled with technological advances such as geographic information systems (GIS), have prompted both a need and an expectation for greater geographic detail in the collection and presentation of data. Yet these expectations must be met within the context of current government downsizing, federal budget constraints, and the changing process for collecting census and other demographic information. Conference participants recommended combining a short federal form for collecting baseline data with an option for state and local governments to add questions for a fee. This approach could also work for the collection of other household data. For example, allowing the addition of questions to NPTS would enable states and local governments to collect additional data while reducing up-front administrative costs. Many participants suggested that the transferability of household travel demand information from the NPTS to local applications also be explored.

Migration and employment patterns are among the data elements for which participants requested much greater geographic detail. Nontraditional data sources, such as chambers of commerce and tourist bureaus, can provide information on trips taken by pleasure travelers. However, concerns exist about the availability and quality of employment data in formats that will be useful for transportation decision making. For example, although welfare reform is expected to affect travel demand significantly, data for forecasting this effect are lacking. Specific employment data needs are presented in the section on Economics.

Participants encouraged the Bureau of Transportation Statistics (BTS) to represent state and MPO needs to the federal producers of population, household, and labor data during design of data-collection programs, including the American Community Survey conducted by the Census Bureau. Although collection of basic census data is a federal responsibility, most participants believed that it was extremely important for the American Association of State Highway and Transportation Officials (AASHTO) and the Association of Metropolitan Plan-

ning Organizations (AMPO) to have the opportunity to include state and local add-ons. State and local governments should support census programs designed to obtain local input. States and MPOs were generally considered to be jointly responsible for collecting non-census-related transportation data.

Economics

Globalization is prompting the need for analysis of international macroeconomic data to provide background for state and local transportation decision making. The federal government was identified as the most appropriate agent for collection and analysis of such data, but states and MPOs need ready access to this information because they need to know about shifts in global trade that might affect state and local transportation services. Better data are also needed to identify relationships between economic productivity and transportation investment, including the following:

- Changes in patterns of building and development;
- Tax data that reflect economic activity;
- Military base abandonments and conversions and direct and indirect spending by the military on communities;
- Housing market data, such as housing costs;
- Numbers of tourists and visitors, as well as location and time of visits and method of travel;
- Business establishment characteristics; and
- Use of transportation investment incentives to support business locations.

Some conference participants called for data on trade and tourism to be collected among partners in the North American Free Trade Agreement (NAFTA), to examine the impact of international activity on states and localities. Trade and tourism data should include transportation characteristics, such as modes used. Data should be obtained on supporting infrastructure such as international port and airport facilities and warehousing.

Access to employment data is inadequate in most states, according to many participants. Information that should be made more accessible by either the federal or state governments, private companies, or both in partnership include

- Employment and worker characteristics by economic sector, worker residence, and place of work for small geographic units (i.e., traffic analysis zones);
- Accurate and comprehensive geocoding of employment to traffic analysis zones;
- Characteristics of multiple-job holders;
- Labor force availability and wages;
- Transportation system access to employment opportunities;
- ES202 employment data (e.g., employment estimates based on business tax records);
- Shifts in population and employment, including changes in work location and work behavior of the individual (e.g., telecommuting responses); and
- State-level employment and labor.

Land Use

The impact of transportation improvements on land use development and the linkage between land use and transportation are long-standing concerns. Although new data may be necessary to improve land use models and performance measures, fragmentation of state and local responsibilities has hampered previous efforts at coordination. Conference participants described the following land use data as important for transportation decision making:

- Tax assessment data for base-year models;
- Surveys of local land use policies;

- Economic development plans;
- Land use ratios for commercial, industrial, and institutional sectors per capita;
- Suitability of vacant land for various purposes, as determined by policy, physical, and market criteria; and
- Values of land overlaid against transportation improvements.

The need to improve transportation models goes hand in hand with the need to provide more and better land use data. Large MPOs were often seen to have a primary role, along with federal and state governments, in tying parcel-level land use data to transportation models, especially in matching the models with data and format. However, funding is scarce for land use modeling integration, which hampers MPO efforts to interface land use and transportation models.

Despite these difficulties, model capabilities and data availability are being improved in a parallel fashion at both the national and metropolitan levels. An overarching objective of these efforts is to capture trips that are hidden in traditional origin-destination analysis, especially errands and social activities that take place on trips between work and home. Several MPOs (e.g., the Portland Metropolitan Service District and the Puget Sound Regional Council) are shifting from fixed origin-destination models to activity-based models. Other MPOs have taken actions to improve the linkage between data sets that are relevant to modeling. For example, the North Central Texas Council of Governments provides information on regional traffic patterns and vehicle emissions in compatible data bases. DOT and the Environmental Protection Agency (EPA) jointly sponsor the Travel Model Improvement Program (TMIP), which supports training and regional information centers for MPOs; data research relevant to transportation, land use, and air quality modeling; investigation of short-term improvements to existing models; and longer-term development of new models such as the Transportation Analysis Simulation System (TRANSIMS).

Discussion of models at the conference generally concentrated on the "chicken and egg" dilemma: models designed around existing data often limit analysis to "working where the light is good," whereas models designed around policy issues without concerns for existing data cannot be calibrated or substantiated. Modelers were encouraged to join other data users in their dialogue with data providers to ensure the development of new data resources to support new modeling requirements.

Improvements in Socioeconomic Data

Demographics

[1] There was wide agreement that the long-form survey should be continued in Census 2000, and that organizations at all levels of government with a stake in sound transportation data should support the efforts of the Bureau of the Census in this regard. The Bureau of the Census was encouraged to seek the input of its federal, state, and local transportation customers in instituting continuous measurement.

[2] BTS should continue to be diligent in protecting state and local needs for census data, particularly the data collected by the long-form survey. AASHTO and AMPO are in a position to foster improvements in Census 2000, such as faster results and better-quality data.

[3] The BTS-sponsored study by the Transportation Research Board (TRB) on changes needed to transportation models and other analytical methods should be expanded, perhaps as part of TMIP. A major goal of the new joint effort would be adapting these methods to use continuous census data instead of a single estimate each decade.

[4] MPOs need to be more closely involved in obtaining, correcting, and gaining access to detailed addresses for use in Census 2000. The Bureau of the Census should develop a new allocation method for nongeocoded addresses, assign land use classes, and involve MPOs in

solving address problems by identifying a sworn MPO agent to pinpoint local address corrections. Among the areas in need of additional attention in Census 2000 are methods for reporting characteristics of households with multiple residences. The Census Bureau should also provide better resolution of the Public Use Microdata Sample (PUMS) and small-geography versions of the Data Access and Dissemination System (DADS) and should provide custom cross-tabulations for small geography.

[5] Several steps could be taken to address the need for better data on population shifts. First, BTS could undertake a national effort, perhaps in concert with U.S. tourism agencies, to develop a better definition of tourist activity (i.e., dynamics). Second, research should be conducted to develop a method for forecasting immigration and using forecasts to measure expected state and regional impacts.

[6] The ability of states and MPOs to use NPTS as a data-collection mechanism should be enhanced through strengthened support for add-on samples, as well as by allowing states and local governments to add questions of local interest. DOT is the logical agency to lead this effort and to evaluate the cost-effectiveness of expanding the NPTS to provide greater geographic detail. TRB or perhaps the Federal Highway Administration (FHWA) might review the experiences of state DOTs and MPOs in adding samples to NPTS.

[7] The federal government and the states should help make employment records more readily available to MPOs and, if necessary, obtain any additional data required to make site-level information available.

Small-area data such as those collected through the census PUMS files could be useful if they were made more widely available, and many participants advised collecting PUMS data for more areas and in more detail than before. The federal government and state departments of transportation were also encouraged to facilitate development of a protocol for getting data from state employment departments. Federal leadership was widely viewed as key to helping labor and employment agencies understand the transportation need for such data. BTS was often urged to evaluate states with successful data-sharing programs for employment-site data to identify best practices. AMPO and AASHTO were suggested as partners to work with BTS to investigate sources for this type of data and to improve intergovernmental communication.

Economics

[8] Data on trade and tourism, including transportation characteristics such as modes used, are needed to examine the impact of international activity on states and localities. Especially needed are data on trade among NAFTA partners. Data on supporting infrastructure, such as international port and airport facilities and warehousing, are also needed.

[9] Macroeconomic and external factors drive changes in travel need. Some conference participants called for BTS to analyze background changes and their travel implications and cited National Cooperative Highway Research Program (NCHRP) Project 2-20, Economic Trends and Multimodal Transportation Requirements, as a start. TRB was often suggested as the logical organization to synthesize profiles of state and local practice for short-term national forecasts and regional methods.

[10] There was strong support for DOT's efforts to identify international trade corridors and provide MPOs and states with access to analyses of global and macroeconomic trends affecting transportation.

[11] There was general agreement that the Commodity Flow Survey (CFS) was important to transportation planning and should continue. Given the widely expressed concern about the geographic detail of existing data, many participants specified that the states and MPOs

should work with BTS and the Bureau of the Census to develop commodity flow data at the county level.

International trade flow data are available but many participants believed that such data are being used inefficiently. Although the CFS contributed to filling in the knowledge base about domestic trade, methods to improve the use of global trade flow data are still needed, as well as national monitoring of freight technologies that affect port capacities.

[12] Research or a pilot project should be conducted on the creation of subarea employment data sets, methods, federal data enhancement, and private source acquisition and use. A collaborative effort could be launched by BTS, TRB, DOT, and the U.S. Department of Labor. Market research models, institutional data-sharing, and "piggybacking" on existing survey instruments should be encouraged to increase the availability of detailed employment data without adding significantly to the collection burden.

State departments of labor and the Bureau of Labor Statistics (BLS) could collaborate to evaluate the implications of disaggregated data for transportation. With BLS, DOT was encouraged to build a workplace address file similar to the Master Address File that will be available to MPOs for review and correction. Some participants suggested that AMPO identify problems and potential solutions for collection, correction, and access to addresses at the regional level.

Land Use

[13] Agencies at all levels of government should step up efforts to address the link between transportation and land use. DOT could lead the way in developing research to improve land use models and should continue to emphasize the relationship between transportation and land use through its research and funding priorities. States were encouraged to form closer working relationships with local governments to develop a linkage model between land use and demographic forecasting processes.

[14] Pilot studies are needed on innovative data-collection methods for linking travel demand (both passenger and freight) and system performance to land use. For example, land uses could be related by individual parcel, travel behavior, and trip generation (vehicle, pedestrians, total person-travel) for the development planning process. Methodologies for collecting data include loop detectors and observers collecting passenger vehicle data. The FHWA project on average vehicle occupancy may be useful for improving the passenger data.

[15] BTS and TMIP were encouraged to develop guidelines for conversion from an origin-destination approach to an activity approach to modeling and forecasting. Models should be developed and enhanced using more than the traditional household survey and methodologies. Other data could include establishment and activity data to pinpoint the purposes of trips that start or end at places other than home or work.

MPOs need assistance in adapting existing models and should be involved in developing a new modeling process as well as supportive tools such as surveys to tie travel measurement to measurement of daily activity.

Financial Data

Transportation decision makers need more financial information in a wider variety of formats than ever before: as inputs to major investment studies, to aid in analyzing alternative financing for transportation projects, and to forecast revenue that will be available for maintenance, system management, and new projects. The costs of transportation to the user, the value of time, and the need to price transportation services fairly are of concern in decision making.

Revenue Forecasting

Under the Intermodal Surface Transportation Efficiency Act (ISTEA), reliable revenue forecasts are critical to compliance with the requirement for fiscal constraint in state and metropolitan planning. An important aspect of such forecasting is credible risk analysis of uncertainties. "Cost creep"—the expansion of project scope to incorporate ancillary elements—is a part of risk assessment that many conference participants believe needs attention.

Numerous conference participants cited the lack of credible, clear information on revenue sources as a significant stumbling block for current financially constrained transportation planning processes. For example, many MPOs have difficulty estimating (or relying on local estimates of) transit revenues because subsidies, cost of operation, and prices that will affect transit revenue streams are driven by policy.

In several cases, revenue data could be improved by access to better information earlier in the decision-making process: financial-aid forecasts from the federal government are a key input, as are better estimates of local transportation tax revenue and expenditures, and data on the suballocation of state resources for transportation improvements. Several participants pointed out that data availability is only a partial solution because data sets are not comparable and mutual trust is often lacking among key decision makers at all levels of government. A single, publicly accessible, national financial data set appeared on the wish list of several working groups, although with the acknowledgment that partnerships are crucial to realizing such an objective.

Data on current and long-range changes to the revenue stream are also needed. For investments already made, participants called for clear measurements of financial performance and data for fiscal management, including debt service, pay-as-you-go financing, and level of bonded indebtedness.

Specific data needs relating to revenue from taxes were identified as follows:

- Truck registration data from the International Registration Plan (IRP) and truck use characteristics from the International Fuel Tax Agreement (IFTA);
- Federal and state sales tax revenue;
- Sales and fuel tax revenues by fuel type and changes to revenue with changes in vehicle fuel economy; and
- Expenditures on fuel taxes by businesses and households as a percentage of income, and other variables indicating the impacts of fuel taxes.

Specific data needs relating to revenue from other sources were identified as follows:

- Long-range substate-level financial projections;
- Financial impacts of transportation system pricing (tolls, parking policies, and so forth);
- Identification of finance streams to support maintenance;
- Cash-flow prediction at all levels of government, including identification of current and future revenue (needed for all levels of government);
- Returns on different investment strategies, including tax increment, special assessment districts, and developer impact fees;
- Relationships of toll charges to revenues for both new and established facilities;
- Carrier revenues; and
- Data for toll facility analysis, including usage and the value of time.

Alternative Financing

Although decision makers are taking a closer look at alternative methods for supporting transportation projects, such as toll financing and private development or operation, the specific risks and potential benefits of these approaches are difficult to predict. Accurate forecasts of toll revenues are of particular concern to MPOs and states. Cost-benefit data for these financing methods are needed, along with tools to assess the risks at which public funds may be placed. Transportation agencies were encouraged to reach out to members of the

private-sector financial community with expertise in taxation and revenue estimation for assistance in devising methods and applying them to toll revenue forecasting.

The impact of toll facilities on demand is also difficult to determine and deserves more attention. Several current NCHRP projects address the costs of time, including Project 2-18(2), Valuation of Travel-Time Savings and Predictability in Congested Conditions for Highway User-Cost Estimation. However, these studies do not focus on MPO-oriented needs regarding the value of time, and the work should be extended to reflect this consideration. In addition, information is needed on the following elements: the impacts of different pricing on use and shifts in use of the system across all modes; innovative financing and new forms of revenue (e.g., charges on telecommunications); and the state of the economy (this could perhaps be included through a set of adjustment factors for different trip purposes, economy, and modes). Analysis of differential pricing options should consider who pays for travel (i.e., individual or company).

Other needs were identified as follows:

- Data on the statutory limits on creative financing;
- Comparison and feasibility analysis of public-private partnerships; and
- Administrative costs associated with privatization.

Costs and Assets

Cost and expenditure data should include

- Capital and operating costs of maintaining and managing existing and future transportation systems;
- Clear articulation of prices and costs for programs and services;
- Costs for infrastructure imposed by development, such as water, sewer, and other public services;
- Data for life-cycle costing;
- Right-of-way, construction, and raw materials cost estimates;
- Capital costs;
- Expenditures by all levels of government by highway functional class;
- Expenditures by revenue source;
- Data base on letting costs; and
- Highway and other transportation cost allocations.

The fiscal value of the transportation system—including the lease or sale value of rights-of-way—and the opportunity costs of delayed investments were recommended for further research and documentation, as well as the value of public and private fleets (e.g., public transit bus fleets, rolling stock, safety and public works vehicles, and privately owned vehicles). Some participants recommended the inclusion of state DOT administrative costs (i.e., salaries and expenses) in the state-level assessment of system values and costs. Small-city and rural financial data for urban and rural allocations should also be included.

Conference participants acknowledged the need to include many more variables in cost accounting than ever before, including quantified values for the environmental and social impacts of transportation decisions.

Although much new fiscal information is needed or new forms for existing data may be called for, many conference participants agreed that the data on federal project forms could be streamlined and that much of what is currently included is not needed.

Improvements in Financial Data

Revenue Forecasting

[1] TRB was encouraged to review current methods used by states and local governments to forecast or estimate transportation revenue from all sources (federal, state, and local) for

planning, programming, and cash-flow management, including how states handle risk and uncertainty. The study should document past problems with revenue forecasting. The TRB Finance Committee was encouraged to build on existing work to compile sources and methods for revenue source forecasting, perhaps engaging the investment community in investigating how to better meet the needs of the federal, state, and local transportation agencies in this area of data collection.

[2] Numerous participants suggested that AMPO and AASHTO coordinate efforts to develop methods for substate-level forecasts derived from higher-level forecasts (i.e., "step-down forecasts").

[3] An NCHRP report was suggested on how public information campaigns affect transportation revenue, financial operations, and budgets; and on ways to link budgeting and financing. Groups whose input would prove useful in preparing the report include the National Governors Association, the National Conference of State Legislatures, state treasurers, and the Government Finance Officers Association.

Alternative Financing

[4] Reliable methods and accurate documentation for estimating revenue from toll projects should be developed, including near- and long-term elasticity effects on demand for the affected facility and the system at large.

[5] Greater attention should be paid to methods for analyzing fiscal risk in relation to the use of private funds. A nationwide inventory could be conducted by TRB, DOT, the Government Finance Officers Association, or a consortium of the three, to determine the effects of toll facilities on demand and revenue with comparisons of projected and actual demand and revenue.

[6] The financial impacts of alternative and innovative revenue sources should be studied (e.g., weight-distance charges, toll roads, and charges for use of public rights-of-way and for use of air rights for telecommunications and fiber optics). The study should include an inventory of what is successful, what the most accurate measures are, impacts of legislation, and the state of the art.

[7] Information on institutional arrangements for financial management of toll facilities should be compiled, perhaps by AASHTO.

Costs and Assets

[8] Research was suggested on the economic value of the transportation system, described as a capital stock measure at present and potential capacity and including the lease or sale value of rights-of-way. The size and capital value of state, local, and transit authority vehicle fleets should also be documented.

[9] Local and state governments should develop methods to identify reasons for cost overruns and should develop or participate in the development of an inventory of risk factors in project costing.

[10] Citing the need for research into methods for collecting continuous information on the costs of the transportation system (e.g., operational costs and capital improvement expenditures and outlays), several conference participants suggested an NCHRP pooled-fund study in this area. A goal of the study would be to develop a data unit to measure per-mile actual costs by project.

[11] Federal, state, and local transportation agencies should develop a consensus on the principles of full accounting for transportation costs. A peer review of current methods of full-

cost analysis was suggested, perhaps under the auspices of TRB, which would lead to development of such principles to include social, economic, and environmental considerations and the needs of both system users and nonusers. In addition, some participants requested a national effort to monitor, synthesize, and disseminate information on how to measure and quantify quality of life and the transportation system's impact on it. DOT was suggested as the logical agency to carry out such an effort.

Partnerships

[12] Data on project costs and federal revenue should be made more widely available to MPOs to assist them in developing financially constrained plans, transportation improvement programs, major investment analyses, and so forth. TRB was urged to facilitate cooperation among states, MPOs, and local governments to develop a method for validating financial data, addressing the need for trust among all players.

Supply and System Characteristics Data

The transportation system is a collection of many components, including networks, facilities, services, and vehicles. The size, extent, connectivity, age, and physical condition of these components provide the basic description of the supply of transportation for decision makers. Except for vehicle fleet data, most of these characteristics can be measured for geographically specific facilities and links on the transportation network.

Conference attendees emphasized that the transportation system to be measured included all modes of transportation, the linkages among the modes, and the linkages between intercity and metropolitan systems. Attendees also emphasized that data should include both public and private transportation, reflecting the growing state and local interest in freight transportation, which is dominated by the private sector.

Networks and Facilities

Transportation networks—roads, pedestrian and bicycle facilities, railroads, pipelines, terminals, ports, and airports, maintenance facilities, and other physical manifestations on the landscape—are the most visible components of the system. Data needs related to this physical infrastructure were identified as follows:

- Greater geographic detail about the location and connectivity of the transportation infrastructure, including supporting facilities such as park-and-ride lots, rail-highway grade crossings, and data-collection sites (e.g., traffic counting locations);
- Capacity and speed measures for the facilities and network links in the geographic data base;
- Operating restrictions, such as truck size and weight limits and passenger vehicle occupancy restrictions, by time of day;
- Tolls and other facility-specific charges;
- Functional class and urban or rural class of each highway segment;
- Frequently updated condition measures, particularly with regard to long-term pavement performance and deterioration rates, for bridges, arterial and local street systems, and other physical infrastructure;
- Inventory of materials used in construction and maintenance; and
- Information on jurisdiction to identify the agency or company responsible for maintenance and operation of the facility so that data on supply and cost can be related.

Transportation Service

The existence of physical transportation infrastructure is a necessary but not sufficient condition for connecting locations: service must also be provided. Service is almost universal for

private motorists and users of small trucks, but fewer roads can be used by larger trucks. Except for charter service, most for-hire buses operate on fixed routes on limited portions of the highway network at certain times. Service on rail networks also follows specific schedules and routes, usually constrained by ownership or trackage rights. Geographically specific information on transportation service is thus indispensable to fully understanding the extent, connectivity, and condition of the supply of transportation.

As identified by conference participants, specific data needs for transportation service parallel those for transportation facilities and networks: location, connectivity, and capacity of public transit, passenger and freight railroads, waterborne commerce, air passenger and cargo networks, trucking, and intermodal services. Some services, such as paratransit, water taxi, and air taxi, must be measured in terms of areas covered instead of specific routes. In both areawide and route-specific service, connectivity and capacity must be measured by time of day.

Conference attendees widely recognized the importance of condition data, which are primarily related to the vehicles operated by the service provider. The need to identify transit and paratransit services operated in compliance with the Americans with Disabilities Act was also stated.

ITS Infrastructure

Conference attendees recognized the increasing importance of intelligent transportation systems (ITS) to the operation of transportation facilities and services, as well as the value of ITS as a new data source. ITS infrastructure includes facility-specific control systems (such as freeway intersections with ramp meters) and communications networks that often parallel the transportation facilities and modes being served. Data on the location and other characteristics of ITS infrastructure must therefore be linked with other geographic data on transportation infrastructure to understand the extent and effectiveness of ITS technology.

Linkages Between Transportation System and Areal Data

As described in the section on Impact and Performance Data, decision makers are concerned as much with how the transportation system interacts with its surroundings as with the system itself. To link data on the transportation system—including its physical infrastructure, services, and communications infrastructure—with data on the systems in surrounding areas, conference attendees recommended several steps, outlined in the section on Improvements in Supply and System Characteristics Data.

Vehicle Fleets

Except for pipelines, transportation facilities and services require fleets of vehicles, trains, planes, and vessels to move people and goods. Several attendees emphasized the need for data on vehicle fleet sizes, characteristics such as age, and geographic distribution. Support was voiced in particular for the Truck Inventory and Use Survey, which measures a variety of vehicle characteristics for commercial and private trucks, vans, and minivans. The need for similar data on other vehicles, such as buses and publicly owned vehicles, was also noted.

Reassessment

Several of the potential building blocks for the desired transportation data set—including the Highway Performance Monitoring System, the National Bridge Inventory, and the Section 15 transit reports—are being reassessed by federal, state, and transit industry partners. Participants recognized that these reassessments are under way and urged that the recommended changes to those federal reporting systems be implemented.

Improvements in Supply and System Characteristics Data

Networks and Facilities

[1] A nationwide geographic data base was requested at a scale of 1:100,000 or more, identifying the location and connectivity of transportation networks and facilities—including highways, rail lines, bridges, bikeways, pedestrian facilities, pipelines, passenger and freight terminals, intermodal facilities such as ports and park-and-ride lots, supporting facilities such as transit garages, rail-highway grade crossings, and data-collection sites such as traffic counting locations. BTS and its partners on the Federal Geographic Data Committee (including the U.S. Geological Survey) should continue to work with DOT's other modal administrations, states, and MPOs to implement fully this transportation data base, which can also be linked to areawide data on population, economic activity, and the environment.

[2] States and MPOs should work with BTS and its partners to keep the nationwide geographic data base up to date, especially with regard to condition measures, particularly for long-term pavement performance and deterioration rates; for bridges and arterial and local street systems; and for other physical infrastructure.

Transportation Service

[3] Government agencies at all levels should consider geographic data on transportation service, including service by the private sector and less conventional service such as paratransit, as integral to a full understanding of the extent, connectivity, and condition of the supply of transportation and to an understanding of how well the transportation system complies with special laws such as the Americans with Disabilities Act.

ITS Infrastructure

[4] BTS and its partners on the Federal Geographic Data Committee could work with MPOs, the DOT Joint Program Office, and private groups such as ITS America to develop agreed-on definitions of ITS infrastructure and services and to incorporate ITS infrastructure into the nationwide geographic data base for transportation.

Linkages Between Transportation System and Areal Data

[5] Compatibility is needed between the geographic referencing system used to collect and publish census data—the Topological Integrated Geographic Encoding and Reference (TIGER) system—and the nationwide geographic data base for the transportation network. Several participants suggested that DOT and the Bureau of the Census work together to create this interface.

[6] The populations, employment, and economic activities covered by transportation facilities and services should be measured for geographic accessibility.

[7] Land uses and historic features in and along rights-of-way should be classified and inventoried.

Vehicle Fleets

[8] The Truck Inventory and Use Survey (TIUS) and the CFS should be adapted for more widespread use at the state and MPO levels. BTS and the Bureau of the Census are the logical partners to carry out this task.

Reassessment

[9] DOT should continue the HPMS and Section 15 program reviews and should revise these requirements to be more responsive to state and local needs and input. Many conference participants characterized the MPOs as preferring a bottom-up, consistent, and standardized scheme for compiling Highway Performance Monitoring System (HPMS) data. Privatization of HPMS and Section 15 reporting might also be feasible and should be researched.

Standard methods for flexible collection of data on pavement and intermodal system deterioration should be facilitated. A partnership between AMPO and AASHTO was broadly viewed as essential to developing a needs-based, multiuser inventory for monitoring such data that would be useful to states and MPOs, not just to the federal government. Integration of a single monitoring system was suggested, from which users could take the highway data needed.

Demand and Use Data

Conference participants generally agreed that data on demand for and use of transportation should support multimodal planning and cross-modal comparisons. Information about the scale and character of passenger and freight demand should be broken out by socioeconomic population categories and economic establishments. Data bases on demand characteristics should permit assessment of demand at national, regional, and local levels and should provide for the calculation of corridor-level throughput. Information on demand should also encompass unquantifiable data, such as impacts on land use of political influence and non-data-driven decision making.

Much of the demand and use data traditionally collected is still needed. In addition, better quality is needed for traditional origin-destination (O-D) data, which should be collected at a greater level of geographic and temporal detail.

User Behavior and Characteristics

The greatest number of identified traveler demand and use data needs fell under the category of user behavior and characteristics. Specific data needs related to this recommendation were identified as follows:

- Activity by location, including data on land use, housing, and employment;
- Trip generation by age;
- Journey to work by mode and trip length;
- Latent demand and induced demand;
- Time of day of travel;
- Use of time and deferral of trips;
- Trip chaining;
- Work schedule changes and incidences of telecommuting and teleshopping;
- Actual versus theoretical trip routing;
- External travel distribution;
- Local travel of out-of-town visitors, including business travelers, a common definition of which should be developed;
- Migration patterns of "snowbirds" (i.e., people who move to warm climates in the winter);
- Identification and measurement of customer satisfaction;
- Nonwork trip demand;
- Characteristics of the transportation disadvantaged;
- Changing trip generation characteristics;
- Social characteristics of users by mode;
- Demand characteristics of the elderly; and
- Usage characteristics by mode (vehicles per unit time, loadings, people versus freight).

Freight

Freight data have been neglected in transportation planning. The following demand and use data needs were identified with regard to freight:

- Freight movement by mode;
- Enhanced statistics on commodity flow;
- Freight demand by time (just-in-time delivery data, in particular);
- Accurate O-D and movement characteristics data for international freight;
- Border crossing information by vehicle type and by origin and destination;
- Port data;
- Cargo moving in transit through the United States; and
- Inter- and intracity freight and goods content.

System Use

It was the sense of the conference discussions that decision makers want to enhance their understanding of the composition of the traffic flow on facilities (i.e., the kind of vehicles and the nature of the passengers and freight being carried, not simply vehicle counts). Specific data needs in this regard include

- Different vehicle types broken out by origin and destination (i.e., use versus FHWA classification of roadways);
- O-D patterns of passenger travel and goods movement by purpose and by daily, weekly, or seasonal variation;
- Traffic counts, traffic volumes on highways, and passenger ridership on transit;
- Personal trips by alternative modes (e.g., light rail and bicycle);
- Vehicle use characteristics by type of vehicle (e.g., occupancy and classification), especially for high-occupancy vehicles;
- Vehicle miles traveled (VMT) and traffic counts;
- Travel time;
- More relevant characteristics of trip production and attraction; and
- Airport and ground access demand.

Conference attendees recognized the continuing importance of relating system use and surrounding land use patterns and economic activities, citing the following among specific data needs:

- Impact of different urban designs on travel behavior;
- Trip generation for land use development types, including trip length, mode, and purpose; and
- Trip attraction data.

An expanded area of interest in system use is special generators, such as the occasional major event (e.g., a national or international sporting event) or large special-use facility (e.g., a hospital) that generates exceptional traffic demands. The increasing importance of tourist demand and the interest in and use of recent events such as the Atlanta Olympics as proving grounds for transportation technologies strengthen this interest.

Specific data needs related to this recommendation were identified as follows:

- Trip-generation and distribution data on fixed special generators such as hospitals, prisons, universities, tourist attractions, and airports;
- Trip-generation and distribution data on special events; and
- Traffic impacts of special events by type and size of event.

Improvements in Demand and Use Data

User Behavior and Characteristics

[1] Higher-quality data should be collected on personal travel behavior, including trips, trip length, purpose, mode, time, and location or flows. Nuances such as trip chaining and mode shifts within trips should be captured.

[2] Data should be gathered on the impacts of strategies to influence system use, including traveler information, transportation system management (TSM), transportation demand management (TDM), and price and service elasticities.

[3] The Federal Transit Administration (FTA) and the Federal Aviation Administration (FAA) should be encouraged to conduct cognitive research on the influence of perceptions of security and safety on demand for transportation service (in particular, transit and airplane travel).

Freight

[4] Increased just-in-time freight deliveries and the impact of international trade on all sectors of the economy demand greater focus on freight data needs. BTS was encouraged to work with its federal partners to make national data on domestic commodity flows, international trade, trucking, and other aspects of freight transportation more specific to states and MPOs. BTS could also work with states and MPOs to foster local freight studies and to link local studies with the national data sets.

System Use

[5] A variety of new tools should be developed for continued multimodal O-D data gathering. Collection and analysis methods are especially important for data on vehicle occupancy and person trips, trip purposes, nonwork travel, and trip chaining. New cost-effective methods are needed for evaluation of vehicle traffic and for household interviews, diaries, mode-neutral data collection, and household trips.

[6] Data "mining" of existing sources would help locate existing and identify missing data on trip generation, which are widely available. TRB could conduct such a review, and FHWA could fund research into the traffic impacts of special generators and construction.

[7] More research is needed on the best ways of estimating passenger trips on barrier-free transit fare systems (systems that allow advance, one-point payment for all fares), for example, by looking at revenue streams to estimate passengers. More research is also needed into the effect of transit-oriented development on trip generation.

System Operations Data

System operations data should be based wherever possible on data obtained efficiently and unobtrusively from traffic and transit operations. Such data can form the basis for understanding demand and system performance. For example, analyzing system volume against capacity, especially during peak hours, provides an important snapshot of demand for a specific facility. Information on when and how many travelers violate transit fare policies or high-occupancy-vehicle (HOV) restrictions can support reassessments of policies as well as enforcement.

The working groups acknowledged that system operations measures are only as good as the definitions on which they rely and the performance goals they support. Agreed-on

definitions were recommended for such indicators as reliability and congestion. Transportation officials at all levels were urged to address the need for such definitions and to acknowledge and address the parallel universes of user perception and actual system performance. Additional discussion of the role of customer perceptions in assessing system operations and performance can be found in the section on Impact and Performance Data.

Reliability and Congestion

One important but underexamined aspect of reliability is its variation by time of day, day of week, time of year, and weather conditions. Information on personal dwell times (average time an individual spends in traffic or transit) is also valuable and needs to be designed, collected, and analyzed. Several participants suggested travel-time studies, broken out by mode for door-to-door travel and for transfers.

Several attempts have been made to define congestion for the purposes of measuring system performance (including NCHRP Report 398, *Quantifying Congestion*, to be published in 1997). However, the relative nature of congestion—its varied manifestation on systems of different sizes and its subjective perception by individuals—is an obstacle to the development of a single standard measure. Nonetheless, the working groups suggested several ways to articulate congestion measures:

- Collect and organize data to distinguish between congestion that results from incidents (nonrecurring) and that from capacity restraints (recurring), including incident data, vehicle volume and speeds, and location, extent, and duration of congestion;
- Refine data to evaluate the economic impacts of congestion;
- Measure the effects of human factors on traffic flow;
- Break out systemwide versus local (e.g., corridor versus intersection) congestion management measures;
- Collect and compare data on traveler perceptions of what constitutes congestion versus measurable congestion; and
- Maintain data on vehicle occupancy per hour, particularly for HOV lanes.

Data are especially needed to evaluate responses to scheduled disruptions (e.g., construction), special generators (e.g., special events), or unanticipated incidents. For example, information on the traffic impacts and nontraffic characteristics of catastrophes such as bridge failures is needed, so that data can be modeled and used to develop alternative routing plans (e.g., the conversion of two-way streets to one way by time periods). Information on the effectiveness of signals, signal inventory, and operation during construction periods is also needed.

Freight Operations

Freight operations are largely private. The proprietary nature of much freight information has posed a challenge for documenting systemwide transportation operations. Data on freight activity that are needed include turnaround time at marine and air terminals; factors affecting choice of routing for commercial shipments; and truck arrival times at delivery destinations. Some participants suggested better documentation of the value and impact of weigh-in-motion systems on truck safety. Many conference participants also suggested that knowing the effect of system pricing on freight planning would be helpful, particularly with regard to just-in-time delivery.

Jurisdictional Coordination

Systems operators do not typically interact or exchange data across local and state boundaries. This traditional, jurisdictional approach presents a barrier to using operations data for regional or statewide decision making. Policies to promote intermodalism—such as unified

regional transit passes and the establishment of intermodal hubs for freight—rely on the quality of data sharing and partnership among various jurisdictions. In addition, new information technologies (i.e., intelligent transportation systems) demand compatibility among local system components to be fully effective. Conference participants cited these trends to highlight the need for greater local-local and state-local coordination of system operational information.

Improvements in System Operations Data

Reliability and Congestion

[1] All levels of government should cooperate to develop a definition of highway reliability. AMPO and AASHTO should take the lead in collecting data on reliability (e.g., travel time).

[2] Better data should be collected to promote the understanding of congestion and develop common measures and definitions. The feasibility of developing definitions of congestion and delay should be evaluated and the impact of these factors on system performance by mode should be examined.

DOT could provide funding for a study by the Institute of Transportation Engineers (ITE) or a similar organization to attempt to define congestion and delay, and also to measure their effect on different subpopulations and changes in effect by season. Such a study could build on the findings of NCHRP Report 398, *Quantifying Congestion*. A federal pilot study, conducted with metropolitan areas and states, would help to develop a methodology for analyzing recurrent versus incident-related congestion, including traffic congestion due to special events.

Congestion monitoring will continue to be the prime responsibility of the local operator (state highway system, local public works department, MPO, etc.). With respect to nonhighway congestion, a new methodology is needed to characterize congestion and delay by nonhighway modes (e.g., transit, pedestrian, airline). Additional funding to support this might come from FTA.

[3] A pilot study was called for, perhaps under DOT's sponsorship and hosted by a metropolitan area or state, to collect and analyze data on the economic effect of system downtime (e.g., winter snowstorm recovery in the Northeast). This information was widely believed to be necessary for investment decisions and evaluation of economic development plans, particularly because just-in-time freight delivery is becoming more prevalent.

Freight Operations

[4] Estimation of trip activity rates, such as the method developed by ITE, should include freight-generation and distribution equations for urban area orientation and for site and land use orientation.

Urban freight movement was generally agreed to be a neglected area of study that has become increasingly important as the scope of long-range metropolitan planning has expanded to include private transportation operations. Among the subjects in need of research are estimation methods of level of freight activity (by ton and other measures) at intermodal facilities.

[5] Federal agencies should take the lead in exploring and facilitating integration of private freight data with sufficient privacy protection, for example, by examining BLS and Census Bureau practices and initiating discussions with the private sector. States and MPOs should talk to shippers first and should make the integration operational.

Time-of-delivery data are needed for transportation planning and system operations. The port authorities, states, and MPOs need to work together to integrate the data, with the states and MPOs taking the lead.

[6] MPOs and states should convene a forum to address the fragmentation of responsibility for system operations. Coordination is especially needed to facilitate data exchange to implement and collect information from ITS. It was suggested that federal guidelines for ITS development include all potential data customers and that FHWA provide funds to make this possible. States were urged to demonstrate leadership in gathering the appropriate players together.

Impact and Performance Data

Through the eyes of the user, system performance looks quite different from the facility performance that transportation managers measure. Many conference participants described the level-of-service measure for highways as too limited for assessing transportation operational performance, particularly in light of the increased focus on intermodalism and customer orientation. However, a broadly acceptable alternative has proved elusive and will require detailed study and consensus.

Performance Measures

Conference participants urged research to better orient performance measures toward customer perceptions and behavior regarding the reliability of the system, variability in travel times, and quality of trip. It was widely believed that measures of customer satisfaction should be a routine part of the evaluation of system performance and that qualitative measurements should be developed to evaluate the system's ability to move people and goods by corridors and specific locations.

Many participants called for federal support to improve the comparability of system performance data across modes, with periodic updates. Research and compilation of state and local practices would focus on which measures of performance make the most sense for assessing system reliability, delay, performance by time of day, and the impacts of maintenance and construction on the transportation system.

One aspect of research into performance measures could be cognitive research on their comprehensibility to decision makers and the public. The question arose whether level of service is easily understood or whether the more esoteric measures are equally valuable and understandable. Another question was whether performance measures are at too broad a geographic level (areawide measures) to be sensitive to changes in transportation improvements.

The following factors were often recommended for measurement to accurately assess performance in terms of user perceptions (using neutral data on system operations as a baseline):

- Travel times and speeds that the customer considers effective for all modes compared with perceived and actual times and speeds;
- Amount of delay acceptable to the user broken out by time of day;
- User costs;
- Value of user's time;
- User sensitivity to toll charges;
- Quality of trip (for which an agreed-on definition should be developed, taking into account the customer's perceptions);
- User mode preferences;
- User benefits relative to benefits to nonusers; and
- Customers' views about traffic-calming strategies.

Communities, Safety, and the Environment

Many participants believed that the impact of transportation on communities should also be better documented. Cross-modal system performance measures that address societal, eco-

nomic, and other broad goals are needed to move transportation decision making beyond capital cost assessments to choices that make the most sense for particular communities. Specific data needs relating to this recommendation were identified as follows:

- Impact of current system and decisions affecting it on different socioeconomic groups;
- Measurements of quality of life;
- A sustainability index;
- Social impact of transportation alternatives, primarily bicycling and walking; and
- Measurements of negative impacts of transportation improvements (e.g., noise, vibration, inconvenience, damage to community cohesiveness, effect on property values).

Access and mobility are particular areas of interest. Because social equity is of increasing concern in transportation, measures to address these issues were seen as critical. Data are needed to aid in evaluating the extent to which the transportation system provides access to employment, services, and recreation, as well as the connection between access to all transportation modes and neighborhood character (i.e., aesthetics, noise levels, safety). Data on the level of mobility afforded by bicycle use and walking, as well as on system support of those modes and the impact of investments in system support, were also requested.

Numerous participants noted the quality and availability of safety impact and performance data for highway and transit incidents and fatalities; however, one participant noted that more attention should be paid to personal safety (i.e., risks of crime). This comment highlights two important, emerging needs in transportation data. First, measuring system performance in terms of characteristics (number of automobile or rail accidents) can be complemented by a fuller consideration of customer preferences (concerns about carjacking on the highway or personal theft on public transit). Second, the best sources of data on personal safety, and especially on user perception and reaction, may be nontraditional sources, such as municipal police, eyewitness accounts, or the media. Participants supported the continued collection and distribution of the following information:

- Rates of fatal and nonfatal accidents by mode;
- Fatality and injury rates for automobile passengers;
- Customers' perceptions of safety (including personal safety) and the impact on choice of mode; and
- Correlation of delay and accidents.

In addition to vehicle inventory and use data cited in previous sections, data collection was suggested on the effects of the following factors on air quality and the environment, in part to meet the new air quality conformity regulations:

- System elements not harmful to the environment;
- Accurate emissions data for all relevant modes;
- Acceleration and deceleration;
- Transit ridership;
- Variety of and user responses to TDM programs and congestion pricing;
- System conduciveness to use of alternative modes, including bicycling, walking, and ferries;
- Environmental justice, the interaction between environmental considerations and concern for social equity; and
- Inventory of important habitats, to be used as a red-flag tool for future impact analyses.

Discussions at the conference reaffirmed the need to characterize the effects of the whole transportation system on land use and urban form. Transferable data are lacking with which to measure transportation behavior changes related to different land use scenarios, reduced trip rates, trip length, and mode choice.

Economic Impacts

The role of transportation in a region's economic performance deserves greater attention, according to numerous workshop participants. Data needs include

- Economic impact of congestion (especially on freight movement);
- Impact on personal and business incomes of transportation system decisions; and
- Economic impacts of transportation programs designed to reduce energy consumption or environmental degradation.

Performance measures for freight movement should be defined in terms of the characteristics and services most valued by the trade community, including ease of access to ports, efficient processing and permitting, and streamlined cross-border inspections.

Improvements in Impact and Performance Data

Performance Measures

[1] Research was called for to develop new level-of-service concepts that would replace the current measures and would focus on customers' perception of service. TRB, NCHRP, and the Transit Cooperative Research Program (TCRP) were named as possible partners to conduct such research.

Some participants recommended that a consortium of states, MPOs, and DOT identify an acceptable substitute for measurement of level of service, perhaps incorporating a measure of customer satisfaction or linking level of service to such a measure. TRB was encouraged to spearhead such an effort.

It was also suggested that DOT, AASHTO, and AMPO convene groups using performance measures to share information and discuss ways to produce useful outcomes for transportation decision makers. AMPO could ask political leaders how data on performance could be presented to them so that it is understandable and can be integrated into their decision-making process as well as which performance indicators they are most interested in.

Participants often expressed the conviction that transportation decision makers at all levels should be involved in defining the customer, identifying customer needs, and integrating user evaluation of the system into planning and decision making. MPOs and state departments of transportation were identified as the appropriate agencies to collect performance and impact data that would be fed back into the system design and transportation improvement processes. The collection and analysis processes should be designed to capture information on the system, the users, the measurable performance of the system, and the user's perception of system performance.

[2] Before-and-after studies of project effectiveness were called for. The question arose as to how the effectiveness of improvements can be measured. Of particular interest were measures of effectiveness for ITS implementation.

Communities, Safety, and the Environment

[3] A lexicon of definitions of accessibility and mobility should be compiled, giving consideration to definitions that are likely to be easily understood and used by decision makers.

[4] More and better data should be obtained that describe the impacts of the transportation system on communities, urban form, and populations. DOT could develop methodologies, performance measures, analytic tools, guidance, and techniques to help states and MPOs assess the contributions to and impacts of transportation on quality of life (both personal mo-

bility and other important goals of community life) and to communicate those impacts clearly to the public.

[5] Better data on the security and safety of the transportation system should be collected. Federal, state, and local agencies should collaborate to define core items for safety data collection and establish linkages between safety and other data bases. Participants expressed concern about the efficiency and effectiveness of methods used for safety assessment.

[6] More and better data should be gathered to evaluate the impact of the transportation system and decisions affecting it on the environment.

[7] Efforts to compile data on fragmentation of habitat need to be coordinated, and these data need to be related to geographic information on transportation networks and facilities. Several participants named EPA, DOT, the U.S. Fish and Wildlife Service, and U.S. Geological Survey as possible collaborators to address this need.

[8] Many participants called for an alternative to the current method for obtaining air quality data through traffic sampling, which was widely seen as burdensome to the states and resulting in data of questionable quality. Traffic sampling is currently under examination in the HPMS review process. It was suggested that DOT and EPA involve TRB in research into a better approach to traffic sampling, especially with regard to air quality data.

[9] Data are needed that measure the transportation system's energy use and energy consumption by type of user.

Economic Impacts

[10] More data should be collected to determine the impacts on the economy at the national, state, and regional levels of all decisions affecting the transportation system, including investment, lack of investment, system changes, and service changes.

[11] A frequent request was for the development of performance measures suitable to freight. TRB and DOT could lead an effort to develop such a measure. A cost-benefit analysis for truck freight operations was suggested for use by states and MPOs that would include a yearly update of truck vehicle operations, time, safety compliance costs, capital cost, and environmental compliance costs. This area of research was recognized to be highly controversial and complex.

[12] AASHTO, FHWA, FTA, BTS, and the Office of Management and Budget were encouraged to work together to develop comprehensive measures of time by value and purpose for economic evaluation of long-range plans.

Methods

Many suggestions regarding data methods were similar from one topic discussion to another. Areas mentioned in all or nearly all six topic discussions are customer orientation, ways to improve how data are shared and presented, and public-private data coordination. The need to harness new technologies to enhance data efforts was a major theme of discussions about methods.

Defining the Customer

In discussions of socioeconomic and financial data, the customer was most often interpreted as the data user (i.e., transportation staff or decision maker). Especially in discussions of the

Highway Performance Monitoring System (HPMS) and Section 15 transit system reporting requirements, participants believed that a valuable way to ameliorate the data-burden dilemma is to promote the understanding that data producers are also data users at various times. To the extent that agencies seeking or requiring information understand the importance of involving data producers in discussions of what type of data should be collected and how, the end-use data will be strengthened. One group recommended that the federal government develop guidelines to build a sense of ownership and to ensure uniformity among collectors of operational data at all levels of government.

In discussions of system supply, operations, demand, and impact, the customer referred to was usually the transportation system user, and the criterion for successful data activity was its relevance in the context of a broad canvas of community desires. TRB was often named as the lead agent for fostering research and discussion on information pertaining directly to transportation agencies' missions in serving the customer, such as travel comfort, system damage, safety, and delay data.

Some participants indicated that the public sector does not understand how to collect and analyze the data on customer perspective most relevant to system operations and performance (this criticism was aimed more at the highway sector than the transit sector). User input and responses to information about traffic performance and system reliability in all modes were mentioned for inclusion in evaluations of efficiency, a concern that reflects the groups' frequent discussions of user-oriented alternatives to the level-of-service criteria, which measure vehicle flow. This problem was believed to be a priority for attention and a current obstacle to the development of relevant measures of the impact and performance of the transportation system.

Presenting Information

Many problems faced by transportation data professionals are rooted less in the data issues themselves than in the absence of clear, concise, and compelling ways to demonstrate data to decision makers. GIS, graphics, and other communications tools are important assets, along with local demonstration projects that can show officials the effects of specific approaches (e.g., toll charges, transit express service, and HOV lanes) on metropolitan travel.

Conference participants gave special consideration to the needs and responsibilities of decision makers representing system users (e.g., elected or appointed officials). Demonstrating the value and relevance of data was considered crucial to continued success with this audience, particularly at the local level, as concerns for individual privacy become more prevalent and as funds for data activities become more scarce. One working group strongly recommended closer attention to the interaction—and often the discrepancy—between the public decision-making process and the technical process. Visually compelling presentation methods that could demonstrate the impacts of transportation proposals are lacking, and the integration of graphic displays into metropolitan travel demand forecasting was encouraged. For example, MPOs need to enhance the display of the transportation simulation networks they use to characterize highway and transit lines in their data files. Currently, the networks are abstract interpretations and may not cover geographic areas to the extent needed for metropolitan and statewide transportation improvement programming. Many conference participants called for better ways to present data at a scale appropriate to the task (e.g., long-range planning, forecasting and modeling, major investment analysis, or short-term transportation improvement programming).

New Technologies

Geographic Information Systems and Global Positioning System

In addition to their value for presentations and visual analysis, geographic information systems (GIS) have many potential applications: assessing system characteristics, evaluating

methods for addressing system capacity requirements against an accurate backdrop of environmental and historic resources, documenting land use and travel patterns, and even tracking financial data. Among the most consistent suggestions was improved linkage between GIS and travel demand software. Global Positioning System (GPS) technologies can increase the accuracy of GIS systems by collecting real-time data on system operations. New technologies can yield economies for data activity, including faster exchange and the ability to layer and more easily synthesize or compare different types of information.

GIS and new, high-resolution imaging technologies can provide the more detailed land use and transportation profiles necessary for increasingly sophisticated modeling and forecasting processes. Participants discussed ways to capture detailed data on trip making (trip length, chaining, purpose, etc.) through the GPS devices deployed in rental cars. These data could then be used to study visitor trip patterns and purposes.

Of special interest to several conference participants was the potential for integrating financial data with data on supply and system characteristics in GIS, which could then be made available to decision makers who participate in financially constrained planning. In general, financial cost accounting and revenue projection received a great deal of attention in many of the discussions of data methods.

GIS and GPS technologies could be applied to determining site specificity for all data items. For example, all data on supply and system characteristics could be geocoded and referenced to a GIS-based system. Performance, incident, and safety data could also be integrated into such a system.

Intelligent Transportation Systems

Much attention is being devoted to the potential of ITS for improving the efficiency and performance of state and metropolitan transportation systems. These emerging technologies also have profound implications for data collection, storage, and distribution. Capturing and sifting the vast amount of data produced through ITS will be a significant challenge.

Participants at the conference believed that the impact on transportation decision making of technologies such as the Internet and other telecommunications advances is an important area for federal agencies to monitor. It was suggested that this be done in partnership with other appropriate federal agencies (e.g., the Federal Communications Commission).

Many agencies, organizations, and private companies have a stake in the success of ITS, but no clear leadership has emerged to address the data collection, planning, and programming opportunities inherent in these technologies, particularly the extraordinary capabilities they possess to break down information by time of day and by individual user (for example, ITS could be instrumental for evaluating HOV use). Conference participants recommended specific roles of agencies and organizations, which are described at the end of this section.

The level of detail made possible through ITS contributes to greater concern for individual privacy. The question of how to protect the confidentiality of information provided by respondents to surveys is certainly not new, but the malleable boundaries of the Information Age have elevated this concern. Less-intrusive data-collection instruments were called for.

The quality and usability of ITS data were discussed by most participants, with the caveat that "more is not necessarily better." One working group described the danger of "stuff overload" and urged the retention of traditional data methods, particularly for collection and presentation, because not everyone is proficient in the use of advanced information technologies. Methods for sampling from continually incoming ITS data may need further attention, a concern that one participant compared with the concern about the shift to continuous census data collection. A related observation was that although technologies such as the Internet make widespread data collection more feasible, such tools are still far from being in universal use. Research is needed into potential selection bias in reliance on the Internet as a survey instrument.

Improving Data Methods

Defining the Customer

[1] Data professionals at all levels were urged to learn about, use, and improve on recognized methods for discovering and measuring customers' needs and attitudes. Focus groups and surveys were often mentioned as valuable means of collecting the views of system users.

Presenting Information

[2] DOT should continue support for the development of linkages between geographic systems and transportation data bases with the goal of improved presentation of information to decision makers and the public.

New Technologies: GIS and GPS

[3] Government agencies and private organizations at all levels (national, state, and local) should have a role in making optimal use of GIS and GPS for data storage, synthesis, analysis, and presentation.

[4] Research is needed into the costs of creating a GIS data base of transportation systems that would include both state and metropolitan data, including an inventory of successes and failures to date. Several participants believed that NCHRP was the appropriate leader for such research.

[5] BTS and its partners on the Federal Geographic Data Committee should continue to work with other DOT officers, states, MPOs, and industry groups to implement and maintain the nationwide geographic data base for transportation. Federal agencies would work with state and local partners to develop common formats and definitions for geographic data, to sponsor research on improved methods of geographic data integration, and to support state and MPO efforts to build and update the national picture with local data.

[6] States and MPOs should be primarily responsible for the integration of transportation data into GIS-based systems, perhaps with financial assistance from DOT through a pilot study. State and local police were suggested as logical agents to implement the GPS for accident site locations. For example, the Kansas State Patrol is among those already using GPS devices to locate accidents.

[7] Because remotely sensed data from satellites available to civilians are improving in resolution, variety, and cost-effectiveness, a major new coordinated effort is recommended to bring these data to state DOTs and MPOs. Members of the Federal Geographic Data Committee (including BTS and the U.S. Geological Survey) could work with states and MPOs in this effort.

New Technologies: Intelligent Transportation Systems

[8] States and MPOs should be key players in ensuring that ITS technologies are designed to collect system operations data and that ITS data can be used to validate transportation models. TRB and DOT were encouraged to monitor emerging ITS technologies and relevant regulations to ensure that state and local data needs are met and that information derived from these systems is useful in state and local decision making.

[9] The federal government should continue to coordinate priority-setting for the use and maintenance of ITS data. DOT-sponsored pilot studies could examine new technologies to collect vehicle occupancy and classification data that contribute to enhancing the trans-

portation planning process. ITS America, AASHTO, and private organizations were encouraged to work with the agencies funding ITS to ensure that components are built into these systems to support data reduction, retention, and dissemination to enhance the systems' usefulness for planning and programming. DOT, TRB, and AASHTO were suggested as partners in the research and development of software aggregation tools to allow formatting and summarizing of ITS operational data for planning.

[10] Transportation agencies should work with the National Governors Association and National Conference of State Legislatures to develop model state legislation for the protection of the privacy of respondents using the Internet and other advanced media, and to ensure the confidentiality of data. Cognitive research could also be carried out on privacy issues to determine how people feel about being "tracked."

INSTITUTIONS

An understanding of the relative roles of organizations at the national, state, metropolitan, and local levels is integral to the discussion of how institutions should support data activities for state and local decision making. An overview of these roles, with proposals from conference participants for strengthening them, precedes the sections containing general recommendations for institutions.

National Organizations

AASHTO and AMPO were widely viewed as leaders in determining or initiating joint actions between states and MPOs, documenting best practices, and facilitating continuing education of transportation professionals. These organizations also are in a powerful position to suggest legislative changes that will improve data activities.

As important partners in ongoing research, proper storage, and widespread dissemination of data, these organizations frequently coordinate peer review and research into means for enhancing data. Discussions at the conference highlighted the need to strengthen the clearinghouse role of AASHTO and AMPO, as well as to recognize the importance of these groups as liaisons with federal agencies and other national organizations.

Federal Agencies

It was widely agreed that the federal government is responsible for "universe" data (e.g., national samples, national activity factors, global trade data) and plays a major role in the collection, analysis, and dissemination of financial data. Strengthened partnerships were called for between DOT and other key federal agencies such as the U.S. Department of Commerce, Federal Communications Commission, and U.S. Geological Survey so transportation-related data from these agencies can be made more compatible with transportation data as well as more useful to decision makers. At least one opportunity already exists in this regard: coordination of data on transportation and other geographic information such as data on land use through the Federal Geographic Data Committee, chartered by an Executive Order to create the National Spatial Data Infrastructure.

As the primary agent for supporting research into data methods and coordinating data standards, the federal government was called on to lead the way, in close collaboration with the states and MPOs, in the review and establishment of a clearinghouse of local and state data methods. The federal approach to data activities should mirror the institutional shift in other areas of governmental practice, from a "top-down" to a "bottom-up" process for policy setting. In data activities, this change translates into a federal emphasis on aggregating data instead of requiring it within parameters that reflect little state and local input.

Specific actions that BTS, FHWA, FTA, and DOT's other modal administrations could take with regard to increasing their responsiveness to state and metropolitan priorities include the following:

- Completion of the evaluation of the Highway Performance Monitoring System and implementation of the resulting recommendations,
- Assessment of functional classification systems for highways and other modes,
- Consolidation of FHWA and FTA reporting requirements,
- Improvement of state and MPO access to comparative cost and revenue data, and
- Support of conflict mediation approaches to resolve disagreements over data (national organizations such as AASHTO and AMPO were also encouraged to take this position).

Current federal efforts in technology sharing, transfer, and training were generally described as having great value. Continued efforts in this direction gained broad support among participants. However, federal legislation was sometimes recommended to remove barriers to the sharing of data among institutions, between the public and private sectors, and among levels of government.

States

Serving as brokers between the federal government and the MPOs, and focused increasingly on partnership and outreach to nontraditional agencies, states were seen as stakeholders in removing barriers to effective data activity, especially data sharing. State DOTs are data "customers" who must fulfill the requirements of statewide transportation policy as defined by the governor and legislatures. States also gather data, specifically on system characteristics, functional classification of highways and rights-of-way, project finance, and geography. Statewide clearinghouses were encouraged, especially for GIS data. States have a role in coordinating data standards and in priority setting for data collection. Training, technical assistance, university staff development, and funding for data research remain important functions for the state. Also important is the need for a statewide direction for transportation policy.

Metropolitan Planning Organizations

MPOs were attributed with a major role in promoting public participation; outreach to nontraditional agencies and groups has become more important in recent years. Like federal and state governments, MPOs also are focusing on the need to strengthen partnerships.

As data collectors, MPOs are responsible for regional data, and many MPOs have made strides in bartering or buying data. For example, the Metropolitan Area Regional Council in Kansas City purchases business and economic data, and the Kansas Department of Transportation has purchased employment data for the state's MPOs from other state agencies and from private marketing firms.

The data methods for which MPOs are best known are the various modeling processes for land use, air quality, and trip forecasting. In the research arena, MPOs frequently host pilot studies of innovative methods.

Local Agencies and Authorities

Local governments collect local road system data; conduct or participate in comprehensive land use planning, zoning, and issuing of building permits; coordinate services related to transportation, including environmental protection and safety; and maintain jurisdictional data (e.g., information on city limits). Transit authorities collect and maintain transit data.

Local governments also are data customers in the sense that decisions to propose specific projects may be influenced by such information.

Local transportation departments are responsible for detailed safety data and keep close tabs on system characteristics and conditions (e.g., through operations data, bridge data, and functional classification of rights-of-way). These agencies also have the closest contact with the public. They therefore can have important insights into the performance of and demand for local systems.

Strengthening Institutional Roles

Partnership

[1] Data gatherers and data users should form partnerships and determine clear responsibilities for specific data activities, both among jurisdictions and between the public and private sectors.

Data need ownership, care, and feeding, but convincing various jurisdictions to accept the responsibility is a problem. Each level of government needs to define its role as a stakeholder in data management. The Texas Department of Transportation recently issued a statement of policy in this regard, which can be considered a model.

Data needs for the general good are especially vulnerable to becoming "orphaned" when private providers do not perceive the profitability of collecting and providing the data, and when no agency perceives the usefulness of the data for its specific jurisdiction.

[2] States and MPOs do not have the resources to investigate the full range of transportation data available. Although BTS does produce a data catalogue, efforts in this area should be expanded and a compendium of secondary data sources added. Information on how to fuse secondary and transportation data should be included.

The public sector in transportation spends considerably less per professional on providing access to data resources than many other sectors, including those for medicine and agriculture. Given the high value of data to the field, this situation ought to be remedied. A comprehensive catalogue of data sources is needed, but the sector's need goes beyond that, perhaps even to a clearinghouse that would store and disseminate all publicly available transportation data, as well as provide technical assistance to its customers. Any such effort should include points of contact for data sources to assist potential users in determining data quality.

BTS's National Transportation Library could assign staff to be responsible for clearinghouse functions such as providing assistance in locating alternative data sources and distributing responsibility for acquiring, storing, and providing access to data. AASHTO and AMPO could provide clearinghouse functions with regard to information on institutional processes at state DOTs and MPOs, for example, detailing the procedures used to develop performance measures.

[3] Public-private partnerships and new institutional relationships for development and distribution of data should be explored.

To assist all data-collection efforts undertaken by state and local agencies, partnerships with universities and private companies were suggested, which might assist specifically in improving collection methodologies.

Democratic access to data was discussed as an important federal enforcement issue. For example, several MPOs and states are frustrated by the inaccessibility of ES202 employment data. The federal government, which funds collection of these data through the U.S. Department of Labor, was encouraged to take a hand in ensuring access for states and MPOs. Federal guidelines and principles were suggested for balanced public-private partnerships for data collection and dissemination. Several participants believed that agencies should be more willing to purchase or trade better-quality public and private data.

In the area of financial data, federally guided methods or institutional arrangements were called for to provide specific information from the federal government to states and from states to MPOs.

[4] Public agencies and private entities should increase coordination regarding data access. Collaborative agreements with trade organizations could be useful to this effort, and cost-sharing or purchase of data should be considered.

Partnerships with private data holders were considered by most participants to be crucial to getting better-quality data, particularly with regard to employment and freight data. However, the competitive environment among private companies and the attendant proprietary nature of their data pose a significant obstacle to realizing this goal.

It was suggested that BTS take the lead in facilitating access to and use of private data through "win-win" arrangements such as buying or sharing data, partnering, and privatizing collection, analysis, and storage.

[5] National research on data sharing between metropolitan areas and states was frequently requested, and numerous participants suggested a training syllabus on data sharing and partnerships.

Participants expressed interest in making data resources available for identifying comparable metropolitan areas and finding ways to discuss issues related to transferable parameters and comparable travel behavior data. Examples of data and tools for discussion include HPMS, household travel surveys, and instrumented versus uninstrumented ITS miles. A proposed study was described that would be similar to the Characteristics of Urban Transportation Demand (CUTD). DOT already funds a research project on how states or MPOs can share nationwide travel survey data (or any other national data sources), for example, how locales can "borrow" NPTS data to meet their own needs.

[6] A consortium of federal modal agencies and state, regional, and local transportation agencies should determine key data elements, conventions, and protocols. TRB could facilitate this process.

Differences in data-collection and analysis methods among transportation agencies at all governmental levels hinder the exchange of valuable information. It is necessary that an effective coordination process for data exchange be created, one that relies on common formats, flexibility, aggregation, sampling, and methods. For example, it would be helpful if all DOT surface transportation agencies had mutually consistent financial data bases that incorporated standard items and accounting practices.

DOT is a logical agent to provide guidelines for standardizing a variety of data and data-collection methodologies, such as those pertaining to causal relationships for safety, but it should not itself establish standards.

BTS could relate local data over time by making use of compatible formatting and measurements for data sets collected at different times. It might also develop a data dictionary for critical transportation inventory elements to enable bottom-up distribution of data elements for creation and maintenance of a base inventory.

New Technology: GIS and ITS

[7] The U.S.Geological Survey, ITS America, the Joint Program Office of DOT, and BTS were encouraged to cooperate in developing a national GIS. Federal agencies could coordinate with state and local governments to maintain and update the system, to explore an ITS connection, and to look into funding for state and local transitions from their current GIS systems to a national version. All levels of government should cooperate with the private sector (especially freight) with regard to data needed for a national GIS transportation data base. For example, it was suggested that all levels of government coordinate with public and private rail agencies to develop a data base of railroad crossings and add it to the GIS data base.

Freight

[8] A forum between public-sector data stakeholders and national freight stakeholders was suggested by many participants, with the goal of sharing data. TRB, BTS, AMPO, and AASHTO were among the groups identified to coordinate such a forum.

This national forum would go far toward encouraging better relationships between the public and private sectors and toward opening discussion of such key elements as how to get freight flow information without jeopardizing the privacy of companies. National associations and federal agencies should work with national private-sector businesses in the freight industry to determine what data they need from transportation agencies and what data sharing could be realized. The TRB Committee on Freight Transportation Data can help define free or fee-based freight data sources, and bartering is also a possibility. DOT could review existing data sets to ensure accurate and usable freight information that is appropriately aggregated to support transportation planning and decision making at state and local levels while maintaining private-sector confidentiality.

Air Quality and Other Environmental Data

[9] DOT, EPA, and TRB were encouraged to convene a dialogue between the transportation and environmental (i.e., air quality) communities. Topics that could be broached at a transportation environmental roundtable include the need for education on how the emissions performance process works, discussions of needs in analytical accuracy, weaknesses in current air quality models and methods for addressing them in new models, and the need for tools to evaluate broader externalities related to impacts of improvements after implementation.

KEYNOTE PANEL

Role of Information in Transportation Data Content, Analysis, and Institutions

T. R. Lakshmanan, *Bureau of Transportation Statistics*
Robert E. Skinner, Jr., *Transportation Research Board*
Francis Francois, *American Association of State Highway and Transportation Officials*

The focus of this conference is the importance of data to support state and local transportation decision making from identification all the way through to interpretation. Substantial changes are under way, including accountability, performance measurement, a broadening of the current mission within individual agencies and organizations, creation of new programs and new projects, and addition of new talents and skills. The panelists were asked to help set the scene for discussion of opportunities and challenges within this framework.

T. R. Lakshmanan

This is a very important conference, likely to contribute to the efforts that BTS, TRB, AASHTO, AMPO, and their many customers plan to pursue. The conference program calls on the participants to develop recommendations to help improve state and local transportation decision making in the future. That is a broad and challenging assignment. We are dealing with a period of considerable socioeconomic change, three aspects of which I would like to discuss.

The first aspect is the ongoing upheaval in technology. Everybody knows that information technology is symbolic of the kind of technologies that are being introduced. Such technologies are transforming the production system and the transportation system.

The second aspect is the evolution under way in the institutions governing transportation. Until congressional action is complete on the New Economic Crossroads Transportation Efficiency Act (NEXTEA) submitted by the Clinton administration, we will not know to what extent the institutional context for transportation programs will be changed. The expectation

is high that there may be institutional innovations in terms of greater flexibility, devolution, and new financial instruments. A further institutional innovation is the notion of accountability in government. We have to justify our agency resources in terms of the final services we provide our consumers.

The third aspect, which is less tangible but very significant, is cultural background, one element of which is the end-of-the-century view. Leaders who set the public agenda often talk about the challenges of the 21st century, the necessary preparations, and the bridge to get there. I mention cultural background because of those metaphors relating to the way we begin to think about the future of transportation. Therefore, it is critical that we better understand the nature of ongoing change as we use such metaphors.

First, a few views on the value of information. The famous lexicographer Samuel Johnson talks about the value of counting. Counting is what we statisticians do. We count and collect data to make the vague and indefinite clear and precise. John Locke, the English philosopher who greatly influenced both the English and American Constitutions, said, "I attribute what little I know to my having not been ashamed to ask for information." It is paramount to seek knowledge from the data that you have gathered. To go one step farther, transportation information is for decision support.

There are two important aspects of counting: counting transportation and making transportation count. In counting transportation, you always ask three questions: Are we counting the right thing? Are we researching the right phenomenon or process? Are we looking for information and a knowledge base to support decision making? If the answer to the first question is yes, it is best to ask, Are we measuring those things correctly? Are we measuring outcomes? How appropriate are our measures of outputs and inputs? How reliable, timely, and consistent are the data?

There are a number of prerequisites to making transportation count. You must be able to distribute the data extensively, to exchange the data, and to engage in data fusion, that is, the merging and juxtapositioning of diverse data bases. Data fusion is very important for data analysis, and great advances have occurred in that area in the past few years. By merging or juxtaposing the information that becomes available from very different sources, you can see new relationships and infer new connections.

We interpret and analyze the data and gain increased understanding of transportation patterns and trends, all the while guided by three types of decision perspectives—strategic, management, and operational. If the perspective is strategic, you ask, What do I want to do in the future? What investments are appropriate?

From a management perspective, you need to know what objectives should be achieved and to what extent the information is useful to management. These four questions cover the management perspective:

- How can we support good management decisions on the basis of data and analysis?
- Is the information used appropriately to support the decisions? (This is the critical question.)
- Are the information and knowledge producers gaining the confidence of the professionals involved, as well as that of policy makers?
- What can be done to improve matters?

From the operational perspective, the change in information technology has produced large quantities of data, and the vastly expanding data base can, if structured properly, provide decision support to operate transportation systems. The key question is, How can we use the enormous richness of data to develop guidance for management and for operational planning in transport agencies?

This conference is significant in terms of identifying the information necessary to support state and metropolitan decision making. We are witnessing and anticipate further enormous structural changes in transportation. We should think of the emerging transportation system at the state level in a dynamic, not in a static, context.

Most people know that the programs that we have today are really solutions for yesterday's problems. For each of these programs, interest groups and support groups have developed over the years. Where are the interest and support groups for the dynamic, future-oriented enterprise in which we are now involved? Perhaps the participants in this conference have that role. This conference may be a turning point, developing a response to the dynamic situation. What can we possibly learn, or what should we attempt to learn here?

The total gross domestic product (GDP) in the United States in 1995 was about $7,240 billion. That is the value of goods and services produced in a typical year, of which the transportation-related share is $771 billion, or about 11 percent. In comparison, education has only a 7 percent share and health has 14 percent. Eleven percent of the net income produced in the country is from the transportation sector, so transportation is a really big player.

Most of the transport GDP is produced by the private sector. Only 18 percent is produced in the public sector, namely, state, local, and federal (including the Department of Defense). To make efficient and effective choices, improved transportation information and knowledge are critical for choices in the private transport sector. A major purpose of transport information programs is to help the functioning of private transport markets.

Of the 18 percent of the GDP produced by the public sector, only 15 percent is attributable to federal sources. Of the 78 percent produced by state and local sectors, most of the value added in public-sector transportation is at the state and local levels, not at the federal level. The remaining 7 percent is generated by the Department of Defense, which buys a lot of planes, ships, and transport infrastructure. If mistakes are made in the state and local systems because of poor information, one can say that they are much more inimical to U.S. economy and productivity than similar deficiencies at the federal and local levels. Of course, the private sector is dominant.

Some changes are also taking place in the context of all transportation systems. As the great American philosopher Yogi Berra said, "The future ain't what it used to be." In the last 25 years, per capita income went up as the population grew 30 percent and the GDP grew nearly 100 percent. Now look at some of the transportation aspects of the economy, keeping in mind the 100 percent increase in GDP. The value of international trade in constant dollars increased more than 475 percent from 1970 to 1995. International trade in goods as a proportion of GDP was 8 percent in 1970 and almost 20 percent in 1995. (Note that this is 20 percent of the 1995 GDP, which is twice as high as that in 1970.)

Enormous growth in transportation, taxing the existing infrastructure system, took place during this period. Domestic freight registered a 65 percent increase. International waterborne trade increased 93 percent, almost the same rate of increase as the GDP during in the same period. In addition, intercity truck ton-miles grew 124 percent and aviation freight ton-miles witnessed a 465 percent increase.

During the same period there were basic changes in the economy. The first aspect of this change is what I call a "dematerialized" economy, by which I mean that the economy is using fewer materials and less energy per dollar of GDP than before. Look at some traditional materials such as steel, cement, and paper, which formed the backbone of the industrial economy. For $1 of GDP (in constant dollars) from 1950 to 1990, fewer materials were used than before, in spite of a much richer and varied economy and our consumption of more goods and services. We are becoming less and less material- and energy-intensive than before. More of the value is being added in lighter goods, higher-value goods, and information and knowledge-based services.

The dematerialized economy has obvious implications for transportation. Markets have become global. We sell our products, import goods for our production and consumption, and visit leisure-time destinations all over the world. The nature of our transportation institutions is changing as well. In the past 20 years, we deregulated transportation services and privatized many transport activities, and a variety of incentives are being offered to promote private financial participation in infrastructure investments as well as in some infrastructure services. In some countries—New Zealand, for example—this trend toward privatization of transport infrastructure services is quite advanced.

Another development is the incorporation of transportation into production activities. Some producers do not engage in the final assembly of a product. Logistical companies collect (on a "just-in-time" basis) various component parts for assembly and delivery. Thus, production and transportation are becoming highly intertwined.

According to 1995 statistics for exports from metropolitan areas, Detroit, Michigan, is the largest exporter in the country; San Jose, California, is the second largest. There's a great difference in the ranking of the top 10 metropolitan areas and the ranking of exporters.

Another major change is taking place. Twenty years ago nobody could have predicted the regional shift between 1980 and 1993 in port trade. The East Coast, particularly New York and New Jersey, was dominant in 1980; now West Coast ports are dominant. This shift took place in a very short time, suggesting that change is afoot in terms of where goods are coming from and where they are going as well as what is being exported and where it is going.

On the basis of data from the Commodity Flow Survey, eight high-value commodities with a reported worth of more than $5,000 per ton account for only 2.1 percent of the total tonnage moved in the country, yet they account for 41.2 percent of the total value of goods. These items include computers, instruments, electrical and other machinery, apparel, and transport equipment. Half of the value is in a few high-value, light commodities that account for only 4 percent of the total tonnage, whereas raw materials, natural resources, food products, heavy industrial products, and the like account for 96 percent of the tonnage and half of the total value.

A change in the structure of the economy is under way—changes in sectoral composition and in structural and spatial aspects, with corresponding implications for transportation. External markets are going to grow much more rapidly in transportation. The demand for transportation, indeed for all kinds of service in transportation (vehicles, infrastructure services, traffic control, etc.), is growing more rapidly abroad. In the first two or three decades of the next century, transport demand is going to be dominated by Asia and Latin America. As American transportation firms participate in meeting this demand, what consequences will follow for the U.S. system?

In many growing industries, the half-life of a new product is very short, just a few years. What is being produced is changing, and production inputs are likely to change frequently. What is being transported is changing how it is being transported. These fundamental changes are rapidly taking place in the transport system.

Information technologies allow two kinds of improvement: we are able to do "old" things—things we have done before—faster, more cheaply, and more reliably and safely; and new activities are available. Information technology also provides major support for transportation operations. Information technology is very different from earlier major transportation innovations. For innovations like jet aircraft or the diesel engine to spread broadly, the industry had essentially to sacrifice still-functioning equipment, which slowed the spread of the new technology.

Information technology, however, essentially complements transport technology. Information technology makes existing transport equipment function better and more productively and therefore it is developing very quickly. It permits older transport services to be cheaper and better and also enables the introduction of new transportation services. The computerized reservation system, for example, is not only a reservation and booking system but has allowed many new services for the airlines—financial analysis, marketing, leisure travel services, and so forth. The changes created by information technology have been taking place for some time, but when the way we work and interact with others changes because of information technology innovations, bigger changes may be in store.

Just to complete the story, demography is destiny. If a demographic change occurs now, we will experience the consequences 15 to 25 years later, like the passage of the baby boomer generation through the seven ages of man. The anticipated aging of the population in the next 15 years is a case in point for transportation.

Keep these dynamic economic, demographic, spatial, and institutional changes in mind as you think during this conference about what we need to do and what can be done. Some of these dynamic factors operate in the short term, and others develop in the long term. Ulti-

mately we are concerned about conversion of information into knowledge to support state and local transportation decision making. What level and type of investments are appropriate? What kinds of safety provisions should we develop? What management initiatives can be supported by the available information? What guidance is provided by the information for operational activities?

At BTS we are trying to democratize the access of information to all our customers, using devices like the Internet, CD-ROMs, other data products, or other kinds of mechanisms. It is most important to realize that social gains are high when you decentralize knowledge in an emerging era—the 21st century—when a large number of institutions will be making decisions. Information is the glue that holds these institutions together and coordinates their activities.

The more information that we make available by democratizing data access for a larger number of data users, the more new knowledge will be created and the better will be decisions made by customers. In the private sector, information provision, knowledge creation, and better decision making are constantly occurring as subcontractors provide ideas for the prime contractors and vice versa.

The last issue I want to discuss is measuring the performance of systems and agencies. Two kinds of measurement are involved: how well the transportation system is doing and how well individual transportation agencies are doing. As you know, a great deal of information is being collected by information technologies on the operational activities of transportation agencies. For example, in aviation, a large volume of information about normal operations is collected by air traffic controllers, radar, inspectors, and weather forecasters. For instance, during a Boeing 777 flight, data on 700 flight parameters are collected eight times a second. Analysis of these data along with the data on the ground can reveal what kind of weather and other conditions lie ahead for the planes that come through an hour later, 20 minutes later, 15 minutes later, and so on. From a safety perspective, this information is terribly important. When a confluence of unusual events and special circumstances produces a disastrous result out of simultaneous occurrences of what would otherwise be common events, the system collapses. In other cases, the gradual evolution of procedures, aging of aircraft, or an interaction of factors can lead to dangers. In such cases, analysis of large amounts of data could predict what is novel and what is different, and we could anticipate potential threats to safety so as to take effective countermeasures.

If you look at certain daily travel patterns in metropolitan areas—to determine what the peak times are, where there may be special patterns, and why the informally observed traffic delay patterns on a Monday and Friday seem to be somewhat different from those on Tuesdays, Wednesdays, and Thursdays—can these patterns be checked by using information from intelligent transportation systems? If the differences exist, why are they occurring? What are the reasons? What can we learn for future operational guidance and for future traffic control actions, if any? There is a large potential for operational guidance and for safety actions.

I noted earlier that the second area of institutional performance refers to the various state and local agencies and the federal transportation agencies. These agencies receive resources from society and perform certain activities. How do they account for their resources in terms of the value of the services they perform? This accountability issue is here to stay in the current political environment.

The Government Performance and Reporting Act at the federal level and the actions it calls for as well as the activities in some states like Florida, Minnesota, Oregon, and Wisconsin in establishing "benchmarks" and in performance accounting call for measures to evaluate transportation agency performance and the collection and analysis of necessary data.

These are not easy tasks to perform in terms of information, analysis, and guiding objectives. Further, there is a major cultural transition as we move away from a world where we were mainly concerned with measuring inputs such as budgets and person years and outputs such as miles of roadway and track to the use of outcome measures such as mobility, economic consequences such as productivity, and unintended consequences such as environmental degradation and safety problems.

It is going to take some time to identify what measures to choose for the outcome and output variables that measure performance in this way. The requisite knowledge is going to take

some long-term learning. However, once you choose a measure, how to determine that measure is important. Does the measure you chose really capture the concept behind what you want to measure? Is it measuring it properly? Is the sampling method appropriate? Is it timely? Those kinds of questions are relevant to setting up a performance measurement system.

In all of this, BTS can help. This conference is the beginning of the road. To quote from an ancient source: Let it first blossom, then bear fruit and then ripen.

Robert E. Skinner, Jr.

I have developed a list of eight points about transportation research, some of which we in transportation research know instinctively but don't remind ourselves of often enough or explain to others. Several of these points apply to transportation information and data needs.

The first point—and by far the most important—is that transportation data and information matter. There are a host of decisions for which data and information are prerequisites. We know these to be information needs related to making investment decisions, operational decisions, design decisions, and performance assessments. Stated differently, the lack of appropriate information also matters and can do so in unfortunate ways. The goal is to affect decision making, not to collect data for the sake of data.

The second point is that data collection programs, just like research programs, are a tough sell. The creation of BTS may have bucked that trend. At one level, everyone appreciates the value of information, but the appreciation of information does not necessarily translate into support for data collection programs. The payoffs for data collection are, in many cases, long term. The linkage to improved decision making from data is often ambiguous, and the whole notion of benefits and costs for data collection programs is uncertain. So when times are tough—and budgetary times seem to be perpetually tough for those of us involved in public-sector programs—it can be hard to generate sustained support for data programs. At a time when we are deferring critical maintenance on infrastructure systems, what chance do data and, for that matter, research programs stand? The implication is that it is incumbent on us to build cases to demonstrate why data are important, how they affect specific decisions, and how they have affected past decisions and will affect future decisions.

Third, data collection programs appear fragmented and disorganized, and actually, in many cases, they are fragmented and disorganized, sometimes for very understandable reasons. After all, our transportation system is incredibly decentralized. We have tens of thousands of owners of transportation infrastructure, tens of thousands of private suppliers and contractors who provide service, tens of thousands of institutional users, and tens of millions of individual users. We also have an incredible mix of data collectors at different levels of government, in both the public and private sectors, and an incredible mix of users, with different perspectives and different needs. At one level our aim is to rationalize and coordinate all of these data collection efforts, but at another, we need to recognize that fragmentation, even a little bit of chaos, is inevitable in this enterprise that we call data collection.

Fourth, data collection programs must address tomorrow's needs, not yesterday's or even today's. There is a trap—a trap we're all well aware of—that we may institutionalize data collection programs that are geared to yesterday's needs. If we do that, the results are irrelevant, and that makes it very hard to develop the support that we need for new data collection programs or even to sustain support for existing ones. For example, the revolution in information and communications technology is going to have profound effects on transportation

because it affects our choices about where we live and our notions about the workplace and where, how, and when we work, and it has already changed how goods are manufactured and distributed. The question remains, Are we collecting the kind of information that will help decision makers anticipate and understand these changes and adapt to them effectively?

Fifth, there are some questions that data, even excellent data, cannot answer or meaningfully address. For example, there are many questions related to highway safety for which we will never collect enough accident data or traffic exposure data to come up with reliable estimates. Can you imagine collecting enough data to assess the benefits of changing edge stripes on the side of the highway from 4 inches to 6 inches? Sometimes we just have to decide what we can do and what we can't. Perhaps we will never find a satisfactory way to characterize congestion. I hope that is not the case, but if it is, it will not be because of our inability to go out and collect the data, but because we aren't able to agree on the right measure for congestion. Given our limited resources and the need to demonstrate relevance, we should be extremely pragmatic about what we can and cannot achieve with new data collection efforts. And perhaps we need to be absolutely ruthless in examining data collection efforts that are already under way.

Sixth, as with so many other things in life, balance is important in data collection programs. No one really knows what the right mix of data collection and information gathering programs should be, and we have no methodological way of determining it. But we do know that we need to touch a lot of bases in developing a program, and we have to make a lot of tough, hard choices and trade-offs. We need data for planning, for aiding and improving design, for system management, and for assessing performance. We also need data oriented toward local, state, and national needs and, increasingly, toward international needs.

We want continuing data to monitor system performance. Sometimes we need to collect special purpose data when unusual opportunities arise. For example, the Northridge earthquake in California provided opportunities to observe travel behaviors that were perhaps unprecedented and to collect information about those changes.

We need data to help us with our immediate needs. We need data for our long-term needs. In this conference the question of balance is going to be foremost in many people's minds.

Seventh, as with other activities that some people perceive to be of marginal importance, data collection and information gathering programs need champions. We have been fortunate to have had some champions, some of whom are with us today, who have been laboring in this vineyard for a long time. But they can't do it alone.

There is some good news, and, of course, if there's good news, there's bad news. The good news is that every phase of transportation has information and data needs, almost every position in every agency in some sense depends on data. Therefore, data collection should be everybody's business. The bad news is that when something becomes everybody's business, there is a tendency, a human tendency, for it to become nobody's business. So one of our challenges is to try and educate people about the need for data collection and information gathering efforts and to try to enlist some champions, not just from the data community, if that's the right word, but from the mainstream, operational side of transportation agencies.

My eighth and final point is that the devil is in the details. My observations have been relatively straightforward. The hard part lies ahead—dealing with the details and the specifics:

- What information should be collected?
- How will it be collected?
- Who will collect it?
- Exactly how will this information be used?
- Who decides and who pays?
- What should the balance be between public and private agency responsibilities, government at different levels, the collectors versus the users?
- How should data be stored and disseminated?
- What level of abstraction is appropriate?

- How do we assess whether the data we are collecting are being used as expected? In fact, we need data about data to determine when we need to make changes in our data collection programs.

Questions like these will be very close to the surface in all the discussions here. I am looking forward to a stimulating, interesting, and, I hope, an influential conference.

Francis Francois

My role here is to try to give some perspective on this conference from the standpoint of AASHTO and its member departments, 30 of which are represented here. State departments of transportation (DOTs), have been major data users for a long period of time. When they were highway agencies only, they worried about the performance of the highway system, and indeed they still do; they worried about the capacity of the system, and they still do; and they worried about the safety of the system, and they still do. They have gathered and looked at statistics for years on these aspects of the highway system. More recently, they have had to work with environmental issues and gather data to look at air quality, water quality, and many other aspects.

As transportation agencies and not just highway agencies, which most of our member departments now are, the world has enlarged considerably. As a result of the Intermodal Surface Transportation and Efficiency Act (ISTEA) we need to look at the data relating to intermodal issues in each state—rail, aviation, water, pipeline, trucking, and other issues—more than we did before. As planners, we also, in most states, have a role in programming public resources to meet transportation needs. And increasingly, particularly as transportation becomes multimodal, we have to look at what the entire transportation system is doing. All of this takes data.

We also need to be concerned with the relationships among state, local, and metropolitan governments, especially since ISTEA was passed. This has caused us to look at issues from a statewide perspective. Some state transportation agencies used to confine their viewpoint primarily to the area outside their cities and metropolitan areas. That is no longer possible. We now also need to be aware of issues in cities and metropolitan areas.

We tend to look at data in an attempt to help improve the revenue stream that flows through a state transportation agency, whether from the state legislature—in those infrequent times when they are willing to give more money—or whether from Congress. Over the last few years, a major activity of every state transportation agency's statistical and data staff has been generating formulas to see how funds can be allocated to their own benefit as opposed to someone else's.

AASHTO has dealt with the requirements of the transportation system using data from the U.S. Department of Transportation (DOT) and AASHTO data to put together a statistically sound estimate of the requirements of the nation's transportation system in its several modes. We looked at both highways and transit, which is what will be funded under the reauthorized legislation, as well as a number of other modes and issues.

AASHTO has stayed out of the formula issue, but clearly individual member departments have not. The reauthorization battle is under way in Congress. A number of different players are already on the field. There is the Step 21 bill, which has at least 22 states as its sponsors. Opposing them are the 16 ISTEA Works states. They oppose each other in this sense: Step 21 lists, compared with ISTEA, some 38 winners and 14 losers. ISTEA Works lists 36 winners and 16 losers.

Then there's the administration's bill, the National Economic Crossroads Transportation Efficiency Act (NEXTEA), which offers strong support for BTS, something that AASHTO

had requested. The new legislation would strengthen BTS and its program in several areas, asking that the Bureau look at transportation issues globally, not just nationally, and enhance the relevance of their work to state and local governments. The administration is also disposed toward the use of BTS resources to help the states do a better job, for instance, conducting training programs. We hope that Congress will be so disposed also. The bill would improve the effectiveness and efficiency of the data-sharing activities of BTS.

There are other players in the field and many ideas as to what the transportation program itself at the federal level ought to be, and they will obviously affect many of the issues that we're dealing with here.

Planning roles vary considerably among the states. A typical, relatively rural state that has few urbanized areas, very little transit, and highways as the primary way of moving people and a relatively stable population has one viewpoint of the kinds of data that it needs. That typical state is trying to operate within a relatively stable environment and does not need the kind of data needed by urbanized states concerned with rapid new growth, changing industries, and air and water quality issues. Many of the concerns of those states are reflected in the activities of AASHTO's Standing Committee on Planning. AASHTO is trying to look at the diversity among and between the states and to satisfy their different needs.

The Comprehensive Transportation Information and Planning System (CTIPS) was created mainly to work with a number of the larger urban states in making better data available to them. Unfortunately, CTIPS is not a well child and that is one of the reasons AASHTO is so deeply involved in this conference.

The states are now engaged in evaluating the Highway Performance Monitoring System (HPMS). Looking at the results of a recent survey, it is quite clear that states have a variety of viewpoints on HPMS and what ought to be done with it.

This brings up a key issue: the difference between what the federal government needs and what the state and local governments need, which is more important, and how to sort out the roles between states and MPOs and between local governments and the federal government. Should we meet all data needs and at what costs and with what resources?

The agenda for this conference zeros in on six transportation data areas, and the background material gives many thought-provoking comments on these data areas: socioeconomics, finance, supply system and characteristics, demand and use, system operations, and impact and performance. We also need to think about data collection and methods, and institutional issues. All of these are important to the states, more important to some states perhaps than to others.

What are some of the issues that the state DOTs want to discuss? What answers are they searching for? Quite obviously, one is the costs and other resources that are involved. In a time of constrained resources, are there more efficient ways to gather data? Do you have to do it yourself? Can you get it somewhere else? Who does it? How is it done? What are the best ways of doing it?

Whatever data systems are put together, there must be recognition of the uniqueness of each state. Our 52 member departments—the 50 states, District of Columbia, and Puerto Rico—are all different. No two are the same in governmental structure, transportation systems, geography, or makeup of the population, and the data systems we use have to recognize that. The system should relate to the state, its MPOs, and its cities and its counties. If it is not built and centered on this basis, it will not be well received and well used. In addition, data systems must be flexible. There are many changing needs, and there will be many new ones.

What is the best way to access our data? Is the Internet an answer? Is it *the* answer? Are CD-ROMs a better tool for certain kinds of data? Magnetic disk? Magnetic tape? Printed reports? The medium may be different for different kinds of data and for the different entities, public and private, that need to use it.

How do we ensure that the quality of the data is good? To a great extent, it depends on a better understanding of statistical methods. Statistical methods need to be emphasized more at BTS and in the states than they have been in the past. You can get a lot of mileage out of a small amount of data if it is statistically sound. So quality of data is very important. If you can't trust the data, the information will not be used.

What's the role of the private sector in all of this? Can the private sector be a data provider for us, at least in certain areas? Talking intermodally, we must rely on the private sector because it includes the airlines, the railroads, and the trucking companies. The last are very jealous of their operational data, as you know.

But can we go beyond that? Are there private-sector sources for our information needs and would it be better and cheaper to use those resources? Ultimately, what is best done by the federal government, the states, the MPOs, the cities, and the counties with respect to collecting and analyzing data? The institutional roles need to be better understood and thought through. This was never really done because until ISTEA there wasn't any great need for it in most areas. The new approaches to planning in ISTEA, at least those concepts of it that are here to stay, are good. But to make them work, we have to work together, understand each other, and sort out our respective roles.

The big challenge is to look at transportation as a system. Ultimately, it is a system that involves highways, railways, water, aviation, and pipelines, all of which function together to provide the transportation needs of our industries, our businesses, and our people. Unless we who are responsible in the public sector for guiding and providing transportation facilities recognize that, we are not going to do the kind of job that should be done.

There are tremendous ties between transportation and the economy, ties that are important to each state, to the people who live there, and to every city and county. They are important to political leaders because it's the local economy that makes up the economy of the nation.

Why are these ties important? Take, for example, just-in-time deliveries. In 1990 the automobile industry handled 25 percent of its deliveries on a just-in-time basis; in 1997 that number is 95 percent and climbing toward 100. What that means for each state is that if the road system is down, the factory is down, deliveries are down, and incomes are down for everyone. It means that if there is a major snowstorm and it takes 4 days to clear the roads rather than the 3 days it might take using more modern equipment, a full day has been cut out of just-in-time deliveries, causing a lot of inefficiency in the national economy.

We need to understand what the role of transportation is in attracting and keeping industry. The state of Wisconsin has just finished locating all of its principal employers relative to the state's highway and transportation network using the Global Positioning System. In this manner they can understand why industries are located where they are and what the role of just-in-time delivery is for the state, as well as the importance of the transportation system to the development of the state economy. Governors, state economic development agencies, and MPOs should be asking what they can do for their regional economy.

TRB Special Report 234, *Data for Decisions*, contains a two-page list of deficiencies in our transportation data. Although we have improved in some areas, most of those deficiencies still exist. The leading deficiency was the lack of data on supply and demand, commodity flow, and passenger flow. A strong argument was made in the report that effective transportation planning cannot be done until those two kinds of flows—who's moving where and why—are understood both from a personal transport and from a freight standpoint.

Are other federal mandates coming that will require data use? The final version of a national freight transportation policy was recently issued by the U.S. Department of Transportation. This is intended as a final policy statement to guide federal decisions affecting freight transportation across all modes. Of course, whatever decisions the federal government makes affect each of the states.

DOT's interest is to ensure that the nation has a safe, reliable, and efficient freight transportation system that supports economic growth and international competitiveness both now and in the future. It includes highways, airports, rail facilities, ports, pipelines, waterways, intermodal transportation, and freight carriers and shippers. The policy statement allows for variations in state, regional, and local conditions, requirements, and resources, but we need to provide the state, local, and regional viewpoints. The federal government intends to make decisions on the basis of this policy.

The issue of the managing and monitoring systems established under ISTEA still exists. We need to understand what is happening with respect to management systems. Louisiana,

Washington, and Oregon are moving along very well with their management systems. In Oregon information is gathered and used to explain state programming decisions to the public.

What does AASHTO want of this particular conference? What new resources do we need? Is there more research that needs to be done? What are some of the areas that need research? What other kinds of resources do we need?

I come back to the issue of training programs. How do we communicate with each other more effectively than we now do? Are the Local Technical Assistance Program (LTAP) centers useful to local governments? Are there ways we can use LTAP to bring them into the data arena better than we do?

It has been suggested that we ought to revitalize the old state road conferences and make them transportation conferences; the states, cities, counties, and MPOs would all meet once a year for 2 or 3 days and talk through what issues they're mutually working on and why and what their goals are within a state.

What are the new challenges that we're going to face? I don't think we know at this point. We do know that we are entering a new century. What are some of the things that lie ahead? Linking our transportation data and decision process with the land use decision process is very difficult to do, but it is considered necessary by many people. Transportation has been reactive for too long. We've taken whatever land use decision was made and tried to make it work. However, transportation should lead the land use decision process, not follow it, but that means a much closer working relationship between the transportation community and the planning and zoning community, the development community, and city and county officials. What alternative is there? All involved parties need to work together to design limited access, to determine capacities, and to design workable solutions. It will not be easy, but if we intend to manage the transportation system, we ultimately must do it.

Transportation and the economy, transportation and the environment, transportation and the computer age—what more do we need to know from a data viewpoint to deal with these areas? And how do we analyze the data? Will our transportation technology change in terms of the kinds of transportation we need and how we transport things?

Looking ahead 10, 20, 30, 40, 50 years, undoubtedly things will change as computers continue to develop. Therefore, we need to construct data systems that will allow us to identify trends and do some planning while they are still trends so that when they become reality, we can work with them.

Look at the century now ending. It came in with railroads as the backbone of everything. There was a net of railroads, including urban railroads, that covered the country. You could travel on streetcars, literally, from New York to Chicago and back again. All that is gone. There still are railroads, but they now serve a different purpose, and except for the Amtrak lines, they do not move people.

At the beginning of this century the automobile was a toy, but it is now a necessity that every American wants and needs to live in the kind of society that we've built. No one would have imagined in 1900 that we would move most of our goods by truck, but we do. The airplane was invented during this 100 years and has also brought about drastic changes.

So I think it's safe to predict that we'll see new transportation technologies and new uses for computers as we look ahead. How do we put together data systems, data analyses, and trend analyses that will allow us to meet these challenges? That is why we are here at this conference. Given the leadership that you have here, I'm certain it will happen.

History of Data Collection

Kevin Heanue, *Federal Highway Administration*

I'd like to dedicate this history to the late Jim McDonald, who for 40 years, much of it with FHWA, was a true believer in and advocate of analytically based and data-based planning. I doubt that there was a data conference that he missed, and as we carry on his work, he is in a way partly responsible for our being here.

For all of us, it helps to reflect on where we've been in relation to data programs and how we've justified them at various times. So I want to take three cuts at history in terms of time, the evolution of transportation technology, and some of the applications of data, mostly in the highway program.

My interest and my bias are knowing how to convince Congress to invest in transportation and how to convince the public that there's a need to invest in new capacity. In my job, I am challenged on those two fronts every day.

When I was asked if I'd make this presentation, I happened to be reading a new book on Meriwether Lewis of Lewis and Clark fame. The introductory chapters are about the Colonial and pre-Colonial periods in the United States. The Lewis and Clark expedition was really about transportation, economic development, and economic competitiveness—how to reach the Northwest in a way to prevent the Russians from moving into that territory and to beat the British to it. The expedition explored parts of the Louisiana Territory, where the French were charging a tariff in New Orleans for all the goods coming down the Mississippi. Transportation then was very central, and the taxes associated with international trade were equally central to the young nation.

My next source is *America's Highways*, a 220-year history of highways written by a group of FHWA retirees at the time of the Bicentennial. On the basis of that text, I want to talk about a series of firsts.

I was struck by the fact that early transportation in this country was intermodal. There really were no options. You shipped goods by boat as much as possible or you traveled by horseback or as a pedestrian on trails because there were relatively few roads.

The first federally funded road appeared in 1755 when General Braddock drove a military road west from northern Virginia in the French and Indian War. It's now roughly the route of

Virginia Route 7. This single-purpose, one-effort road disappeared 3 years later because it wasn't maintained.

The first real road in the country, according to the FHWA history, was not built until 1775. It took the entire Colonial period almost up to the time of independence before you could make the trip from New York to Philadelphia by land with a wagon.

In the Colonial period, I found the first application of the "soft match." Country road authorities required all men—landholders, freemen, indentured servants, and slaves—to serve time maintaining the roads. It was a broadly based requirement, but you could contribute either your time or your money to the effort.

In Maryland and Virginia, I found the first MPOs. In the counties, eight land-owning men made all the road decisions. The MPO concept comes in because the Governor could veto any of their decisions. In the Colonial period, we also have the development of the first state transportation plan. In 1791 in Pennsylvania, a plan was submitted to the state legislature laying out toll roads, roads that would remain free, and sites of canals.

Surprisingly, in President Washington's administration, we had the first application of innovative financing. Colonel Ebenezer Zane of Wheeling, Virginia, asked Congress for a franchise to construct a road into Ohio. He said to Congress that he didn't want them to pay him anything to build this road; he would build it with his own funds. He asked for a square mile of land at each of the three major river crossings, and said that he would earn enough money back to pay for the road. Congress granted him the franchise, he built the road, and it was very successful. Also of interest, Congress said, "You have to operate ferries at each of these three crossings, and federal judges will set the tolls."

During Jefferson's term as President, we find the first National Transportation Plan. Submitted at the request of the Senate, it was characterized as "comprehensive" and "forward-looking." The plan consisted of an inventory of the transportation resources of the country—roads and canals. The FHWA historians describe it in terms relevant to all plans since: "Unfortunately, it had little immediate effect on U.S. transportation policy."

In *America's Highways* there's a discussion by Secretary Gallatin, then Secretary of the Treasury, that has many firsts in it. Gallatin uses macroeconomics to describe how toll roads contribute to the national wealth. He also describes a benefit-cost analysis and the role of interest costs in doing that analysis. With respect to deficit financing, he goes out of his way to say that there are still public benefits even if a toll road becomes defunct. The bondholders lose, but the public still gains because the infrastructure exists. There is even a discussion of "induced travel," outlining the value of benefits from diverted traffic and new traffic in the form of loads that couldn't be carried without the investment. We ought to try to resurrect some of those principles and put them in more of our reports to Congress today.

I'm going to skip over the 1800s. There's just too much—toll roads, canals, railroads, steamboats, and the changing role of government. It's a fascinating period, but I want to digress a bit and talk about the evolution of technology. In a paper by Bill Garrison about 10 or 15 years ago, he talked about the evolution of transportation facilities and how, through much of history, the sail and the horse and oxen were the only means of transportation. Speed was governed by the ability to sail or the ability of a horse to move on its own or pull a wagon.

Then in the 1800s, within a short period of time, an enormous change was brought about by relatively few inventions. The steam engine brought us both the railroad and the steamboat, orders-of-magnitude improvements in efficiency. Then the internal combustion engine was invented and we had both highway and air travel, another order-of-magnitude change only 60 years after the steam engine. Next, another increment occurred with the jet engine, which opened up international travel in a way that the piston engines hadn't. After that we have to think in increments of change; no order-of-magnitude changes are on the horizon. Technology, particularly information technology, may bring us order-of-magnitude changes in behavior. We'll have to see.

The evolution of information technology begins with the history of FHWA's predecessor agencies, the Bureau of Public Roads (BPR) and before that the Office of Road Inquiry. In 1894, the Office of Road Inquiry sent maps of the then-known roads to most of the counties

in the eastern states and asked county officials to correct the maps and add any new roads. Thus, this new agency was in the data business within its first year.

A very important point timewise for this conference is 1904, when the groundwork was laid for the highway statistics program. Every county in the United States received one of 60,000 questionnaires asking about taxation and sources of revenue, road laws, total expenditures for roads, length of roads, and surface types of all roads—the first national inventory. The survey was conducted only in rural areas because it was believed that the cities had their own resources and that the federal government didn't have to get involved at that time. Nevertheless, those data categories of 1904 have carried through into our highway statistics today. I guess we should ask ourselves whether we still need them after almost 100 years.

I was struck by the fact that the inventory listed 2,150,000 miles of roads and 78,000 cars. Cars were used primarily in the city because the rural roads still weren't good enough in 1904. Amazingly, we now accommodate the most automobiles that we've ever had on less than twice the number of road miles that we had at the time of the automobile's invention.

Next I would like to shift to early attempts at planning. Statewide planning was begun in pilot states. Thus, counting traffic and weighing trucks became the beginning of the scientific basis for looking at surface transportation. A landmark occurred in 1925 in Maine, where planners established a relationship among population, vehicle ownership, and traffic, forming the basis for making 5-year travel forecasts for the first time.

Urban transportation planning first occurred in 1927 in Cleveland with the Regional Area Traffic Survey. Federal, state, county, and city officials cooperated in the first metropolitan urban transportation study, and BPR paid 50 percent of the cost. In the 1920s one of the best pieces of legislation to affect the highway program, the Hayden-Cartwright Act, set aside 1.5 percent for planning and research. (It didn't have to be spent, but up to 1.5 percent could be set aside.) Highway planning surveys were set up in 1934, and the systematic data collection that has been the backbone of the highway and then the transit programs dates back in a comprehensive way to that point. As traffic grew, something significantly better than the two-lane road was evolving in the urban areas, the urban parkways, which were quite different from the rural primary highways.

In a series of landmark reports to Congress in the 1930s and 1940s (*Toll Roads and Free Roads*, *Interregional Highways*, and *Highway Needs of the National Defense*), BPR did a very effective, analytically based job of characterizing the nature of the highway problem and options for addressing it, primarily the need for a higher class of highways. All this was leading up to the achievement 20 years later of the Interstate system.

Another big landmark occurred in 1936 when the Pennsylvania legislature authorized studies leading to the Pennsylvania Turnpike, which opened in 1940, the first long-distance freeway.

In 1941, the first year of World War II, Congress in the first Defense Act set aside $10 million for postwar highway planning. In terms of today's dollar, that must be equivalent to $100 million. (Planning was really respected in those days.) In 1944, there was a major highway bill looking toward postwar highway construction on the roads that had not been maintained during the war. A key point in the 1944 act was urban eligibility. For the first time the federal government funded roads within urban areas, the urban extensions of the rural primary system.

The late 1940s to the early 1960s was the age of the large-scale urban transportation studies characterized by massive home interview surveys coupled with external urban traffic surveys on major roads. These were incredible efforts of data collection and processing in precomputer days. I recall coming to work for FHWA at the end of that period and seeing rooms of cartons filled with punched cards containing home interview survey results. About 90 percent of the urban studies was data collection and 10 percent was analysis. They were, in effect, a one-shot analysis because there was no ability to continually analyze the data or to establish a continuing planning process.

During that period a tremendous debate was going on between those who believed that the only way to do urban transportation planning was with a large inventory of data and those who believed in the emerging mathematical simulations, the first traffic models. I credit

Al Voorhees, who in 1955 wrote a paper titled "General Theory of Traffic Flow," as being the true founder of traffic modeling. The paper evolved from his Yale Bureau of Highway Traffic thesis, and it won the Institute of Transportation Engineers President's Paper Award that year. His work permitted the movement from data-based studies to simulations using small sample surveys. Voorhees was also a promoter of small sample home interviews for calibration purposes.

At that time I happened to be assigned as a trainee to the Hartford study that Voorhees, then with the Automobile Safety Foundation, was directing. When the gravity models didn't seem to be working, we made 200 home interviews in order to calibrate the models and continue the study.

Governor Ribicoff of Connecticut at the time wanted to complete the Connecticut Interstate program in 4 years, for which traffic forecasts were needed. Voorhees was brought in with some FHWA staff and got the job done. The late Lee Mertz went to Hartford and taught them how to compute trees for traffic assignment. As I recall, they had a Burroughs data processing computer. With 78 zones and a fairly lean network, computing the trees took 22 hours, something we do in seconds now. That was the nature of urban planning in those days.

There were three schools of urban transportation planning. FHWA (BPR) was promoting a gravity model trip-generation approach. Doug Carroll, then Director of the Chicago Area Transportation Study (CATS) and later Director of Tri-State Regional Planning Commission in New York, led another analytic school that I'm going to characterize as a geography-based methodology. A group of professors from the University of Pennsylvania who conducted the Penn-Jersey Study, which became the Delaware Valley Study, formed another competing school. After Doug Carroll hired Lee Mertz for Tri-State, Mertz returned to FHWA.

The 1962 Highway Act mandated urban transportation planning. The National Environmental Protection Act in 1970 and the first Earth Day changed forever the nature of the highway planning business. In 1964, the Urban Mass Transportation Administration, now the Federal Transit Administration, evolved as a part of the Department of Housing and Urban Development (HUD). Late in that period HUD's 701 comprehensive planning program ended, leaving transportation planning on its own.

At TRB conferences in the 1970s those interested in metropolitan planning heard a lot of talk about emerging "third generation" models, but they never appeared. We are just now on the verge of reinventing the planning process, and it is hoped that the TRANSIMS project may result in our next-generation model.

The year 1990 brought ISTEA and its linkage to the Clean Air Act. The intermodal nature of ISTEA resulted in significant changes in planning that will be recalled as future histories are written.

Reauthorization 1996: what does it mean for planning? I am personally proud of the accomplishments we've made in transportation planning, but I think we have to do a lot better. We still have major problems in reaching the right audiences with the right message. Let me make the following comments:

1. It's a personal frustration of mine that the current reauthorization is not analytically based. There was a lot of outreach and input on how to restructure ISTEA. Everyone agreed that there should be minor restructuring, but the planning community didn't bring an analytical base to that process.
2. Next I stress the importance of a more effective dialogue with Congress. I don't think that cost estimates do the job. We've lost credibility by describing to Congress the dollars we could spend if the "needs estimates" were provided to us in program dollars. Instead we should talk in terms of the economic benefits these dollars will bring as investments.
3. The current planning process is not geared to intelligent transportation systems (ITS). To access funds under ISTEA in metropolitan areas, you have to go through the metropolitan planning process and then through the statewide planning process with their project plans. Our planning process tools are structured around providing new capacity, adding an increment of a lane, 2,000 vehicles an hour. They're not geared to the incremental improvements that ITS deals with.

4. A successful planning process ends with a transition to project development, and we are not doing very well with that transition. Recently I looked at an Environmental Impact Statement on a major project to see how planning was covered. The four alternatives studied were described in only four pages, but the transit alternative got less than a page, and the no-build alternative got a page and a half, most of which was a description of the geography of the route, where it would go, and what it would cross. There were four pages on what deicing compounds would do to the adjacent flora and fauna, and four pages on one endangered bird species and how it might be affected. Despite the enormous annual investment in metropolitan planning, we have a "disconnect" between our environmental analysis and the project development.

There's a highway project in California, the biggest one in the country today with 1,500 homes and over 3,000 people to be displaced. The project was justified in terms of capacity as determined in the *Highway Capacity Manual*: Adjacent routes would be operated at Level of Service D if the project were not built, and a Level of Service C could be achieved if the project were built. That's the reasoning to convince 3,000 people who are going to lose their homes that this project is needed.

5. On the international scene, I find myself reaching for international answers to domestic questions these days. Certainly in the Pacific Rim countries, you can observe in action ITS concepts that are just being talked about in the United States. As for innovative finance, look to both Europe and Asia for sucessful ideas. We've got to open our eyes to the world.

6. I'd like to close with a preview of a TRB report on sustainability, an issue that is going to be significant for the next 20 or 30 years. The theory of sustainability asks the question, How do we meet the needs of the present without compromising the ability of future generations to meet their needs? The National Academy of Sciences appointed a committee to study transportation and a sustainable environment. U.S. transportation does have a sustainability problem, not with the criteria pollutants addressed today through the Clean Air Act or with fuel availability, for which many resources and alternatives exist. Global warming, biodiversity, and habitat loss are three sustainability issues described in the report in some detail. I believe that the environmentalists are going to be concerned once that report comes out and say, "What are you going to do about it?"

Global warming is a global problem. We could shut down U.S. surface transportation today, and only 5 percent of the global problem would have gone away; 95 percent of it is still there. It requires a long-term, worldwide solution.

Outreach Efforts

Rolf R. Schmitt, *Bureau of Transportation Statistics*

In summarizing the outreach efforts for this conference, my comments are based on insights gained from participation in several forums, including Session 78 on data needs for state and local decision making at TRB's Annual Meeting last January, in which many of you participated; many committee meetings at the TRB Annual Meeting; meetings of the Association of Metropolitan Planning Organizations (AMPO), the Urban and Regional Information Systems Association (URISA), and AASHTO committees, particularly the Standing Committee on Planning.

We also experimented with outreach via the Internet. The Internet is still a young and evolving technology, evolving so rapidly that sometimes we are overwhelmed by it. Our Internet site for this conference did not get much use, partly because we spent so much time figuring out how to make it work and how to make people aware of it. Nevertheless, it shows great promise for future efforts.

To give an idea of the Internet's explosive growth and the problems of managing it, 18,000 documents were downloaded from the BTS site in the month of January, an increase of 80 percent over the previous 6 months, and there's no end in sight to that growth pattern. BTS will keep the data needs site on the Internet as a way of getting the results of this conference out to the global community.

What are some of the things we've learned from these outreach activities? We see clearly that the importance of data and information is growing for a number of reasons and that this importance is belied by our tendency to apologize for the need to collect data. In times of budget constraints, agencies will spend money on fixing potholes rather than on collecting data on them. However, if we don't collect the data on potholes, how are we going to know which potholes are the most important to deal with first? This tendency to apologize for the need to collect data rather than demand resources for data collection seems to be partly because data collection is an afterthought in the budget process.

Yet there was a time when data collection was considered very important. Although little was known about travel demand, forces of change in transportation, and finding solutions to transportation problems, there was an appreciation for data and information.

The growing importance of information is underscored by the enormous amount of reorganizing, reengineering, restructuring, resizing, and rethinking in state departments of trans-

portation (DOTs). The same is probably true for metropolitan planning organizations (MPOs).

States are talking about downsizing and trying to deliver on the more-for-less mantra. Several state DOTs assume that information systems will be the magic bullet for delivering more services with fewer people. These states are seeking better ways to handle data and are asking what kinds of data are relevant to more efficient operations. The importance of accountability is very real at all levels of government. Performance measurement is an issue that is not going away.

Although AASHTO has been very strong in telling the federal government not to get involved in state-level performance measurement, particularly in terms of telling the states what to do, the states recognize that they must do performance measurement for their own purposes.

Technology is also changing the supply and demand for transportation data. Intelligent transportation systems, geographic information systems (GIS), and the Internet are technologies for effective collection, analysis, display, and distribution of data.

Successful efforts to democratize data access have created a whole new customer base. In the past, transportation information was available only to the big MPOs and the states that could spin nine-track tapes and manage punched cards. Now, however, anyone with a microcomputer can access enormous amounts of information on CD-ROM or download it from the Internet. The smallest agency or local citizens group can do more analysis today than the big agencies did years ago.

Along with the ability to distribute so much data to a wider user community comes the job of explaining to this new customer base how to use the sophisticated data sets. My favorite example is the Truck Inventory and Use Survey, in which several different variables represent the weight of the truck. The appropriate variable depends on the application. It is an enormous task to provide the educational and technical support needed to help a broader community use these powerful data sets effectively. The job continues to grow as the community expands and finds new applications for data.

Data needs also change with apparent shifts in state DOT planning horizons, which appear to be moving from a traditional 20-year to a 10-, 6-, or 5-year cycle, more closely linked with the state legislature and with programming of reconstruction and other investments. The data requirements to support shorter-term, locally specific actions are quite intensive.

Data needs are also being driven by new or reemerging topics such as freight transportation. Goods movement has not been a major concern for most state DOTs and MPOs for years, but freight is a hot topic today, a new frontier for both data collection and the development of analytical methods for state DOTs and MPOs.

I spent much of last summer on some state field visits, dovetailing those visits with FHWA's parallel effort to review the Highway Performance Monitoring System (HPMS). The initial focus of the visits was to look at internal versus external data flows. We found that most data flows are internal to state DOTs and suspect that the same is true for MPOs. For example, the area of programming involves collecting information on highway condition to feed into models that identify where to do next month's repaving. The data collection, model run, and decision making are all internal to the state DOT.

We should not ignore these internal flows and focus just on external flow among states, MPOs, and federal agencies. Help with management of these internal flows in terms of technical assistance may be central to the role of AASHTO, TRB, AMPO, and even the federal sponsors. Federal and association sponsors collectively wish to advance the state of the art in facilitating both internal and external data flows. We are not here to say what should be done; rather we are seeking ways to identify and share the best practices for accomplishing data collection.

We have had surprisingly few calls for improving consistency and standard setting. On the one hand, such improvements would support easier comparisons among jurisdictions and reduce costs by achieving economies of scale in developing methods of data collection and analysis. On the other hand, improved consistency may not support the current diversity of

decision-making environments. We do not want a lowest common denominator that serves no one.

There is an enormous diversity in decision making, data collection arrangements, and assorted institutional arrangements. Urban-area traffic counting is a good example. Some states do traffic counts for MPOs. In other states, or other parts of the same state, the MPO may do the counts under contract to the state, or the MPO may do its own counts.

With respect to external flows among levels of government, we have observed several different models of data sharing. The traditional models are national surveys and censuses. Many local data needs are met with journey-to-work data from the decennial census, the Commodity Flow Survey (CFS), the forthcoming American Travel Survey (ATS), and the Nationwide Personal Transportation Survey (NPTS). Although these data collections are designed initially to meet national needs, topics are often included or a large enough sample is used to support state and local applications. With NPTS, states and MPOs may pay to have larger samples taken in their areas to support local applications. HPMS is a very different model because it is a state-based sample implemented by the states to create a national picture.

The National Spatial Data Infrastructure (NSDI) is another model for data sharing, established to create an electronic map of the United States. Counties are supposed to share their geographic data bases with states, which in turn share geographic data with the national government. NSDI recognizes that those doing the most detailed work are at the local level and that GIS standards would provide the technical ability to merge the local maps into a national picture. Establishing standards and requiring everyone to share data raises all sorts of interesting institutional problems, which are often—perhaps unfairly—called "unfunded mandates."

Another model is local incident reporting, best illustrated by the Fatal Accident Reporting System (FARS). Local police officers report all fatal crashes in a consistent format; the results are totaled and reported to the federal government. A problem with this model is that police officers are more concerned with aiding the injured and restoring traffic than filling out reports. Incomplete data often result.

Missing data in incident reports involving trucks are resolved by a follow-up effort called Trucks Involved in Fatal Accidents (TIFA), which provides yet another model. The federal government pays for postcrash interviews to obtain data missing in the original accident reports. This model was recommended by Lee Mertz as a good one for improving data quality in general by using follow-up teams on a sample or universe basis.

Another model is establishment reporting, in which government agencies fill out reports to other agencies, such as the Section 15 reporting system for transit, and private-sector establishments report to regulatory agencies, such as the Surface Transportation Board.

The final model is loosely described as synthetic data. This model includes the many cases in which data are generated from models that the rest of the world may treat as actual observations. We do this with economic data in the form of input-output tables and locally when we report trends based on applications of the four-step travel demand forecasting process to turn small samples of information into traffic flows.

In conclusion, we have seen through this outreach a period of great institutional and technological change. These changes are often unnerving but also hold great promise. There is a tendency in our business to hope that technology will bail us out. Historically, technology has come up short, as I often articulate in a speech about GIS, "25 years of broken promises, but there's still hope." However, recent improvements in monitoring and control systems, in data delivery media, and even in GIS software suggest that the promise of technology may come true this time.

Will technology fundamentally change the game and open up new possibilities? Certainly the development of computerized logistics management systems and electronic data interchange affects the freight side. Can government agencies find ways to meet public data needs by capturing data from those systems instead of using obtrusive surveys?

The way in which we monitor truck weights is an example of how technology can reduce costs, reduce respondent burden, and improve data quality. It can also change the nature of the data being collected. Formerly, when we pulled trucks over and put them on a portable

scale, we could learn from the driver what was in the truck, where it was going, and so forth. However, the results were biased because many truckers bypassed the scales. It was also expensive to have personnel on site to make the measurements. Now we use weigh-in-motion equipment. The truckers are not impeded, we get more observations, and data collection costs are reduced. Unfortunately, this very efficient, very effective system tells us only the axle weight and spacing of each truck. We no longer know what is in the truck or any characteristics of the driver.

Changing technology may help us do what we used to do more efficiently, but technology can fundamentally change the kinds of information obtained.

Future Trends

Stephen Lockwood, *Parsons, Brinckerhoff, Quade & Douglas, Inc.*

This conference has a very broad focus, as defined by the six data areas to be covered, many of which reflect a federally driven historical preoccupation with capital facilities provision and preservation and data systems that relate to capital stock issues, whether for asset management or asset investment.

It is increasingly important to focus on data relating to the core responsibilities of state and local governments (as distinct from the federal government) as the owners of the infrastructure itself, namely, service provision and system performance. As we move into the 21st century, making the delivery of service more efficient will become a central focus of institutions that own transportation infrastructure. The institutional mission will focus increasingly on the provision of service through systems operations and demand management as distinct from construction and preservation. This mission will include an increased focus on performance management in addition to asset management and will affect both data needs and data development.

The performance orientation will include data focused on service attributes, a set of attributes that go well beyond the indicators that preoccupied our data systems in the past, which were principally costs, capacity, volume, and speed—the traditional asset-management-oriented data items.

What households and commercial users want today is reliability, safety and security, navigation aids, and Yellow Pages data. However, our data systems are entirely focused on costs, capacity, and speed, to the exclusion of the rest. Thus, what customers want and what our changing economy demands require a set of data items that we're not currently addressing. We need to move toward a performance focus and begin to recognize data that reflect operations and management system status and other kinds of customer-related information.

In the course of producing this new kind of information related to service attributes that reflect performance, we're going to be looking at new data sources; at new players, both public and private; at a very different framework of technology and institutions than in the past.

Much of this information is going to be produced as a by-product of intelligent transportation systems (ITS), which are organized around the production of real-time information for operational management of the system and customer information in real time during system use.

This same information will be useful for the planning, budgeting, and policy-making functions that traditional data systems have historically served at the state and federal levels.

A major change will be the attitude toward this information. In ITS, information itself is a form of service and has a service functionality, service value, or maybe even a market value. It is not hard to imagine the existence of a relatively complete profile of system performance and origin-destination matrix on a link-by-link, hour-by-hour, or even minute-by-minute basis—a huge database—used for operations but also available for purposes that are not operational, such as planning and policy development.

ITS promises to produce a data flood. It may not be visible to most of us at this conference because those who are producing this information are not part of this constituency. I think that's something we need to be concerned about. The ITS community has developed a systematic architecture for transportation systems operation built around a rigorously defined network of automated data collection analysis and transfer covering much (although not all) of the same substantive data items. At other conferences, largely outside the orbit of most of us here today, other transportation professionals are outlining their data needs, how they're going to distribute the data, and defining the standards and protocols for the data items, the data descriptions, the performance specifications. A major investment is being made.

If we're going to have any impact on that process, we need to get involved in ITS architecture development. This architecture presents a rigorous, well-thought-out framework that

- Recognizes that there are a variety of data users who are providing transportation functions in an operations and management sense,
- Includes a communications system to collect and transmit that information among the parties who agree to use it, and
- Has an institutional framework involving many players outside our normal orbit, such as law enforcement agencies and private-sector service providers.

In the future, many data-intensive services will be provided by the private sector via in-vehicle devices supplied by "independent service providers" who will develop large data bases that may be of interest.

My main message, therefore, is that a great deal of new data is already being developed by parties outside this room, with policies and standards being set by parties outside this room. New technologies are constantly being developed relating to data storage, and decisions about those technologies are being made by parties outside this room. There are multiple users for the information that's being developed, customers in real time, system operators who come from the same institutions that many of us represent. I believe this represents an important gap between the planning and the operations community that we need to really work hard to overcome. We're the stakeholders who stand to gain by bridging this gap.

It is estimated that between the public and the private sectors, the ITS industry will invest some $450 billion in the next 15 years in information-based services and products. No one is going to come to us and say, "How would you like to have this data formatted for your purposes?" We have to go to them. We need to develop new relationships.

In developing new relationships between operators (who have data) and planners (who want data), several key challenges must be met, particularly where the private sector is involved, such as privacy and disclosure issues and proprietary data. In the future, our major challenge will be too much data rather than inadequate data.

However, the opportunity to grapple with the substantial new sources of information that ITS promises—and to shape their development in ways that may be more suitable to our interests—is one we must work to capitalize on. The increased focus on systems performance and the development of ITS information systems represent a tremendous challenge, and we must pay attention.

In any case, I'll leave you with the sense that in the future we'll either be here playing the same game that we've been playing for the last 20 years, only with less money, or we can be part of what is an enormously rich and dynamic environment in terms of transportation-related information that brings its own issues, its own challenges. The best expression of our understanding of what the future holds will be that the next conference or another conference of this nature should bring these two communities together for our mutual benefit.

EPILOGUE

Vision for the Year 2027: What We Have Accomplished

Bruce D. McDowell, *Intergovernmental Management Associates*

These comments are offered from the future to describe the 30 years of achievement in information systems that could result from the findings of this conference. It is the year 2027. The U.S. Department of Transportation (DOT), state departments of transportation, and metropolitan planning organizations are all linked by a common performance-based geographic information system (GIS). Each of these agencies uses the system to manage its own programs for peak performance. Data reporting between agencies is no longer necessary: any report an agency needs can be designed and downloaded from the common GIS the same day.

This modern data system has allowed DOT to demonstrate the performance of the nation's intermodal transportation system in maintaining the United States' status among the most productive and competitive nations of the world, in improving and protecting the environment, in conserving energy and other natural resources, in promoting social and environmental justice, and in ensuring that the quality of life in America remains the envy of the world's other nations. Using the common data system, DOT has also convinced Congress to raise transportation funding to adequate levels.

These great strides were possible because of a meeting among the best minds in America's transportation data community in March 1997. That symposium in Irvine, California, led to insights about how to harness the full potential of new GIS technologies developed in the late twentieth century to serve the needs of all of the nation's transportation agencies.

The task was not easy for a number of reasons. First, the federal budget was tight, putting great financial pressures on state and local resources. Second, the necessary performance measures were neither agreed on nor widely available. Third, data collection and reporting requirements were still duplicative, burdensome, and prone to significant opposition.

The key breakthrough occurred near the end of the Irvine conference, when most participants realized that their agencies were all working toward the same performance goals and needed the same kinds of performance measures, although at different levels of detail and on different map scales. When conference participants realized that the rapidly evolving GIS technologies allowed them to move back and forth between these different scales with minimal effort and to help each other stay up to date with virtually no duplication of effort, the data budgets that they had believed to be inadequate became equal to the task. Pooled data began to meet everyone's needs more effectively and efficiently and even began to meet unanticipated needs of the numerous interest groups and citizens who were more involved in transportation

planning processes after ISTEA and its proposed successor, NEXTEA. The planning process itself became much quicker and more effective because of the new federal regulations.

Another important breakthrough at the conference was the agreement that steps should be taken to ensure that all transportation data would have unquestionable validity and objectivity, so that transportation policy debates would not be marred by unproductive squabbles over the quality of the information.

These agreements resulted in a gradual reversal of the dangerous but growing trend in the late 1990s toward reducing the amount of transportation data being collected. That trend, generated by the burdens of duplicative data collection and reporting requirements, was exactly the opposite of what the times called for. For example, ISTEA had established several new performance goals in 1991 that needed more, not less, data support. But, the inefficient data systems of that time were burdening the statewide and metropolitan planning processes and stressing the very tight planning budgets in the 1990s.

In addition, Congress had passed the Government Performance and Results Act in 1993, calling on all federal agencies to develop results-oriented, performance-based budgeting. Quantitative performance measures were at the heart of that effort, just as they were at the heart of meeting ISTEA's objectives. But the data burdens of the day were such that FHWA issued a draft strategic reevaluation of the Highway Performance Monitoring System (HPMS) just 2 months before the 1997 Irvine conference requesting comments on a series of proposals, most of which would have cut back on the amount of data that would be reported to Congress. The basic thrust was to reduce data burdens by reducing data, rather than to reduce burdens by more closely aligning the intergovernmental transportation goals of the federal, state, and local transportation agencies, and integrating the performance measures of those agencies to meet their similar management goals.

The Irvine conference played a decisive role in directing the HPMS reevaluation back toward fuller use of the emerging information technologies to enhance performance data, while reducing the burdens of special data collection requirements not tied to the needs of all the parties. This redirection kept HPMS evolving steadily toward the kind of exemplary performance and results-measuring mechanism that Congress and the electorate were coming to expect in the latter part of the 20th century.

The key concept endorsed by the Irvine conference was that all the data required should be natural by-products of the data needed for managing their programs effectively, efficiently, and equitably, and being held accountable for program results. Only if the managers and their constituencies are relying on those same data to help achieve desired performance and results can others be assured that the data are accurate.

Fortunately, other events were occurring at the time of the Irvine conference that reenforced the ideas and solutions put forward there. For example, the Federal Geographic Data Committee (FGDC) was taking initiatives to coordinate a host of related federal agency data activities. FGDC had just added state and county members to begin forging the vital intergovernmental data links on which the present integrated GIS system depends.

President Clinton and Vice President Gore also were strong supporters of the creation of the National Spatial Data Infrastructure (NSDI), which provided the broader framework that now hosts the 21st-century tracking system for transportation performance and results. Much of the intellectual underpinning for NSDI was developed by the Mapping Sciences Committee of the National Academy of Sciences in the mid-1990s.

By the mid-1990s, the National Academy of Public Administration (NAPA) had a major study under way on the future of the federal mapping, surveying, and charting agencies, which eventually brought government-wide efficiencies that led to the robust and highly integrated GIS system of today.

On this 30th anniversary of the 1997 Irvine conference, I want to express the appreciation of the entire transportation community for the seminal work of that small band of far-sighted souls who charted a new direction into the new century. All of our programs would be greatly diminished without the vital contributions these visionaries made at a crucial turning point in history.

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