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Overview

As part of the U.S. Department of Transportation (DOT) effort to develop a national transportation policy, TRB was asked to evaluate the current and anticipated state of transportation data and to recommend improvements to the information resources that are essential to support informed, rational decision making in transportation. In Phase 1 of this effort, the following forums and workshops were held to provide an opportunity for discussion of issues related to transportation data needs, collection, and use:

- 14th Summer Conference on Ports, Intermodal Shipping, and Freight Transportation, July 24–27, 1989;
- Special Transportation Research Forum Conference on Freight Transportation Data, November 14–15, 1989;
- 6th International Workshop on the Future of Aviation Activity, September 13–15, 1989;
- Scenic Byways Conference, November 6, 1989; and
- A series of invitational workshops on safety and accident data, November 6–9, 1989.

Phase 1 also included the preparation of resource papers on data needs, resources, and issues for surface passenger transportation, freight transportation, passenger air transportation, recreational travel and tourism, scenic byways, and safety. Two separate resource papers were also commissioned: one on institutional challenges regarding information for transportation decision making and one on the impact of emerging information technology on data collection and availability. All papers except the one on air passenger transportation were presented at the 1990 TRB Annual Meeting.

Phase 2 will be conducted by the Special Projects Division of TRB. In this phase, the transportation information and data requirements will be assessed, and specific improvements will be recommended for the information resources. This effort will begin in mid-1990.

In this Record, the various papers prepared for Phase 1 are published. Highlights of each are provided in this overview. The Record also includes a summary of data gaps and issues for all modes of transportation that was prepared by an AASHTO special task force. This summary proved to be a valuable resource for the authors of the papers.

SURFACE PASSENGER TRANSPORTATION DATA NEEDS, RESOURCES, AND ISSUES

This paper concentrates on surface passenger data needs, available data sources, and data gaps. Some observations on surface passenger data and data gaps follow:

- A data system is needed to measure and monitor congestion, system performance, and mobility across all modes.
- Data are required to measure and evaluate "felt" consumer/traveler problems and trends in terms of attitudes and perceptions.
- Information for all modes is required on longer trips (those over 100 miles) to provide for the study of new technologies and substitutions between modes.
- A data system for intercity and user systems is needed. The data collected by the carriers should be a prime point of investigation.
- For highways, the Highway Performance Monitoring System (HPMS) is the best data source. FHWA is currently considering improvements related to pavement data, traffic data, and urban boundary considerations. Other recommendations are the inclusion of congestion measures, obtaining data on new facilities or new alignments, and so forth.
- For public transit, Section 15 reporting has been the most useful source. It does not, however, cover rural areas. Data should be considered relative to safety and security; systems conditions; financial requirements related to rehabilitation and replacement; and fixed facilities, vehicles, and ancillary equipment.
- The Nationwide Personal Transportation Survey should be conducted in 1990. Mechanisms should be investigated for increasing sample size and the reporting of information for specific geographic areas.
- A consolidated purchase of the 1990 Census Transportation Planning Package is highly desirable. The statewide package currently being considered should be implemented along with the urban package.

FREIGHT TRANSPORTATION DATA NEEDS, RESOURCES, AND ISSUES

Two key trends identified in this paper are (a) the continuing reregulation of freight transportation carriers and (b) the increasing importance of freight transportation to the shipper community. As pointed out in the paper, transportation reregulation has shifted from economic regulation of carrier rates, services, and financial condition toward safety and environmental regulation. The declining federal role in freight regulation has led many state and local governments to track freight carrier activities more closely. This trend is expected to continue in the 1990s.

The globalization of the U.S. economy, coupled with growing competition for markets, is enhancing the importance of freight transportation to companies. Instead of having large product inventories in numerous warehouses across the country, shippers are increasingly substituting direct plant-to-customer freight shipments for multi-echelon distribution systems. Such changes are requiring companies to intensify their use of transportation carriers and to use information and enhanced control procedures to better manage freight flows.

According to the paper, existing freight transportation data sources are characterized by the following trends:

- Data collection activities are continuing to shift to the private sector.

- Data types collected have lagged behind emerging national transportation planning and policy issues (e.g., hazardous material flow patterns and overall freight flow requirements relative to economic growth and development needs).
- Data collection methodologies, especially related to freight flows, have not kept pace with changing shipper logistics systems or transportation analysis and planning requirements.

Six key information gaps that must be filled to meet emerging national freight transportation planning and policy analysis needs include

1. Modal/route/facility operating performance data—a critical first step in improving freight transportation planning capabilities at the national level (e.g., the impact of congestion on delays in the shipment of freight);
2. Shipper logistics by industry—how shipper logistics strategies by industry determine freight flow patterns;
3. Intercity freight flow patterns by selected modes, commodities, and origins-destinations—for modes that use public right-of-way/facility needs;
4. Hazardous material movement tracking of all modes and all domestic origins-destinations—to allow local emergency response teams to deal correctly with hazardous material accidents or spill situations;
5. Intracity freight movement requirements and commodity movements—a critical input to defining emerging time-of-day freight traffic restrictions in urban areas; and
6. Emerging shipper requirements, especially supply channel processing and storage/handling needs.

PASSENGER AIR TRANSPORTATION DATA NEEDS, RESOURCES, AND ISSUES

This paper discusses various aspects of the significance of passenger air transportation, sources of passenger aviation information resources, impacts of airline deregulation, existing sources of information, and gaps in air passenger information resources.

Passenger aviation information resources have been affected most by the highly regulated growth of the aviation industry. The primary sources of data for air transportation are statistics supplied to the government agencies that regulate the industry. Unlike other industries, where disclosure of information to the government is voluntary, a significant amount of aviation information is required for compliance with federal regulations.

The Airline Deregulation Act, passed by Congress in 1978, phased out the responsibilities of the Civil Aeronautics Board for regulation of domestic airline route authorization and price setting. International airline economic regulation and the airline data collection system were continued as tasks of DOT. Safety regulation and maintenance of the airway system remained with FAA.

FAA collects a variety of statistical information that is available to the aviation industry. Information accumulated by FAA is available through special request and in periodic publications. The information is collected primarily to assist the agency in the management of aviation safety and the airport and airway system.

Aviation users of current passenger air information resources agree that the data are deficient for strategic planning in several fundamental ways:

- Most government data collection efforts are tailored to provide answers to specific questions of aviation performance. Little effort has been made to provide an easy way to cross-reference data contained in other government information systems.
- No data bases of demographic information for passenger air transportation are regularly collected. Passenger demand statistics are vital for understanding past growth factors and future airport capacity requirements. Without an understanding of the dynamics of demand, accurate forecasts will be difficult to predict.
- Dramatic changes have been occurring in international aviation, e.g., impending liberalization of air services in the European common market. The most serious impediment to understanding the implications of greater international liberalization is the lack of consistent and reliable international air carrier data.
- Other expressed needs include the potential for growth in the small air carrier and regional airline passenger market, greater availability of pilot and aircraft registry information, and forecasts of expected changes in fleet and personnel for all sectors of the aviation community.

As the paper states, the current problems of airport and airway congestion and slow airway system modernization indicate that past planning efforts have not been adequate. While a wide range of information resources is available from government and private sources to begin the planning process, users of the information have indicated it is not being used in the best way to provide answers to the complex problems that must be solved. Unlike the airlines, which have invested heavily in computerized aviation information systems to analyze the current data, the government has not taken significant steps to develop analysis systems for government-collected data. It will be necessary to use the substantial base of statistics produced by academic institutions, independent research firms, aircraft manufacturers, and others in the strategic planning process.

RECREATIONAL TRAVEL AND TOURISM DATA NEEDS, RESOURCES, AND ISSUES

This paper provides an overview of the U.S. travel and tourism industry, currently used data sources and statistics, gaps in existing data systems, and recommended improvements. It considers the transportation data needs of the federal government in formulating policy, as well as the data needs of the travel and tourism industry.

As stated in the paper, travel and tourism—the nation's third largest retail industry and second largest employer—needs to become a priority industry for statistical coverage in future federal agency programs. Travel and tourism is the largest export business in the United States; therefore, it behooves the entire federal establishment to take the industry more seriously.

The paper identifies data gaps and problems in four major categories: (a) research orientation and priorities, (b) research methodologies, (c) data coverage, and (d) data products. Each category is summarized briefly below:

- Research orientation/priorities
  - —Travel and tourism not a priority issue,
  - —Limitations/reductions in data collection (e.g., deregulation),
  - —Cancellation of the National Travel Survey,
  - —Lack of exchange between transportation and tourism industries/lack of user input, and
  - —Lack of integration among various agencies.

- Research methodologies
  - —Small sample sizes,
  - —Quality of data,
  - —Lack of time series/lack of continuity,
  - —Lack of standardization,
  - —Confidentiality constraints, and
  - —Studies often mode-specific.

- Data coverage
  - —Unmet data needs,
  - —Weaknesses in the SIC code system and related data collection and reporting,
  - —Frequency of certain data,
  - —Weakness of rail and bus data,
  - —Lack of information on other aspects of travel, and
  - —Lack of data concerning scenic byways.

- Data products
  - —Publication lags,
  - —Lack of analysis and dissemination, and
  - —No coordinated central source of data.

Recommendations based on an assessment of the gaps and problems related to transportation travel data are presented in the paper. Perhaps the most fundamental of the recommendations include the following needs:

- Travel and tourism must become a priority issue.
- The National Travel Survey should be reinstated.
- Transportation/tourism researchers and data users need greater communication and interchange.
- Needed research must be supported.
- Survey methods and data coverage must be improved.
- A clearing house should be established.

SCENIC BYWAYS DATA NEEDS, RESOURCES, AND ISSUES

As a result of recent legislation passed by the U.S. Congress, scenic byways have taken on increased importance. This paper identifies various categories of general and specific data needs, economic impact data, and benefit/cost data.

An important area of concern is the economic impact of scenic byways. As pointed out, virtually no information is available on this subject. Scenic byways can be viewed as an addition to a region's tourist attractions. To measure the economic impact of this addition, the increase in tourist trips and expenditures directly attributable to the scenic byways program must be determined. Types of expenditures as well as where they occurred should be identified.

A variety of baseline data about the region is necessary (e.g., a list of tourist attractions and the locations of potential scenic byways). Also, information about the characteristics of byway recreationists is essential.

The paper suggests that a number of scenic byways be selected to test and demonstrate byway economic impact models. The models should be refined over several years as the data are gathered.

SAFETY DATA NEEDS, RESOURCES, AND ISSUES

As stated in this paper, safety policy is the process of investment in and evaluation of programs designed to reduce the risk of failure in the performance of the transportation function. The ultimate question for policy purposes is, What is the most cost-effective way of reducing the current probability of system failure? From this follows the question, What data must be available to allow resource investment decisions to be made?

It is a major proposition of the author that any of the global measures of safety, especially those defined in terms of accidents or accident rates, are unreliable and in most cases invalid. They may have political, vis-à-vis policy, attractiveness. However, if the objective is to invest in programs that will reduce the risk of system failure and its consequent costs, a more analytic approach is necessary.

Two different paths of analysis are suggested. One is failure analysis directed at the mechanical, electronic, structural, and human elements of the system. In addition, it includes the analysis of the vehicular and superordinate command and control functions, as well as the interactions with the physical and human environment. The purpose of a formal program of this type would be to provide a flow of data that identifies and prioritizes the importance of failure modes and provides a rational risk assessment. This, in turn, would provide the transportation policy maker a means of identifying safety investments that have a high probability of reducing risk to users. Such investments might include operational, structural, and technological changes in the ways transportation systems are designed, operated, and managed.

The second is accident mitigation, which requires analysis of the chaotic regime occurring after failure of the system. Data on how trauma occurs and the dynamics that determine its magnitude are basic to developing cost-effective structural, operational, and organizational programs that will reduce the effects of accidents.

Every model agency within DOT has a safety responsibility. Every agency has a unit and personnel responsible for collecting, analyzing, and reporting safety data. With the exception of FAA, the focus has been on casualty data rather than safety, as defined in this paper. The safety analysis programs in FHWA and the approach to safety in the Bureau of Motor Carriers are examples. Transit safety has been largely accident oriented, and the data have been embedded in the Section 15 data base. Conversely, the new FAA program to develop

a comprehensive safety data base that would provide a method for assessing and identifying aviation safety issues reflects the recognition of the safety as well as accident dimensions. It is well worth review by the other modes, according to the author.

Finally, although it should be recognized that all modes of transportation are safe systems considering their scale and use, their safety is an essential criterion of their effectiveness. It is unfortunate that poor measures are often used as a basis for policy making at higher levels of safety policy. The result is often superficial and conflicting policy. There is little need for this to be the case. However, moving to a more consistent and coherent safety policy will require more sophisticated and scientific data bases than are currently being used. If they were employed, limited resources could be allocated more effectively and the safety of all modes of transportation could be measurably improved.

INFORMATION FOR TRANSPORTATION DECISION MAKING: INSTITUTIONAL CHALLENGES

This paper initiates a discussion of appropriate institutional forms that a comprehensive transportation information program might take. It delineates the purpose and scope of such a discussion, surveys some of the institutional forms and types now operating in this sphere, and examines the functions that U.S. institutions will have to perform to be effective.

The author's observations are as follows:

- The current national transportation data program needs new institutions and institutional arrangements to give structure to the scope and scale of its activities.
- The idea of a centralized institutional arrangement for transportation information requires further exploration and discussion. At a minimum, discussion should focus on what program elements are appropriate to and benefited by centralization.
- A national transportation statistical system needs to be explicitly defined.
- The forms and content of possible memoranda of understanding between producer and user agencies, following the Canadian model, should be explored.
- Mechanisms for providing opportunities for input and assembly of expressions of data are required.
- Separate intra-DOT and interagency institutions are needed to coordinate data programs and plans.
- An assessment of alternative institutional mechanisms to produce and manage data employed in other sectors of the economy and in transportation statistical systems abroad is desirable.
- Private/public mechanisms for data development need to be assessed.
- Opportunities for new forms of data development based on emerging technologies need to be seriously evaluated.
- Involvement of appropriate congressional committees is essential if transportation data efforts are to be meaningful.

IMPACTS ON DATA COLLECTION AND AVAILABILITY OF EMERGING INFORMATION TECHNOLOGY

This paper describes data collection strategies, transportation data requirements, the role of geographic information systems (GISs), and the importance of data integration. A conceptual model of the infrastructure life cycle provides a framework for fleet management and infrastructure management to illustrate the integration of transportation data. A truck port-of-entry exchange, a methodology for information integration, and technology determinants provide additional rationale for an integrated approach. Innovations in data collection technologies are examined, and their potential for use in integrated systems for policy planning is assessed. The paper concludes with recommendations for more effective use of new transportation data and information technologies.

The author states that the effective use of new data and information technologies for the operations, management, and planning of transportation systems requires integration of information resources. Horizontal integration of data and systems across organizational units and vertical integration across levels are both needed. Horizontal integration is facilitated by GISs and data exchange standards, while vertical integration is helped by systems for data aggregation and abstracting.

As stated in the paper, the GIS concept is a major tool in data integration. However, the state of the art of GIS does not handle well the real-time data base requirements of transportation system applications. Improvements are needed to handle the needs of planning, managing, and operating transportation systems.

AASHTO TASK FORCE REPORT

As a result of AASHTO's efforts to assess the nation's transportation needs and requirements to the year 2020, a special task force was charged to assess and report by mode on data issues and gaps. Because the report was a reference for all the paper authors and because of its relevance to TRB efforts, it is included in this Record.

Passenger Air Transportation Data Needs, Resources, and Issues

JAMES S. CAREY

Significant issues of passenger air transportation are discussed, and the information resources available to the U.S. Department of Transportation (DOT) for planning purposes are detailed. The issues related to air transportation information that must be considered in the national transportation strategic plan are addressed, and deficiencies in the information for transportation planning are pinpointed. Currently available passenger aviation information has been influenced most by regulation of the aviation industry. Unlike other industries, where disclosure information is voluntary, significant amounts of aviation information are required by federal regulations. Two primary regulatory agencies collect data from members of the airline community: the Civil Aeronautics Board and the Federal Aviation Administration. Air passenger transportation statistics are also available from other government agencies, such as the Internal Revenue Service, the Securities and Exchange Commission, and the National Transportation Safety Board. Additionally, many private enterprises regularly publish and collect statistics for the aviation industry. The current information systems are valuable but are largely deficient in fundamental ways. For example, no national information system exists to coordinate the available government data. Also, there are no consistent demographic and passenger demand statistics. Dramatic increases in international air travel present a critical need for more uniform data on international air passenger travel. Specific information gaps include the lack of data regarding airports eligible for FAA funding, the need for timely and accurate data, and the lack of a physical inventory in the national aerospace plan data. It is suggested that the strategic planning team consider the current data as a single national aviation information resource, then determine the importance of each data source to planning requirements. The team must find a systematic way to shape this information into a useful planning tool.

Significant issues of passenger air transportation are discussed and the information resources available to the U.S. Department of Transportation (DOT) National Transportation Policy Team (NTPT) are detailed. Also addressed are the uses of air transportation information, and the deficiencies in the information for transportation planning are pinpointed.

ISSUES IN PASSENGER AIR TRANSPORTATION

Significance of Passenger Air Transportation

Geographically, the United States is enormous, comprising 3.6 billion square miles of land and water. The 50 states are populated by 247 million people, generating $4.1 trillion of gross national product each year. One of the most significant factors making it possible for this far-reaching economy to prosper is the connection of the U.S. cities through the world's most advanced transportation systems. The speed of air travel makes any U.S. city accessible within a day's journey. Obviously, air transportation plays an important unifying factor in the interaction of people and businesses.

In 1988, more than 454 million people (1.3 million per day) traveled by air for business or pleasure. The ability to satisfy this demand for air services is accomplished through the cooperative efforts of federal government agencies, state and local governments, and the private enterprises of aviation and aviation-related businesses. Since the beginning of commercial air transportation, these organizations have worked to build a well-integrated air system in the United States.

Sources of Passenger Aviation Information Resources

Passenger aviation information resources have been affected most by the highly regulated growth of the aviation industry. The primary sources of data for air transportation are statistics supplied to the government agencies that regulate the industry. Unlike other industries, where disclosure of information to the government is voluntary, a significant amount of aviation information is required for compliance with federal regulations.

These regulations were created by the Civil Aeronautics Authority (CAA) following the passage of the Civil Aviation Act of 1938. This federal agency was established to promote orderly development of air services in the United States. CAA recognized early that, to fulfill its responsibilities, it needed timely, consistent, and reliable facts about the performance of the airlines in the industry.

In 1942, CAA instituted part 202.1 of the *Federal Economic Regulations*. This regulation required air carriers to provide uniform financial accounting data. In 1951, the accounting requirements were defined in greater detail with the adoption of 14 CFR part 241 of the *Federal Economic Regulations* entitled, "Uniform System of Accounts and Reports for Certificated Air Carriers." These regulations continue to be enforced today, including the original data requirements, though they have been modified and amended periodically. The most significant change has been the addition of part 298, which provides for data collection from small aircraft operators.

The Civil Aviation Act of 1958 separated economic regulation of the airline industry from air safety regulation. It was largely enacted to avoid conflicts of objectives within CAA. The Civil Aeronautics Board (CAB) was created as an independent federal agency with continuing obligations for economic regulation, while the Federal Aviation Administration

Airline Economics, Incorporated, 1350 Connecticut Avenue, N.W., Washington, D.C. 20036.

(FAA) was created as an additional agency in the U.S. Department of Transportation (DOT).

FAA was given responsibility to devise and implement regulations that would promote airline safety, assure the development and efficient use of airspace, and promote air commerce in the United States and in foreign countries. Since its inception, FAA has instituted federal regulations specifying rules for the safe operation and maintenance of aircraft in commercial service. These rules are primarily contained in parts 121, 135, and 91 of the *Federal Regulations*.

FAA also administers and maintains the airway and airport system by providing funds, equipment, and personnel. It designed and maintains the U.S. air navigation network and operates the air traffic control system. It develops specifications for airport design and provides federal funds for building airports throughout the United States. To support its administrative responsibility, FAA requires airlines and airports to submit operational data so administrators can monitor the performance of the airline and airport system.

Since 1958, these agencies have collected a large body of aviation data for establishing policies, planning, and adopting regulations. The comments of the users of these data suggest that both CAB and FAA have collected the correct statistics to administer their responsibilities. They also are considered to have adequately made the information available to the general public. However, there is a general consensus that pressing issues exist that must be resolved to ensure continued air transportation growth. Additionally, the users feel there are deficiencies in the type and usefulness of the statistics used for planning.

Issues Requiring Data Consideration

Comments provided for this resource paper at TRB's 6th International Workshop on Aviation Activities, as well as recent published comments of industry and congressional leaders, were critical of DOT's readiness to resolve what is seen to be pressing problems facing the industry. In general, the problems are the results of the dramatic changes that have occurred in the airline industry over the past 10 years.

Impact of Airline Deregulation

The Airline Deregulation Act, passed by Congress in 1978, phased out the responsibilities of CAB for regulation of domestic airline route authorization and price setting. International airline economic regulation and the airline data collection system were continued as tasks of DOT. Safety regulation and maintenance of the airway system remained with FAA.

Deregulation was conceived to allow new airlines to be started, thus providing competition for the traditional carriers. A consequence of deregulation was an increase in the ability of traditional airlines to expand into new markets. For several years, the airline industry became highly competitive as the large carriers competed aggressively with new-entrant carriers and smaller traditional airlines for shares of the national air passenger market. The number of air carriers operating in the United States increased substantially between 1978 and 1985. However, by the end of 1989, nine airlines dominated the airline market, carrying 97 percent of all airline passengers.

Comments supplied for this paper indicated that this concentration in the domestic airline industry is an important issue that will affect the future of air transportation services provided by DOT (*1*). The key questions concerning airline concentration are as follows:

- Will concentration mean that more or fewer services will be needed in the future?
- Can a smaller number of carriers provide sufficient passenger air transportation to fulfill national defense interest?
- Are adequate data being collected to reveal the impact of carrier concentration?
- Will airlines be less likely to provide data to the government because of a fear of losing competitive advantage?

An additional consequence of deregulation is that airlines have been more free to act independently to change their corporate and financial structures and to modify their operations for greater efficiency. The concentration of the carriers has been largely due to the merger and acquisition of carriers by airlines that wish to gain market share quickly. This has included purchases of or investment in the commuter and small aircraft operators that provide connecting service for passengers in small communities to the larger carriers. To manage these more complex combinations, airlines have adopted corporate structures that separate these diverse airline operations.

Today, a large carrier operating both large and small aircraft is managed by a nonoperating holding company or by private corporate owners. These new management structures coordinate the financial requirements of all carriers in the group. This corporate organization is prevalent in other U.S. industries, meaning airlines are becoming increasingly similar to their less regulated counterparts. Several TRB workshop participants raised the following questions concerning the changing structure of airlines:

- Will airline holding companies need to focus more on financial concerns than on airline operations in the future?
- With structures similar to other industries, will airlines be less willing to work closely with government in developing the air passenger infrastructure?
- Will this new structure mean that valuable information concerning airline financing will be more difficult to obtain?

The primary change in airline operations that has provided carriers with improved efficiency is the increased use of "hub-and-spoke" airport operations. Before deregulation, the majority of airline flights were operated directly from city to city on specific routes. With hub-and-spoke operations, carriers use centrally located hub airports to feed passengers from smaller cities into long-distance flights to their final destination. Because of this, hub airports have experienced dramatic increases in the number of flights operated during the day. This increase has resulted in delays and congestion at hub airports and at airports that are the most popular destinations from the hubs.

The principal questions raised regarding the issue of congestion were the following:

- Is the government collecting sufficient information to find ways to improve the congestion of airways and airports caused by hub operations?
- How will hub operations and delays affect investment requirements for the airport and airway system?
- What information will be needed to better forecast the impact of changes in airline operating strategies on airport and airway capacity?

Other Issues Affecting Data Requirements

Other issues that will require additional information to facilitate improved strategic planning are

- Domestic passenger demand,
- Increased international traffic growth,
- Alternative airport and airway funding mechanisms,
- Improved airport highway access,
- Impact of airport noise on communities,
- Coordination of federal and local aviation interest,
- Regulation of airline computer management and distribution systems,
- Increase in foreign carrier access to domestic markets,
- Increased foreign investment in U.S. carriers,
- Impact of worldwide airline liberalization,
- Maintaining safety in the deregulated industry,
- Modernization of the air traffic control system,
- Impact of the declining skilled labor force,
- Changes in aircraft financing,
- Access to highly congested airports,
- Opportunities for new-entrant air carriers, and
- Impact of aging aircraft on safety.

To determine the strategic consequences of these issues, a different approach will be required for the collection and use of data. Recent information has largely been used to monitor the effects of regulation on the industry. While it is generally felt that the data currently being collected should be retained, additional information is needed that more specifically provides an understanding of the issues facing the air passenger industry.

EXISTING SOURCES OF INFORMATION

CAB and DOT Statistics

As discussed above, one of the primary information sources for air passenger statistics is the "Uniform System of Accounts and Reports for Certificated Air Carriers," which is maintained by DOT (see Figure 1). This standardized financial accounting system was devised by CAB to ensure that each air carrier that has an operating certificate provides information in a consistent manner. Before deregulation, the data were used to determine whether an airline was financially fit and, thus, could provide scheduled passenger service in a safe and economic way. The data also provided cost and revenue information to allow CAB to set prices for air services in the United States. Since deregulation, this data collection has continued to be valuable for monitoring trends in industry growth and for measuring the demand for federal government obligations.

CAB's financial accounting system consists of a chart of accounts that conforms to federal accounting standards. CAB provides the air carriers with specific accounting rules and detailed explanations of the accepted content of each account. A reporting system known as the "Form 41 schedules" ensures that the information is presented in a uniform manner.

The Form 41 schedules are separated into three primary areas of financial statistics: balance sheet data, profit and loss statements, and operating statistics. The balance sheet accounts (shown in Figure 2) detail the value of the accumulated assets; an airline's liabilities and equity are reported by the carriers. These accounts provide a way to measure the ability of a company to uphold its financial obligations. Additionally, the balance sheet includes a summary of the accumulation of stockholders' equity, which is the increase or decrease in the overall value of the airline.

The second series of financial schedules collected in the Form 41 accounting system is the profit and loss account classifications (see Figure 3). These schedules detail the sources of revenue generated from an airline's operations, the actual distribution of expenses among the various operational areas within the airline, and the resulting profit or loss generated by the airline from its operations.

The profit and loss accounts also include supplementary schedules detailing the line item expenses for each type of aircraft owned by the airline. These schedules show the expenditures for labor, fuel, maintenance, and depreciation. Other supplemental schedules report expenses related to the ground operations that support the aircraft, the sales and advertising of services, the costs of the reservation and distribution network, and the airline's general and administrative costs.

The final statistical requirement of the Form 41 system is the classification of operating statistics (see Figure 4). These schedules detail the traffic carried by the airline, including both passengers and freight. The schedules also provide measurements of the air carrier's capacity in seats and tons. Schedules that present the actual levels of utilization of each type of aircraft in the airline's fleet are also included in this series of reports.

To further monitor changes of service and passenger demand in the U.S. airline system, the operating statistics require the collection of passenger and seat statistics for each segment flown between the cities served by the airline. This data series, known as "service segment statistics," includes the number of enplaning and deplaning passengers at each city on an airline's flight itinerary. To supplement the demand data, DOT requires the carriers to conduct a survey of the tickets sold by the airline. This origin-and-destination survey is accomplished by selecting a 10 percent sample of the actual processed tickets to develop a statistical estimate of the patterns of passenger movements throughout the air transport system.

The reports of the Uniform System of Accounts are submitted in a variety of frequencies. Most of the data are pro-

[ER-914, 40 FR 27017, June 26, 1975]

PART 241—UNIFORM SYSTEM OF ACCOUNTS AND REPORTS FOR LARGE CERTIFICATED AIR CARRIERS

Sec.

FIGURE 1 Uniform System of Accounts and Reports for Large Certificated Air Carriers.

Section 3—Chart of Balance Sheet Accounts

[See footnotes at end of table]

Name of account	General classification
Current assets:	
Cash	1010
Short-term investments	1100
Notes receivable	1200
Accounts receivable	1270
Allowance for uncollectible accounts	1290
Spare parts and supplies	1300
Allowance for obsolescence—Spare parts and supplies	1311
Prepaid items	1410
Other current assets	1420
Investments and special funds:	
Investments in associated companies	1510
Investments in investor controlled companies	1510.1
Investments in other associated companies	1510.2
Advances to associated companies	1510.3
Other investments and receivables	1530
Special funds	1550
Property and equipment	1600–1700

	Operating	Nonoperating
Airframes	1601	1701
Airframes	1601.1	1701.1
Unamortized airframe overhauls	1601.2	1701.2
Aircraft engines	1602	1702
Aircraft engines	1602.1	1702.1
Unamortized aircraft engine overhauls	1602.2	1702.2
Improvements to leased flight equipment	1607	1707
Flight equipment rotable parts and assemblies	1608	1708
Airframe parts and assemblies	[1] 1608.1	[1] 1708.1
Aircraft engine parts and assemblies	[1] 1608.5	[1] 1708.5
Other parts and assemblies	[1] 1608.9	[1] 1708.9
Flight equipment	1609	1709
Allowance for depreciation:		
Airframes	1611	1711
Aircraft engines	1612	1712
Improvements to leased flight equipment	1617	1717
Flight equipment rotable parts and assemblies	1618	1718
Flight equipment airworthiness allowance	[2] 1629	[2] 1729
Equipment	1630	1730
Furniture, fixtures and office equipment	1636	1736
Improvements to leased buildings and equipment	1639	1739

	General classification	
Buildings	1640	1740
Maintenance buildings and improvements	1640.1	1740.1
Other buildings and improvements	1640.9	1740.9
Ground property and equipment	1649	1749
Allowance for depreciation:		
Equipment	1650	1750
Improvements to leased buildings and equipment	1654	1754
Furniture, fixtures, and office equipment	1656	1756

[See footnotes at end of table]

Name of account	General classification	
Buildings	1660	1760
Maintenance buildings and improvements	1660.1	1760.1
Other buildings and improvements	1660.9	1760.9
Allowance for depreciation of flight equipment and ground property and equipment, and amortization of overhaul and airworthiness costs	1668	1768
Land	1679	1779
Equipment purchase deposits and advance payments	1685	1785
Construction work in progress	1689	1789
Leased property under capital leases	1695	1795
Capital leases—flight equipment	1695.1	1795.1
Capital leases—other property and equipment	1695.2	1795.2
Leased property under capital leases, accumulated amortization	1696	1796
Accumulated amortization—capitalized flight equipment	1696.1	1796.1
Accumulated amortization—capitalized other property and equipment	1696.2	1796.2
Property on operating-type lease to others and property held for lease		1797
Property on operating-type lease to others and property held for lease, accumulated depreciation		1798
Other assets:		
Long-term prepayments		1820
Unamortized developmental and preoperating costs		1830
Other assets and deferred charges		1890
Current liabilities:		
Current maturities of long-term debt		2000
Notes payable:		
Banks		2005
Other		2015
Trade accounts payable		2021
Accounts payable—other		2025
Current obligations under capital leases		2080
Accrued salaries, wages		2110
Accrued vacation liability		2120
Accrued interest		2125
Accrued taxes		2130
Dividends declared		2140
Air traffic liability		2160
Other current liabilities		2190
Noncurrent liabilities:		
Long-term debt		2210
Advances from associated companies		2240
Pension liability		2250
Noncurrent obligations under capital leases		2280
Other noncurrent liabilities		2290
Deferred credits:		
Deferred income taxes		2340
Deferred investment tax credits		2345
Other deferred credits		2390

FIGURE 2 Balance Sheet Chart of Accounts.

Section 7—Chart of Profit and Loss Accounts

Objective classification of profit and loss elements	Functional or financial activity to which applicable (00)		
	Group I carriers	Group II carriers	Group III carriers
OPERATING REVENUES AND EXPENSES			
Transport revenues:			
01 Passenger:			
01.1 Passenger—first class	31, 32	31, 32	31, 32.
01.2 Passenger—coach	31, 32	31, 32	31, 32.
05 Mail:			
05.1 Priority	31, 32	31, 32	31, 32.
05.2 Nonpriority	31, 32	31, 32	31, 32.
05.3 Foreign	31, 32	31, 32	31, 32.
06 Property:			
06.1 Freight	31, 32	31, 32	31, 32.
06.2 Excess passenger baggage	31, 32	31, 32	31, 32.
07 Charter:			
07.1 Passenger	32	32	32.
07.2 Property	32	32	32.
19 Air transport—other:			
19.1 Reservation cancellation fees	31, 32	31, 32	31, 32.
19.2 Miscellaneous operating revenues	31, 32	31, 32	31, 32.
08 Public service revenues (subsidy)	48	48	48.
Transport-related revenues and expenses:			
09 In-flight sales:			
09.1 Liquor and food—gross revenues	48	48	48.
09.2 Movies and stereo—gross revenues	48	48	48.
09.3 Other—gross revenues	48	48	48.
09.4 Liquor and food—depreciation expense	71	71	71.
09.5 Liquor and food—other expense	71	71	71.
09.6 Movies and stereo—depreciation expense	71	71	71.
09.7 Movies and stereo—other expense	71	71	71.
09.8 Other—depreciation expense	71	71	71.
09.9 Other—expense	71	71	71.
10 Restaurant and food service (ground):			
10.1 Gross revenues	48	48	48.
10.2 Depreciation expense	71	71	71.
10.3 Other expenses	71	71	71.
11 Rents:			
11.1 Gross revenues	48	48	48.
11.2 Depreciation expense	71	71	71.
11.3 Other expenses	71	71	71.
12 Limousine service:			
12.1 Gross revenues	48	48	48.
12.2 Depreciation expense	71	71	71.
12.3 Other expenses	71	71	71.
. . .	.	.	.
DISCONTINUED OPERATIONS			
95 Discontinued operations:			
95.1 Income from discontinued operations	96	96	96.
95.2 Loss on disposal of discontinued operations	96	96	96.
EXTRAORDINARY ITEMS			
96 Extraordinary items	97	97	97.
97 Income taxes applicable to extraordinary items	97	97	97.
CHANGES IN ACCOUNTING PRINCIPLES			
98 Cumulative effects of change in accounting principles	98	98	98.

[ER-755, 37 FR 19726, Sept. 21, 1972, as amended by ER-781, 37 FR 25223, Nov. 29, 1972; 37 FR 28277, Dec. 22, 1972; ER-797, 38 FR 10926, May 3, 1973; ER-841, 39 FR 11995, Apr. 2, 1974; ER-948, 41 FR 12295, Mar. 25, 1976; ER-980, 42 FR 35, Jan. 3, 1977; ER-1013, 42 FR 37515, July 21, 1977; ER-1401, 50 FR 242, Jan. 3, 1985; Amdt. 241-56, 52 FR 9129, Mar. 23, 1987]

FIGURE 3 Profit and Loss Chart of Accounts.

vided quarterly, but some operating statistics schedules are available on a monthly cycle and some balance sheet and profit and loss schedules are only reported yearly. Distinctions are made between the report forms based on the size of the airline. Smaller airlines report more abbreviated schedules to lessen the burden of compliance with the regulations.

All information collected under the Uniform System of Accounts is considered to be publicly owned and is readily available for use in planning and analysis of the industry. Due to the large volume of data collected, computerized processing and storage is the most effective way for this information to be maintained and disseminated.

The most common criticism of the system by nongovernment users centers on the current method of distribution for the form 41 statistics. The computer distribution of the data is performed by several independent contractors. These com-

Section 19—Uniform Classification of Operating Statistics

Sec. 19-1 Chart of Operating Statistical Elements

	Air transport traffic and capacity elements	Service classes
	AIRPORT-TO-AIRPORT TRAFFIC AND CAPACITY	
501	Interairport distance	Z.
110	Revenue passengers enplaned	A, C, E, G, L, N, P, R.
111	First class	A, E.
112	Coach	C, E.
210	Revenue cargo tons enplaned	A, C, E, G, L, N, P, R.
213	U.S. mail—priority	A, C, E, G, L, N, P, R.
214	U.S. mail—nonpriority	A, C, E, G, L, N, P, R.
215	Foreign mail	A, C, E, G, L, N, P, R.
217	Freight	A, C, E, G, L, N, P, R.
130	Revenue passengers transported	A, C, E, G, L, N, P, R.
131	First class	A, E.
132	Coach	C, E.
150	Nonrevenue passengers transported	A, C, E, G, L, N, P, R.
230	Revenue tons transported	A, C, E, G, L, N, P, R.
231	Passenger	A, C, E, G, L, N, P, R.
233	U.S. mail—priority	A, C, E, G, L, N, P, R.
234	U.S. mail—nonpriority	A, C, E, G, L, N, P, R.
235	Foreign mail	A, C, E, G, L, N, P, R.
236	Express	A, C, E, G, L, N, P, R.
237	Freight	A, C, E, G, L, N, P, R.
250	Nonrevenue tons transported	A, C, E, G, L, N, P, R.
310	Seats available	A, C, E, G, L, N, P, R.
311	First class	A, E, G.
312	Coach	C, E, G.
270	Tons available	A, C, E, G, L, N, P, R.
410	Revenue aircraft miles flown	A, C, E, G, L, N, P, R.
411	Scheduled	A, C, E, G.
412	Extra section	A, C, E, G.
430	Revenue aircraft miles scheduled	A, C, E, G.
431	Scheduled aircraft miles completed	A, C, E, G.
510	Revenue aircraft departures performed	A, C, E, G, L, N, P, R.
511	Scheduled service	A, C, E, G.
512	Extra section	A, C, E, G.
520	Revenue aircraft departures scheduled	A, C, E, G.
521	Scheduled aircraft departures completed	A, C, E, G.
	AIRCRAFT OPERATIONS	
420	Nonrevenue aircraft miles flown	Z.
610	Revenue aircraft hours (airborne)	A, C, E, G, L, N, P, R.
620	Nonrevenue aircraft hours (airborne)	Z.
630	Aircraft hours (ramp-to-ramp)	A, C, E, G, L, N, P, R.
	MISCELLANEOUS OPERATING ELEMENTS	
810	Aircraft days assigned to service-carrier's equipment	Z.
820	Aircraft days assigned to service-carrier's routes	Z.
830	Hours on other carriers' interchange equipment (airborne)	Z.
921	Aircraft fuels issued (gallons)	Z.
922	Aircraft oils issued (gallons)	Z.

[ER-1401, 50 FR 246, Jan. 3, 1985]

FIGURE 4 Operating Statistics Chart of Accounts.

panies distribute the data as a product, at prices that reflect their costs, and generate a profit for providing these services. Their prices are considered to be too high by many users and have proven to be an inhibiting factor in wider use of the information for planning purposes.

Additionally, one of the companies providing the statistics is a foreign firm that has a monopoly on computerized distribution. During the 1960s, this firm was among the first companies capable of providing high-capacity computerized data services. Because of this limited competition, it was able to negotiate a monopoly contract for the maintenance of the CAB airline data system. While CAB had found an effective way to solve its problem of managing the enormous amount of statistics, this company exercised its monopoly power by charging what are considered to be exorbitant prices. Because the data are considered to be publicly owned and are supported by U.S. taxation, this situation has been a source of considerable irritation for many users of these statistics.

Other DOT Statistics

Other sources of valuable information are generated by DOT, but they are not organized into public data bases. Oversight of the industry requires the carriers to make formal requests for authority to fly new routes, enter into mergers, or make any significant change in their organizational structure. For each request, a government "docket" is initiated. (The docket is a numbering system for orderly control of information related to a specific subject.)

During the many years of regulation, thousands of dockets have been initiated. They are a valuable information resource because they provide a historical record of airline strategic activities. A review of the exchange of responses to dockets from other carriers can provide an understanding of alternative points of view on each docket issue. Dockets usually include supporting data in the form of exhibits and reports, which can be used to provide insight into a carrier's objectives.

Other regulatory and legislative processes of both federal and state governments generate a collection of diverse legal opinions, budget reviews, and congressional reports. This information reflects a variety of perspectives on aviation issues from interested industry participants. Though not statistical, the ability to review and cross-reference these documents can have great value in the strategic planning process.

FAA Statistics

FAA collects a variety of statistical information that is available to the aviation industry. These statistics are not as structured as those collected through CAB/DOT data systems. However, information accumulated by FAA is available through special request and in periodic publications. The information is collected primarily to assist the agency in the management of aviation safety and the airport and airway system.

FAA is a large organization with specific informational needs in each area of responsibility (*2*). It is headed by an administrator, who is responsible for establishing overall policies and continually reviewing the operation of the entire agency. The administrator is assisted by a deputy administrator, who helps in the execution of the agency's responsibilities and substitutes for the administrator during times of absence.

Reporting to the FAA administrator are four executive directors. Each director is responsible for a specific activity. The executive directors are assisted by associate administrators, who execute the plans and programs established by the directors. Each of these directors has a specific role in the operation of the agency, and each has developed information resources that are useful for strategic planning.

The executive director for regulatory standards and compliance is responsible for establishing and ensuring compliance with the rules and regulations for commercial aviation activity in the United States. The director is assisted by the associate administrator of regulation and certification, who develops regulations for air carrier operations, devises rules for airway operation, and establishes rules for the certification of aircraft and pilots in the aviation industry. The associate administrator for aviation standards provides oversight of aircraft airworthiness programs, flight operating standards, civil aviation security programs, and aviation medicine programs. This group ensures that FAA regulations are applied consistently at all field offices throughout the country.

The executive director for system operations is responsible for operation of the U.S. airport network and the airway navigation and communication system. Assisted by the associate administrator of airway facilities and the associate administrator of air traffic, this directorate manages FAA's air traffic operation activities. It ensures that the airway system operates safely on a day-to-day basis, that sufficient personnel are trained for continuous operation, and that airway equipment and airport facilities are maintained in good working order. This group continually evaluates the performance of airports and airway services and recommends policies and plans for system improvements.

The executive director for system development is responsible for devising and implementing recommended changes to the U.S. airport and airway system. The associate administrator of airports develops safety standards for airport operations, assesses the changes in the capacity of additional air carrier operations at all federally funded airports, and prepares plans and programs for enhancement and modernization of the airport system. Implementation of the National Airspace System (NAS) is the responsibility of the associate administrator for NAS development. The NAS plan is a comprehensive system devised in the 1970s to completely upgrade the airway system using the most advanced automation and systems technology available. This group is developing the next generation of airway equipment and facilities, which will allow for continued growth in air transportation services in the next several decades. Assisting these associate administrators is the associate administrator for advanced design and management control. This department coordinates the NAS plan implementation with other operational departments in FAA and ensures that orderly operation of the airway and airport system continues.

The executive director for policy, plans, and resource management is responsible for the internal administration of all FAA activity. Executed by the associate administrator of administration and the associate administrator for human resources, this group is responsible for the internal accounting, budget, equipment acquisition, materiel management, and other management systems of the agency. The associate administrator for policy, planning, and international aviation establishes and disseminates aviation policy for U.S. air carrier activity and environmental and energy programs and coordinates international aviation programs with other aviation authorities around the world.

These administrative areas have initiated significant information management programs to provide supporting data for their specific tasks. They routinely make this information available in reports and publications. Several of the statistical databases are available through computer access; however, most FAA information is not distributed in this manner.

The types of information generated from FAA's activities can be summarized in the following categories:

- Airport information,
- Air traffic control and airspace information,
- Aviation activity information,
- Aviation safety analysis information,
- Financial resources,
- Human resources information,
- Materiel resources, and
- NAS facilities information.

FAA has taken significant steps toward building internal computer information management systems to provide readily available data for the activities of the associate administrators. Access to this body of data would be extremely valuable to the strategic planning team.

Each associate administrative section has developed specialized information systems containing data for the planning processes of the agency. This information provides statistics for programs and policy review. It is also used as a tool to analyze significant industry changes. A summary of these data systems is provided below (*3*):

- Airports
  - —Airport pavement analysis;
  - —Airport program management;
  - —Bird hazards system;

—Airport capacity modeling;
—National plan for integrated airports;
—Development and analysis statistical specifications;
—Runway friction measurement system;
—Airport improvements program;
—Regional grants management system;
—Airport noise monitoring system;
—Airports information inquiry and reporting system;
—Airport capacity enhancement reports; and
—Domestic and terminal area traffic forecasts.

- Air Traffic Control (ATC) and Airspace
  —Aeronautical information system;
  —Air traffic problem analysis system;
  —Air traffic planning requirements analysis;
  —Air traffic density analysis system;
  —Obstruction, evaluation, and airport airspace analysis;
  —Air traffic publication and research system;
  —ATC information retrieval system;
  —Air traffic count system; and
  —Air traffic field facility summary.

- Aviation Activity
  —Aircraft statistical system;
  —General aviation activity and avionics survey;
  —Certifications catalogs;
  —Air carrier activity information;
  —Air traffic activity; and
  —Aircraft document index.

- Aviation Safety Analysis
  —ATC health information system;
  —Enforcement inspection system;
  —General aviation accident reporting;
  —Comprehensive airman information;
  —Aviation safety reporting system;
  —Service difficulty reporting;
  —Accident incident data system;
  —Enforcement information system;
  —Airman medical certification data; and
  —Facility performance reports.

- National Airspace System Facilities
  —Obligation planning system;
  —National airspace performance reporting;
  —National energy management statistics; and
  —NAS facilities information.

- Other FAA Information
  —Operator error/deviation reports;
  —Air quality program information;
  —Equipment criteria system;
  —Policy/analytical studies;
  —Aircraft engine emissions information;
  —Environmental noise data;
  —Air carrier delay reporting;
  —International aviation information;
  —Energy policy analysis;
  —Activity forecast;
  —Advisory circular data;
  —Airport noise modeling;
  —Aircraft registration statistics; and
  —Consumer complaint system.

Easier access to FAA information resources was cited as a valuable course of action to pursue as part of the national transportation strategic plan. Additionally, the ability to select related information from a variety of different government data bases to be used in conjunction with the FAA information resources would enhance the value of the data as an analytical tool.

Statistics Provided to Other Government Agencies

In addition to providing detailed statistics to agencies directly responsible for regulation of the airline industry, the airlines must provide information to a variety of other government agencies.

The National Transportation Safety Board (NTSB) is responsible for investigating transportation accidents in all commercial rail, air, surface, and ocean transportation modes regulated by DOT. NTSB provides a system of checks and balances for the safety responsibilities of FAA. The agency has an extensive technical and engineering capability, which it uses to investigate and determine the specific causes of transportation accidents. This activity provides vital information on the effectiveness of FAA regulations on transportation safety. The information collected and the recommendations for changes in regulations provided by NTSB can be a valuable source of strategic planning data.

The Internal Revenue Service receives periodic statements of tax liability from each carrier. In addition to accounting for taxes levied on the revenues of the airline operation, the carriers collect federal taxes on ticket sales. Revenues from ticket sales are used to fund airway system maintenance and modernization.

In executing its responsibility for fair trade in the securities market, the Securities and Exchange Commission collects information from all airlines that issue stock to the general public. This information can be used to measure the viability of companies and to monitor changes that may have negative effects on a carrier's financial viability.

Statistics from Other Independent Sources

A variety of private enterprises specialize in publishing aviation statistics. Newspapers report current events of the industry, supplementing press release data with interviews from industry specialists. Aircraft manufacturers, parts suppliers, industry associations, international aviation organizations, aviation consulting firms, and academic institutions perform research and prepare studies on subjects of specific interest to them. This information is usually provided to the public in the form of periodicals, reports, and newsletters that present analyses of significant industry trends.

The collection of data on airline activity has evolved over many years. Each item of information has been necessary to improve understanding of the passenger transportation industry or to find solutions for specific problems. Most aviation information needed to aid understanding of the industry's past performance is currently available in the public domain.

The regulatory framework to continue and expand government information programs remains in place. Therefore, the NTPT has a substantial resource for air transportation infor-

mation that can be used as the basis for its activities. However, users of the data caution that gaps in the data may limit their usefulness as planning resources.

GAPS IN AIR PASSENGER INFORMATION RESOURCES

From the point of view of passenger air transportation planning requirements, the current information systems are valuable because they provide a variety of data that can be analyzed to aid understanding of the historical performance of the air transportation system. But, aviation users of these data agree that the current data are largely deficient for strategic planning in several fundamental ways.

National Aviation Information System for Analysis

Primarily, all current methods of government data collection evolved from a need for more information to monitor the rapidly changing airline industry. Most of the data are focused on verification of regulatory compliance. In other words, the information is tailored to provide answers to specific questions of aviation performance. Little effort has been made to provide an easy way to cross-reference data contained in other government information systems.

For example, CAB/DOT statistics are best used to determine financial fitness and statistical performance of individual carriers and the industry as a whole. The statistics do not adequately explain the relationship between overall changes in the U.S. economy and changes in airline performance. This type of analysis is undertaken periodically by independent researchers, but the government has not provided these correlations on a continuous and consistent basis.

A report by the AASHTO Task Force on Data Requirements (*4*) clearly summarizes the impact of this gap. After extensive use of several FAA data bases for the development of a year 2020 forecast of state aviation transportation needs, the task force concluded that, though the FAA data bases are extensive, they are inadequate as a resource for strategic planning due to the following reasons:

- No national data exist for airports not eligible for FAA funding.
- The data lack timeliness and accuracy, and much information is old or subjectively derived.
- No relationship exists between the airport physical inventory and the national airspace planning data.
- Future needs are based on projections rather than consideration of strategic alternatives.
- Aviation forecasts are done on a top-down basis. Projections are based primarily on past performance rather than projected passenger demand.
- There are no requirements for accurate state infrastructural inventory.
- No data are collected concerning airport access requirements.

Although the task force was relaying its direct experience with FAA statistics, similar comments were made by others concerning use of government data for planning purposes. All had difficulty finding the interdependent relationships between the data elements because the information to establish these relationships was not readily available in the data they originally found useful. For example, a data item in one data base could not easily be compared with related information in other data bases, or the related information was not available at all.

Gaps in Demand Analysis

Another common criticism of DOT statistics is that no data bases of demographic information for passenger air transportation are regularly collected. Independent organizations develop this type of information; however, they use infrequent surveys that do not fully explain the reasons for changes in passenger preferences or patterns of passenger travel demand.

For example, the Immigration and Naturalization Service collects data for all persons entering or leaving the United States through a customs facility. This provides excellent counts of air movements in and out of the country but reveals little about the type of person traveling and the specific reason for travel. Also, the Air Transport Association of America executes a yearly telephone survey of airline passengers that is administered by the Gallup polling organization. This survey provides a statistical sample of the number of people that have traveled by air in the most recent year, by their age and the frequency and purpose (business or pleasure) of travel. This information is valuable for determining future demand for airport services but is too limited in scope and could be far more detailed.

An additional problem with the passenger statistics currently collected by DOT is the inconsistency of the passenger statistics. The passenger enplanement reports provided by the carriers, though extremely complete, count all passengers boarding an airplane, regardless of origin and destination. Another statistical collection, the origin-and-destination survey, is a 10 percent sample of airline coupons. Independently, these two reports provide helpful information about the movements of passengers at an airport; however, because they are inconsistent, it is difficult to use them together as an analysis tool. The analyst must be careful to avoid the double counting that occurs in the enplanement data when a passenger boards for the return trip and must consider the inaccuracy of the origin-and-destination data caused by the sampling technique.

Passenger demand statistics are vital for understanding past growth factors and future airport capacity requirements. Each region of the country has specific socioeconomic characteristics that affect the rates of growth in travel. Without an understanding of the dynamics of demand, accurate forecasts will be difficult to predict.

Gaps in International Air Passenger Transportation Data

For the past 5 years, dramatic changes have been occurring in international aviation. The impending liberalization of air services in the European common market, scheduled for 1992, has focused airline attention on preparations for a more liberal world airline industry. U.S. carriers have formed strategic alliances to build international distribution systems. They have actively pursued additional international route authority and

have purchased record numbers of aircraft to exploit the opportunity to gain a share of a growing international market.

The airlines of Europe and the carriers of the Pacific Rim have moved aggressively to use the impending liberalization of Europe as a quid pro quo for cabotage in U.S. domestic markets. Their moves to prepare for an open-skies environment have recently included purchase of minority ownership in U.S. airlines.

The most serious impediment to understanding the implications of greater international liberalization is the lack of consistent and reliable international air carrier data. No uniform source of world international statistics exists. The statistics currently collected are limited and outdated. Although international air carrier associations such as the International Air Transport Association (IATA), the International Civil Aviation Organization (ICAO), and the Association of European Airlines (AEA) collect statistics from their members, these data are infrequent and limited. For the purpose of explaining increases in international travel demand, there is no collection of information that relates the growing international ownership of U.S. corporations and its impact on international travel.

Every possible effort must be made to improve international data collection. The regulatory and planning requirements for a liberalized world aviation industry have generated an immediate and serious need for consistent, accurate international data.

Other Gaps in Transportation Data

Several specific areas of air passenger data were cited as having substantial gaps at recent TRB workshops. The gaps are in a variety of aviation data, but all impact the planning requirements for future aviation services.

Representatives of the General Aviation Manufacturers Association and the Aircraft Manufacturers Work Group expressed an interest in more information on the potential for growth in the small air carrier and regional airline passenger market. It was indicated that this information should include the potential growth in the European regional passenger markets.

The workshop participants also expressed interest in greater availability of pilot and aircraft registry information as a planning tool. This FAA data collection is a continuous record of all aircraft registered in the United States as well as a complete list of private and commercial pilots who hold licenses. The primary restriction of these data is the infrequency of availability. Also, forecasts of expected changes in fleet and personnel for all sectors of the aviation community is an important factor in understanding future demand for air services.

A recent article by Cunningham and Brand (*5*) relates deficiencies the authors found in available information. They performed an analysis of the DOT *Air Travel Consumer Report* to determine the report's effectiveness in providing valuable consumer information to passengers. *Air Travel Consumer Report* is a monthly publication intended to provide consumers with quality of service information to assist them in choosing an airline. It shows the percentage of carrier flight delays, levels of mishandled baggage, and the number of overbooking and consumer complaints that have occurred during the year for a particular flight.

To compare the effectiveness of the report as consumer information, Cunningham and Brand developed a model that describes how consumers develop service expectations and perceive quality of service. The model also describes how other companies perceive consumer expectation of service, develop service specifications, and actually deliver service.

Their research concludes that, though the *Air Travel Consumer Report* attempts to present valid indicators of service quality, the information in the report is inappropriate to cause a change in consumer choice when compared with other methods for developing service perception. Cunningham and Brand criticize the data because some of the indicators are factors airlines cannot entirely control (e.g., flight delays and on-time performance). They suggest that the report could have been more helpful if an understanding of passenger perception of airline service quality had been part of the research in designing the report.

Though this article is extremely specific in its point of view, it highlights the importance and value of "systematically evaluating the use and effectiveness" of information to gain significant results (*5*). The research shows how aviation information can be collected and analyzed and can result in an apparently significant conclusion but, without an understanding of related factors, truly important conclusions can be missed.

Another gap in information related to delays is in the FAA flight delay reporting systems. Two primary flight delay reports are collected: the Air Traffic Operations Management System (ATOMS) and the Standardized Delay Reporting System (SDRS). These are used to determine the cause of increases and decreases in flight delays in the airway system.

ATOMS consists of reports made by air traffic controllers and supervisors when a flight is delayed for more than 15 min at a particular airport. The following categories are used for delays:

- Weather,
- Center volume,
- Terminal volume,
- Runway construction,
- NAS equipment, and
- Other.

SDRS delays are reported by a sample of three U.S. air carriers. These reports detail the location of an aircraft at the time of a delay. The following locations are included:

- Gateholds,
- Taxi-out,
- Airborne, and
- Taxi-in.

Though both systems provide information to reveal the reasons for delays in the airway system, many users of the data find that the reports do not adequately explain the problem. The ATOMS system is easily distorted because it relies on the controller to report the reason for the delay accurately. During extremely heavy work loads, it may not be possible for the report to be completed. Therefore, the information may not be reliable in providing the total count of all delays occurring in the airway system. The SDRS system appears to be flawed because the sample of three airlines is extremely small and because the report provides no explanation for

delays at the time of the aircraft operation. This means the two reports cannot be accurately correlated.

As delays continue to grow in the airport and airway system, it will become increasingly necessary to understand their specific causes. This will require a consistent, standardized delay reporting system that provides an understanding of all delays in the airway system and can be used for planning changes in operations to reduce the delay problem effectively.

Another substantial gap in information exists in the area of air cargo statistics. Since deregulation of the scheduled air cargo carriers in 1978, a limited collection of information has continued at DOT. It is possible to determine how many ton miles of cargo are carried by cargo airlines, but there is no report of the cargo capacity, the number of cargo shipments enplaned, the number of cargo departures operated, or the value of the shipments for the entire U.S. air cargo fleet. This information is important for determining the demand and amount of investment that will be required for cargo facilities and activities in the future.

A serious gap exists in consistent information on the costs and requirements for ground transportation for passengers at the beginning and end of air journeys. Each local government has been given the responsibility to provide these transportation services for the air passenger, but there is no way to determine whether these air-related ground services are consistent on a national basis or whether they are adequate to support future growth in airport capacity.

In short, there are substantial gaps in detailed information concerning the operation of the airport and airway system from the point of view of national airport and airway activity. Without data that will allow the government to determine the demand for passenger air transportation on a national scale, it will be difficult to establish priorities for investment in the future. The NTPT must have the ability to collect an orderly and consistent range of data that will provide insights into the real problems that exist in the air transportation system. Only through this approach will alternative solutions to total system requirements be able to be developed.

CONCLUSIONS AND SUMMARY

The aviation industry changed rapidly in the past decade. In the deregulated environment, the key to success for the airlines has been the ability to change their management style from one of implementing regulations to active strategic planning of airline activities. The successful airline today has adopted computer-assisted planning techniques supported by complex data management systems that allow decisions to be made quickly in response to competitive market changes.

The U.S. regulatory agencies must reassess their responsibility for building an airway system that can support future growth. They also must place greater emphasis on preparing for an increasing growth in international air services. This will require working closely with foreign governments to formulate plans for a worldwide system of airways and airports. It will become increasingly important to implement these plans at rates equivalent to carrier demand.

Unfortunately, the current problems of airport and airway congestion and slow airway system modernization indicate that past planning efforts have not been adequate. DOT's pursuit of a national transportation strategic plan is an important first step in correcting today's pressing problems.

A wide range of aviation information resources is available from government and private sources to begin the planning process. But, as users of these data have indicated, the information is not being used in the best way to provide answers to the complex problems that must be solved. Unlike the airlines, which have invested heavily in computerized aviation information systems to analyze the current data, the government has not taken significant steps to develop analysis systems for government-collected data. Additionally, it will be necessary to use the substantial base of statistics produced by academic institutions, independent research firms, aircraft manufacturers, and others in the strategic planning process.

The NTPT must consider the current collection of aviation data as a single national aviation information resource. They must determine the importance of each data source and develop a systematic way to compile this information into a useful planning tool.

To accomplish this, the following tasks will be necessary:

- State, local, and federal governments and the airports and airlines must all agree to provide information to the NTPT.
- The appropriate techniques for empirical analysis of the information must be determined, and efficient analytical tools and state-of-the-art information management systems must be used to facilitate planning activities. This should include computer equipment and software that can be readily used for planning and research.
- An appropriate way to fill the gaps in aviation information must be found in a cooperative effort between all aviation industry participants, both in the United States and abroad.
- The NTPT must find a way to ensure that the information requirements for the strategic planning process can be obtained in a consistent, timely manner.
- There must be a continuous effort to foster the participation of all industry members in future planning activities to ensure successful implementation and execution of programs included in the strategic plan.

If these steps are taken, the national transportation strategic plan can be completed with the best information resources available. With this information, the NTPT will be able to find more accurate strategies to solve the current transportation problems and prepare for continued growth in passenger air transportation.

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Impacts of Emerging Information Technology on Data Collection and Availability

KENNETH J. DUEKER

New data collection and information systems technologies are fundamentally changing the type, quantity, and quality of data available for planning, managing, and operating transportation systems. The challenge is to integrate information technologies to create synergistic effects so that the individual parts are made more useful by contributing to the whole. The infrastructure life cycle management concept illustrates the importance of a shared spatial data base. The combination of planning, management, and operations requirements dictates that geographic information systems function in real time.

Key concerns in formulating a national transportation policy are

- Will today's transportation policies and infrastructure meet tomorrow's needs?
- How well are we meeting today's needs (*1*)?

Studies that have tried to answer these questions (*2*) "have encountered gaps in available information on the condition, performance, and use of the transportation system. As a consequence, . . . TRB is evaluating the current and anticipated state of transportation data, and . . . will recommend improvements to the information resources that are essential to support informed national decisionmaking in transportation. . . . The type of information that are [*sic*] needed . . . and our ability to obtain and use the requisite data are being affected by major technological and institutional forces (*2*)."

This paper focuses on the technological forces, which include the development of automatic vehicle location and identification (AVL/AVI) systems, weigh-in-motion (WIM), motorist information systems, vehicle navigational and route guidance systems, global positioning system (GPS), remote sensing, geographic information system (GIS), electronic exchange of shipping documents, and microcomputer-based data collection and analysis systems. Individually, a number of these technologies have proven useful. Together, how well do they contribute to gathering improved information on the condition, performance, and use of the transportation system to support informed national decision making in transportation?

New data collection and information systems technologies are fundamentally changing the type, quantity, and quality of data for planning, managing, and operating transportation systems. The challenge is to integrate data for maximum effectiveness. Data integration involves the establishment of linkages and standards among data sets. Foremost among linkage mechanisms is location, which is central to the management of spatially distributed infrastructures such as transportation systems. Consequently, GISs, which organize data around location, are essential in integrating data about transportation systems. The "horizontal" integration of data and systems across different data bases involves file transfers and raises a variety of issues concerning data exchange and standards.

The "vertical" integration of data and systems involves the aggregating and abstracting of data as one moves up the levels of an organizational hierarchy. Thus, data integration may mean aggregating locally useful data for strategic transportation policy planning at the national level. At the local level, it also means aggregating or selecting operations data for management and planning. This requires a real-time, transaction-based system for operations and administration, from which management and planning data can be derived as a byproduct, thereby avoiding expensive or duplicative data systems.

This paper describes data collection strategies, transportation data requirements, the role of GISs, and the importance of data integration. A conceptual model of the infrastructure life cycle provides a framework for fleet management and infrastructure management to illustrate the integration of transportation data. A truck port-of-entry example, a methodology for information integration, and technology determinants provide additional rationale for an integrated approach. Innovations in data collection technologies are examined, and their potential for use in integrated systems for policy planning is assessed. The paper concludes with recommendations for more effective use of new transportation data and information technologies.

DATA COLLECTION STRATEGIES

Data for national-level policy and planning can be collected in two ways. One is by means of special and separate national data programs (such as a census) or a mandate (such as the Highway Performance Monitoring System [HPMS]). The second approach is to rely on data being derived as a byproduct of decentralized administrative or operating systems of private firms or state and local governments.

The advantages of national-level special or mandated data programs include control, uniformity, and relevance to the policy being addressed. However, a uniform national-level data program may be costly and time consuming to install. A

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more significant problem may be quality, particularly if firms or state and local governments are not committed. For example, the quality of the data that went into the 1972 and 1974 national transportation studies is suspect. This is a particular problem when the data being collected are subjective rather than objective. Transportation "needs" are included in this subjective category.

A decentralized system where planning data are derived from, or are byproducts of, administrative and operating systems is more likely to produce reliable and accurate data, if appropriate standards are identified and applied by cooperating agencies. For example, uniform transit operating data is collected through UMTA's Section 15. Through aggregation and selection, UMTA is able to generate meaningful reports for federal policy use. From a local perspective, this is not entirely a separate data program but is, for the most part, a logical output of an administrative system. However, it is very difficult and time consuming to establish such a program. A major difficulty is to aggregate, sample, or generalize detailed data to discern underlying trends. It is difficult "to see the forest for the trees."

Although decentralized byproduct-type data programs are conceptually superior, they cannot be implemented in time for immediate policy analysis needs. Consequently, interim strategies must be found. Nevertheless, a long-term transportation data program is needed to reduce reliance on special ad hoc federal data programs, which usually yield suspect data. Routine, ongoing data programs that make better use of new technologies and tap into state and local administrative and operating systems may generate more reliable data for national policy use.

This analysis pursues the longer-term strategy of a decentralized system relying on data derived from administrative and operating systems. In either case, however, data integration is a problem. Any single data program or technology is insufficient, and the data must be placed in context for use in policy. This form of data integration often uses a denominator or conversion to a certain rate, such as per capita, per vehicle mile, or per passenger. It may use a time comparison—to last year or an average year. It may use a spatial comparison—to another state or county or to a median state or county. Finally, it may use subject comparison over a time period, such as comparing investment in transportation with investment in education over a 20-year period.

The challenge is to use the information technologies to integrate data and thereby make the data more useful than the individual data elements themselves. This integration needs to occur at appropriate levels; otherwise, misleading averages or rates may be generated. For example, transit cost and patronage need to be integrated at the agency level to be of most use. Then, comparisons with state and national data regarding costs per passenger are meaningful.

A national-level transportation data program is essential for policy analysis, formulation, and implementation. It will have two components: one orchestrates data derived from state and local administrative and operating systems, while the other collects data directly. New information technologies have application in both instances.

National-level data programs generally rely on sampling or mandated reporting. Information technologies can aid these kind of programs. Generally, computer-aided methods increase productivity. For example, the 1990 National Personal Transportation Study will be conducted by telephone using random digit dialing, with scanner input of forms to the computer. More powerful and versatile statistical packages will aid in analysis and reporting. Similarly, organizations such as Oak Ridge National Laboratory are employing computer-based systems to analyze large, national socio-demographic data sets in conjunction with transportation networks to address policy and planning issues at the national level with greater ease than previously possible. This kind of capability is essential to examine such issues as the contribution of transportation to the greenhouse effect or global warming. In these instances, aggregation of state and local data may not be particularly suitable.

It is difficult to project whether use of new information technologies, such as tagging and tracing a sample of persons, shipments, or vehicles, will become widespread. The technologies may be available, but the design of a national data program of this type may not be feasible or socially acceptable. A more likely data collection or integration program would yield aggregate data, such as traffic flows, in a more timely and spatially representative manner.

TRANSPORTATION DATA REQUIREMENTS

In addressing transportation data requirements, Schmitt (*2*) classifies transportation data as follows:

- *Facility Inventory, Condition, and Performance*. Data on the extent, ownership, physical condition, operating costs, speed, capacity, and other characteristics of rights-of-way, terminal and network facilities, and related transportation infrastructure.
- *Equipment Inventory, Condition, and Use*. Data on the number, miles of travel, ownership, physical condition, operating costs, speed, capacity, and other characteristics of vehicles, rolling stock, aircraft, and vessels that operate on transportation facilities.
- *Carrier Performance and Condition*. Data on the expenses, revenues, ownership, market coverage, labor force, and service characteristics of public and private for-hire carriers, shipper-owned transportation services, transportation services provided by social service and other organizations for their own account, and arrangers of transportation service.
- *Passenger and Freight Flows*. Data on the volume, geography, value, and other characteristics of passenger and freight flows.
- *Demographics and General Economic Activity*. Data on the number, geographic distribution, economic health, output or propensity to travel, vehicle availability, and other characteristics of households, businesses, and users of the transportation system.
- *Safety and Security*. Data on accidents, near-misses, personal injuries, emergency medical services, cargo damage, passenger and cargo restraints, hours of operation, drug and alcohol use, and terrorist incidents and countermeasures.
- *Finance and Program Administration*. Data on public agency cash flow, personnel, tax burden, bonding authority and other revenue sources, trust fund balances, the distribution

of obligations by contractor characteristics and geography, and other characteristics of public finance and administration.

This taxonomy of transportation data types is a useful way to describe the condition, use, and performance of transportation systems. However, all data are not equally important. The AASHTO Standing Committee on Planning (SCOP) provides focus to identify data requirements for national transportation strategic planning (*3*).

The SCOP posed three questions:

1. Are the data adequate in the particular modal area?
2. What information should be collected on a continuous basis?
3. What types of questions should be answered from a strategic planning process?

Responses indicated that the following types of data should be available for all modes:

- Facility inventories,
- Usage data,
- Financial data,
- Quality of service data, and
- Population and economic data.

In addition, the SCOP recommended that policy models be available to test the consequences of

- Various funding scenarios,
- Major changes in policy direction,
- Major changes in any of the above data categories, and
- Impact of external policies (air quality, energy, etc.).

Information regarding the condition, use, and performance of transportation systems is an important input to models that test changes in trends or policies. Consequently, this paper is attentive to data and information technologies that monitor transportation systems. Data on transportation system performance, in terms of mobility and congestion measures, and models of the impact of investment policies on performance are in great demand. Yet, data to develop models are in short supply.

New technologies to support transportation data and information programs are identified in Table 1. To identify technologies for data collection, data integration, and data use in trend and policy models, the transportation system is characterized by the following elements: driver/user, vehicle, fleet, traffic, roadway, network, and the demand side (users and nonusers).

The technologies identified in the table constitute new ways of measuring and understanding human factors, vehicle location and identification, fleet management, data about roadway traffic and the network within which it operates, the flow of persons and goods in networks, and of the flow of the users and nonusers of transportation that make up the socioeconomic group served by the transportation system. Individually, these technologies are being implemented, but most of the effort is toward making the technologies work correctly. Once the data are flowing, attention will shift to integrating and using the data.

TABLE 1 TECHNOLOGIES TO SUPPORT TRANSPORTATION DATA AND INFORMATION PROGRAMS

Transportation System Elements	Data Collection Technologies
Driver/user	•Human Factors
Vehicle	•Driver Simulators Crash Tests Accident Data Analysis
Fleet	•AVL Scheduling/Dispatching
Traffic	•ATR/AVC, WIM/AVI Real-Time Traffic Control
Roadway	•HPMS,LTPP, WIM Infrastructure Management
Network	•Hazmat Routing Transportation Models
Demand Side	•Socio-economic Data

The important point is that the data and information technologies must function together. Although the technologies are useful individually, data integration is required to assess changes in trends and policies. The challenge is to integrate the information technologies to create synergistic effects so that the individual parts are made more useful by contributing to the whole (*4*).

In this way, technologies can function together. For example, AVI and WIM can help enforce truck weight restrictions and provide planning data for roadway design. Similarly, ATR (automatic traffic recorder) technology can serve several functions. Traffic data can be aggregated upward to the system level and provide valuable VMT (vehicle miles traveled) data for national planning. These data can also be used to infer seasonal, growth, and truck factors to other locations on the highway system to serve the needs of highway design at the project level and traffic management at construction sites. A logical next step is to use data collected at a denser set of ATRs, in real time, for motorist information systems and traffic management, with planning data as a byproduct.

OTHER INNOVATIONS IN DATA COLLECTION

In addition to the hardware technologies of data collection, such as WIM, AVL, and AVI, there are other innovations in data collections. Examples of these are

- Administration records exchange/access. This is another example of using operational data for management and planning. Again, selective aggregation is the key ingredient.
- Combining survey data with aggregate data for origin-destination (O-D) estimation. Ben-Akiva and Morikawa have developed a data combination and updating method that corrects survey data for nonresponse biases and reduces sampling errors by statistically combining survey data with aggregate data (*5*).

These examples are mentioned to complete the picture; innovation in data collection is more than hardware improvements. A number of statistical issues must be addressed. For example, statistical techniques to infer appropriate seasonal factors for short-count traffic data locations from permanent

traffic counting locations require the integration of data by location. This can best be accomplished by use of a GIS.

GEOGRAPHIC INFORMATION SYSTEMS FOR DATA INTEGRATION

Because transportation infrastructure is locationally distributed, geographic location is the key to integrating data about infrastructure. The integration of data for infrastructure systems is accomplished by the application of GIS concepts and technology. A consensus definition of GIS was developed for the American Society of Photogrammetry and Remote Sensing and the American Congress on Surveying and Mapping (*6*):

> A system of hardware, software, data people, organizations, and institutional arrangements for collecting, storing, analyzing, and disseminating information about areas of the earth.

A GIS is more than hardware and software to produce maps. It includes a spatial database consisting of structured data that

1. Enables linking of spatial and attribute data for geographic features,
2. Relates data across map layers, and
3. Supports routing, adjacency, and inclusion applications.

The linking of spatial and attribute data (item 1 above) enables spatial access to a data base containing attributes of the selected objects. It also enables map display or highlighting of spatial objects having specific characteristics or attributes. In the first instance, the spatial search identifies objects for which the attribute data are reported. In the latter case, the data base is searched first, and the objects having the requisite attributes are displayed.

The geometric relation of data layers (item 2 above) is often called "polygon overlay" and is analogous to the physical overlaying of mylar sheets. Overlaying reveals the number of point, line, or area objects that are contained in another set of areas (for example, the area of roadway clearing through forested land).

Applications such as routing in transportation networks rely on topology relations consisting of explicit knowledge of the mutual connectivity and relative spatial positions of the points, lines, and areas that make up map space. This maintenance of topology relations is central to a GIS and is sometimes referred to as "map intelligence." The relationships among mapped objects are explicitly maintained.

In addition to the three data structure issues, there are two other important issues related to spatial data bases. The layers of data in a spatial data base must be in spatial registration, either by means of registration to the same coordinate base or by means of common spatial referencing systems, such as route/milepoint or node/link identifiers. Also, the data types or layers in the spatial data base may be institutionally independent or may be managed or controlled by the unit or organization responsible for maintenance. By means of spatial registration, the data layers can be shared as needed, but control and maintenance can be decentralized. This serves to avoid organizational conflict.

The data model used in spatial data bases can be concisely expressed as follows (*7*):

> A data model is the whole of concepts and expression tools that enables the description of a complex set of data items. The main concepts in the . . . data model are features, attributes and relationships. A feature is a formalized entity that is used to represent a topographical object. The properties and particularities of the objects are represented by means of attributes. Properties involving more than one feature are described by means of relationships. A group of features that is strongly related is called a layer.

GISs are important in addressing data integration needs of transportation applications. Examples of partial GISs include network modeling data bases, which are made up of load nodes and links and nodes describing the transportation system, and roadway inventory and mapping systems. These are viewed as partial GISs because they do not fully integrate the roadway inventory information, the roadway cartography, and the roadway network in a flexible systems environment to input, store and retrieve, model, and display the results.

The use of GIS technology for urban applications provides an example of an integrated data base. In the 1970s, the U.S. Bureau of the Census developed a system called GBF/DIME (Geographic Base Files/Dual Independent Map Encoding) for U.S. metropolitan areas. The extent of coverage has been expanded to include the continental United States, and the system is now called TIGER (Topologically Integrated Geographic Encoding and Referencing System) (*8*).

The concepts underlying TIGER are important in understanding the power of data integration. TIGER maintains the relationship of points, lines, and areas that make up the street/road and jurisdictional/statistical systems of the nation. In simple terms, this enables the assignment of people, located by street address, to their correct census geographical units for tabulation. In broader terms, it demonstrates how to integrate data, such as relating socioeconomic data for users of transportation systems to the facilities that supply transportation service. It also demonstrates the power of topologically relating the individual street facilities to enable analysis of flows.

Of course, these concepts are not new, and the process of relating supply and demand for transportation has been incorporated into transportation planning models. However, the challenge is to place the network assignment model data bases and the TIGER files into roadway inventory and real-time operational environments. This requires hardware and software systems having GIS functionality. Unfortunately, current GISs do not support many of the needs of transportation systems, particularly the incorporation of real-time transactional data flows that may come from ATR or AVL systems.

TenEyck et al. (*9*) provide an example of using a GIS to integrate data. Data from the accident record system are integrated with data from the roadway management system to show that "run-off-road" accidents occur on stretches of highway having shoulder drop-offs of more than 2 in. This integration of data at the time of analysis is made possible by relating data via common keys, in this case control sections or, more generally, route and milepoint. The Highway Safety Strategic Transportation Research Study (STRS) program builds on this type of research by targeting the three principal elements affecting highway safety: the vehicle, the roadway

environment, and the driver. This allows an examination of "cross-cutting issues, such as the impact of new technology on highway and vehicle safety, the development and use of better data on injuries sustained in accidents, and the role and control of congestion in highway safety" (*10*, p. 7). This is in contrast with the Long-Term Pavement Performance (LTPP) program of the Strategic Highway Research Program (SHRP). The LTPP program involves monitoring more than a thousand 500-ft sections of in-service highways (*11*, p. 5) and requires data integration by advance planning. It will streamline those analyses that are anticipated but will make difficult those that are not.

FRAMEWORKS FOR TRANSPORTATION DATA INTEGRATION

Integrating transportation data, particularly those coming from new technologies such as ATR, WIM, and AVL, poses difficult problems in systems design. Five system design and data integration approaches to these problems are examined below. One is a conceptual framework called infrastructure life cycle management as described by McDonnell-Douglas (*12*). The second is an example of fleet management in transit organizations (*13*). The third example deals with truck port-of-entry automation (*14*). The fourth example involves information integration methodology (*4*), and the fifth deals with technological determinants (*15*).

Infrastructure Life Cycle Management

Life cycle management is described as a continuous process of planning, designing, constructing, and operating, as illustrated in Figure 1. When applying this concept to infrastructure systems, the life cycle takes on the components of strategic planning, engineering design and construction, and facilities management (see Figure 2). Supporting infrastructure management with new information technologies results in modification of the life cycle concept to include GISs, computer-aided drafting (CAD), computer-aided engineering (CAE), and facilities management (FM). This is also illustrated in Figure 2. The key feature of an integrated system to support operations, management, and planning is a common spatial data base. As a result, changes made by one group

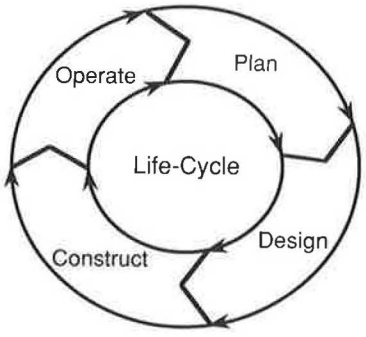

FIGURE 1 Infrastructure life cycle.

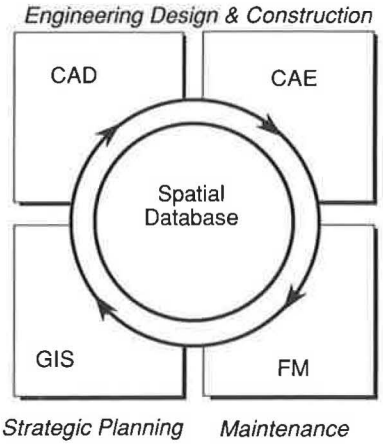

FIGURE 2 Infrastructure management system.

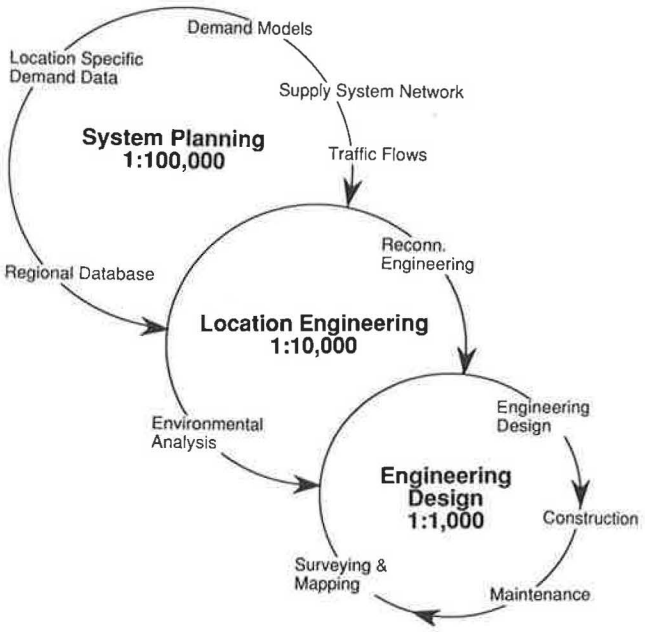

FIGURE 3 Infrastructure life-cycle management: map scale difference.

are available to all. However, the nature of this data base is not easily defined. For example, is it a single data base? Or is it several data bases with file transfers from a GIS structure to a CAD data structure? A number of data standards and file transfer issues must be addressed.

Applying this infrastructure life cycle management concept to a highway information system involves both potentials and problems. The chief problem is one of scale differences (see Figure 3). Operations, management, and planning often require different time and spatial scales, which makes it easier to develop and support separate systems rather than integrated ones (*16*).

The scale at which to support engineering design and construction involves CAD and CAE systems that deal with highway plan and profile information. The highway maintenance

function would use and keep current the as-built plans. The highway planning function related to this detail would include accident and traffic analysis and site planning of adjacent land uses that might require curb cuts and traffic control devices. Again, the key feature of this integrated system to support engineering design and construction, facilities management, and detailed planning is a common spatial data base. Changes made by one group are available to all, and everyone can count on up-to-date data.

However, most planning is done not at an engineering scale but at a more generalized corridor or system scale. At a smaller spatial scale, there is another highway information life cycle. Maintaining information about traffic flows, signs and signals, and accidents does not warrant the spatial detail needs of highway design and construction. Consequently, a cycle whose spatial data base contains more generalized data is needed. This more generalized spatial data base would be statewide rather than project specific and would represent highway elements as single line widths rather than rights-of-way containing facilities. This spatial data base would have the following characteristics:

- A highway system consisting of links and nodes for use in minimum path routing and traffic assignment models,
- An accurate cartographic representation of highway system links for mapping purposes, and
- Use of the route and milepoint spatial referencing system by recording the range of milepoints for each highway link (*17*).

As shown in Figure 4, this method of organizing the spatial data base for the highway system allows data integration. Accident, traffic, and roadway inventory data that are normally recorded by route and milepoint can be related, displayed, and incorporated into models. This is analogous to the TIGER data structure with the route and milepoint replacing or augmenting the address ranges.

Fleet Management

Application of the life cycle management concept to transit fleet management takes on a different form. The temporal dimension becomes more critical, and the detailed spatial scale associated with engineering design and construction is of less concern, unless the transit property is involved with fixed-rail systems. Unfortunately, the use of temporal data in a GIS is not well developed. A recent article by Langran (*18*) provides a review of temporal data base research and its use in GIS applications.

The importance of the temporal scale is illustrated in Figure 5 with different cycles of operations, management, and planning. The real-time operations cycle supports the needs of dispatching and monitoring schedule adherence. The management cycle deals with seasonal or periodic scheduling at the times drivers sign up for routes and shifts, and the planning cycle occurs on a more seasonal or annual time frequency when routing changes are made.

Fleet management is concerned with the flow of data from buses to dispatcher, then archiving and integrating the data for management and planning uses. Transit organizations are adopting new technologies for communications, automatic passenger counting, automatic fare counting, automatic vehicle location, etc. It is the integration of these technologies that is necessary to generate data for achieving the objectives of life cycle management.

Modern radio and computer technology enables a polling of bus fleets (with digital communication) to the dispatcher's computer for identification of the bus, driver, route/run, and operating data, including the odometer reading, door opening, passengers on and off, and location. Immediately, this information is used for exception reports on schedule adherence and for schedule adherence feedback to drivers. For management and planning, selected polling records are aggregated for analysis. Data can be summarized by route, time, driver, bus, and timepoint for analysis.

Currently, the focus of attention in AVL for transit fleets is on implementation of the technology. Early adopters are now focusing on extracting from the flow of data used for on-street service operation to create a historical data base for planning and management using the GIS concept (*19*).

Truck Port-of-Entry Automation

Information technologies, in the form of AVI and WIM systems, are being integrated with existing truck scales and a

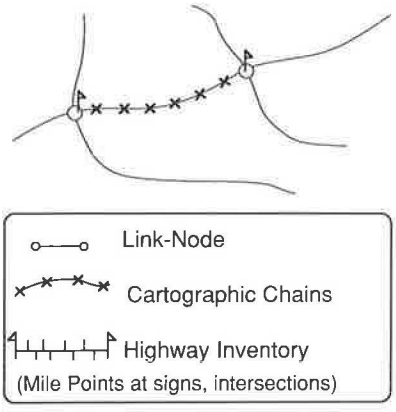

FIGURE 4 Highway system integrated data base.

FIGURE 5 Fleet management vehicular transportation systems.

supervising system computer (SSC) at the Woodburn Southbound Port-of-Entry in Oregon (*14*):

> The purpose of this integration was to allow trucks with transponders, meeting legal weight as shown by the WIM, and Public Utility Commission (PUC) criteria from the PUC vehicle database, to bypass the static scales. Data on these trucks is stored by the SSC. Trucks, without transponders, meeting the legal weight as shown by WIM, are directed to the static scales (where their PUC identification number is keyed into the computer). The SSC brings the PUC information onto the screen. If the trucks meet the PUC criteria with respect to taxes and safety, only its weight from the static scales is recorded. It then is allowed to pass through. Those trucks that do not meet weight or PUC criteria are stopped and issued citations and/or go to the PUC location to obtain permits.
>
> The data is downloaded to the mainframe and changes in the PUC database are uploaded on a regular basis. Daily statistical records and tables are produced by the SSC.
>
> The automation system has allowed the weighmasters to weigh vehicles more quickly, reducing congestion. The system has also revealed outstanding weight-distance tax payments owed by some firms. A chronic offender list is being developed through the use of the SSC. Such offenders typically are found to have a history of overweight or permit violations.
>
> If all trucks had transponders, the automated system would dramatically reduce the number of vehicles weighed at . . . (perhaps by 50 percent), thus greatly reducing the weighmaster workload. This would allow for rescheduling personnel to other duties.

Information Integration Methodology

Achieving the integration of data and systems is a complex matter. Nyerges (*4*) describes a methodology for information integration:

> Information integration is defined in this context as the bringing together of information parts into a working whole, controlling redundancy where appropriate. A synergistic effect is anticipated such that the individual parts are made more useful by contributing to the whole. This bringing together does not mean that the whole is one "physical" whole, however it does mean that the parts cooperate. The term "information integration" is derived from the concatenation of "information sharing" and "systems integration." In this regard, information integration could involve one or more of the four components of a geographic information system: data, software, hardware, and/or personnel. Consequently, information integration could be accomplished through various strategies involving the integration of data, the integration of software/hardware functionality and/or the integration of personnel.
>
> Data integration requires at least two steps: integration of data descriptions for a database, and integration of the data itself. Two types of data descriptions are important for data integration. These are descriptions contained in a schema, and descriptions (definitions) contained in a data dictionary. Structural descriptions in the schema describe how data are represented and stored in a database.
>
> Functional integration involves bringing together separate software/hardware components to enhance or extend the analyses in a system; or reducing/eliminating database management system duplication. This process involves the integration of dissimilar software and/or hardware. Software integration usually involves the merging of data-structure constructs. Hardware integration involves the physical linkage of computers or the linkage of peripherals with computers to enhance data manipulation, e.g., graphics plotters or special high-speed processors.
>
> Personnel integration involves the merging or reorganization of staff. . . .
>
> An information integration methodology . . . consists of four stages. The stages are: (1) integration strategy planning, (2) integration analysis, (3) integration design, and (4) integration implementation. To better understand the nature of the activity at each stage in the process, each stage can be described at three levels of abstraction. The levels are: (a) conceptual understanding, (b) techniques that can be used for expressing the concepts in terms of data constructs, and (c) software/hardware tools available for implementation of data constructs.

Complex problems, such as building a vehicle navigation system, require integration of data and subsystems for address conversion, route planning, route guidance, and position display. New tools are needed to build these complex systems. Information integration tools are important in achieving the needed integration of information technologies, particularly as the trend in computing technology evolves to workstations in a server-net environment. This technological trend makes data integration increasingly feasible.

Technological Determinants

Opportunities for data integration and GIS applications are shaped by technological developments. In a paper by Travis et al. (*15*), three trends are identified that will influence developments:

1. The server-net model of computing environments,
2. Rapid technological change, and
3. The emergence of open systems.

Server-Net Model

The server-net model conceives of computing as specialized services emanating from different nodes of a centerless network. A GIS design involves three kinds of server nodes: GIS servers, data base servers, and user workstations.

Rapid Technological Change

Technological change is occurring more rapidly in computing than ever before. Thus, it is difficult to avoid design constraints and limitations that soon become unnecessary because of technological progress. This difficulty is a major challenge to the GIS concept and data integration designers.

Emergence of Open Systems

Systems constructed according to vendor-independent standards are referred to as open systems and have the distinct advantage of freeing users from dependence on particular vendors and their proprietary standards. The server-net model in an open system computing environment is incrementally modifiable with new server nodes added and old server nodes upgraded or replaced without major impact on the other nodes in the net. This is possible only if the nodes connect to and interact with each other according to standardized protocols.

These rapid technological developments have the potential for further relaxation of economic and institutional constraints to allow adoption of new methods and approaches (*20*). The server-net model and the single data base ought to both reduce cost and reduce the struggle over the control of computing and information. These are democratic forces in contrast to existing centralized mainframe computing (*21*). However, in a decentralized computing environment, a considerable investment of time and energy is needed to work out responsibilities for data layers and standards for data exchange.

The application of technology to transportation data requires frameworks for integrating various data. Without integration, data are of little use. Context is needed. The approaches described above illustrate ways in which integration can be achieved and data made more useful.

CONCLUSIONS AND RECOMMENDATIONS

This analysis shows that effective use of new data and information technologies for the operations, management, and planning of transportation systems requires integration of information resources. Both horizontal integration of data and systems across organizational units and vertical integration across levels are needed. Horizontal integration is facilitated by GISs and data exchange standards, while vertical integration is keyed by systems for data aggregation and abstracting.

GIS technology is a major tool in data integration. However, the state of the art of GIS does not handle well the real-time data base requirements of transportation system applications. Improvements are needed to handle the needs of planning, managing, and operating transportation systems.

A conceptual framework of infrastructure life cycle management is used to show why and how data integration, by means of a shared data base, becomes the new issue. Although data collection technologies are essential, the challenge is to integrate information technologies to create synergistic effects so that the individual parts are made more useful by contributing to the whole.

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Freight Transportation Data Needs, Resources, and Issues

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Current sources of data related to freight transportation in the United States are examined and improvements are recommended that would enhance the ability to make informed decisions on national transportation strategy and policy development. The major focus of the paper is on intracity freight transportation via rail, highway, water, and air. Two key trends are having a major impact on the collection and use of freight transportation data in the United States: the continuing deregulation of freight transportation carriers and the increasing importance of freight transportation to the shipper community. However, a "planning gap" is developing between the public and private sectors in freight transportation. Private companies are increasing their spending on information to ensure efficient movement of goods worldwide, while public agencies are reducing information development commitments for freight transportation right-of-way and facility planning. This paper identifies six key information gaps that need to be filled to meet emerging national freight transportation planning and policy analysis needs: modal/route/facility operating performance data, shipper logistics patterns by industry, intercity freight flows by mode, hazardous materials tracking, intracity freight movements, and emerging shipper needs. Finally, the paper recommends possible data collection options for each information gap and suggests a private sector/public sector "partnership" for freight transportation data collection in the 1990s.

The purpose of this paper is to examine current sources of data related to freight transportation in the United States and to recommend improvements, thus enhancing the ability to make informed decisions on national transportation strategy and policy development. The major focus of the paper is on intercity freight transportation via highway and air. Rail and water transportation (as well as intracity freight transportation) are also considered, but with less emphasis because of ownership and jurisdictional issues.

Key freight information needs and resources examined in this paper include

- Facilities,
- Transportation equipment,
- Carriers,
- Flows, and
- Users.

Information requirements, availability, and gaps have been evaluated relative to the U.S. transportation system user needs, capacity, and performance. The analyses in this paper were based on a thorough evaluation of existing freight transportation information sources (see Appendix A), the results of a workshop on freight transportation data conducted by TRB and the Transportation Research Forum (TRF) (see Appendix B), and numerous conversations with transportation analysts and policy makers who frequently use freight transportation data in their work.

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BACKGROUND

Two key trends are having a major impact on the collection and use of freight transportation data in the United States:

- The continuing reregulation of freight transportation carriers, and
- The increasing importance of freight transportation to the shipper community.

Over the past decade, transportation reregulation in the United States has steadily shifted from the economic regulation of carrier rates, services, and financial condition toward safety and environmental regulation. Public data collected to monitor and control transportation has also moved away from carrier and related economic information (e.g., finances, freight volumes, and rates) toward safety and environmental data (e.g., hazardous materials, traffic accidents and incidents, and Occupational Safety and Health Administration (OSHA) reporting). In addition, the declining federal role in freight transportation regulation (along with the search for new revenue sources) has led many state and local governments to track freight carrier activities more closely within their jurisdictions.

The expectation is that the 1990s will see a continued transfer of freight transportation regulatory responsibilities to the state and local level. States and localities will require information on the volumes and types of freight moving to, from, and within their regions. This information will be necessary for both planning new right-of-way capacity (e.g., highways and airports) and monitoring safety and environmental issues (e.g., hazardous materials flows and air quality). Unfortunately, consistent programs across state and local governments are not in place to collect such information on an ongoing basis.

The globalization of the U.S. economy, coupled with growing competition for markets, is enhancing the importance of freight transportation to companies. Instead of having large product inventories in numerous warehouses across the country, shippers are increasingly substituting direct plant-to-customer freight shipments for multi-echelon distribution systems. Such strategic changes are requiring companies to intensify their use of transportation carriers and to use information

and enhanced control procedures to better manage freight flows.

Improved freight flow management implies better information about where the products are in the plant-to-customer supply chain. Freight carriers and shippers are currently investing millions of dollars in enhanced freight tracking systems. These systems provide close-to-real-time shipment status information, including location, status (e.g., in-transit, in-process, or in-inventory), and delivery time estimates. Many leading-edge companies (such as Federal Express) can tell customers where their material and product shipments are in the vendor-to-plant-to-customer supply chain. Shippers are also maintaining extensive inbound and outbound freight flows and rates by carrier, route, and product class for competitive distribution analysis. In one decade, the U.S. economy has effectively "privatized" the collection and use of freight transportation data by carrier, route, and shipment type. Unfortunately, this information is not available to public agencies involved in transportation planning.

Figures 1 and 2 illustrate the current status of shipper logistics systems development and freight transportation data collection in the United States. Figure 1 details a global distribution operation of a typical U.S. company. Materials are shipped from vendors in the United States, Europe, and the Far East. These materials move in a multimode environment from vendors to company plants and distribution centers. Products are produced and shipped domestically as well as to European markets, again in a multimode environment. Leading-edge companies are monitoring and controlling most, if not all, of these movements, often on a real-time basis. At minimum, they track freight flows by route, mode, and shipment type on an exposte basis.

Figure 2 shows U.S. freight movements from a public data collection perspective. At present, due to continuing economic regulation of U.S. foreign trade, data are collected on movements by mode and product to and from the United States. As worldwide economic barriers decline, foreign trade data collection is likely to decrease in the 1990s. For freight flows moving in the domestic transportation system, little, if any, public information is available on a timely basis. For right-of-way or safety planning purposes, transportation analysts generally do not know what products are moving where by what carrier.

This results in a curious paradox for national freight transportation planning and policy analysis during the 1990s. Individually, private firms have substantially increased their collection and use of origin-destination freight flows and carrier performance data to enhance global competitiveness. Many federal, state, and local transportation authoritics, on the other hand, have substantially reduced freight flow and carrier data collection activities. As a result, most private companies are planning freight movements under the assumption that modal capacity will be available in the 1990s, while public agency transportation planners have little or no information

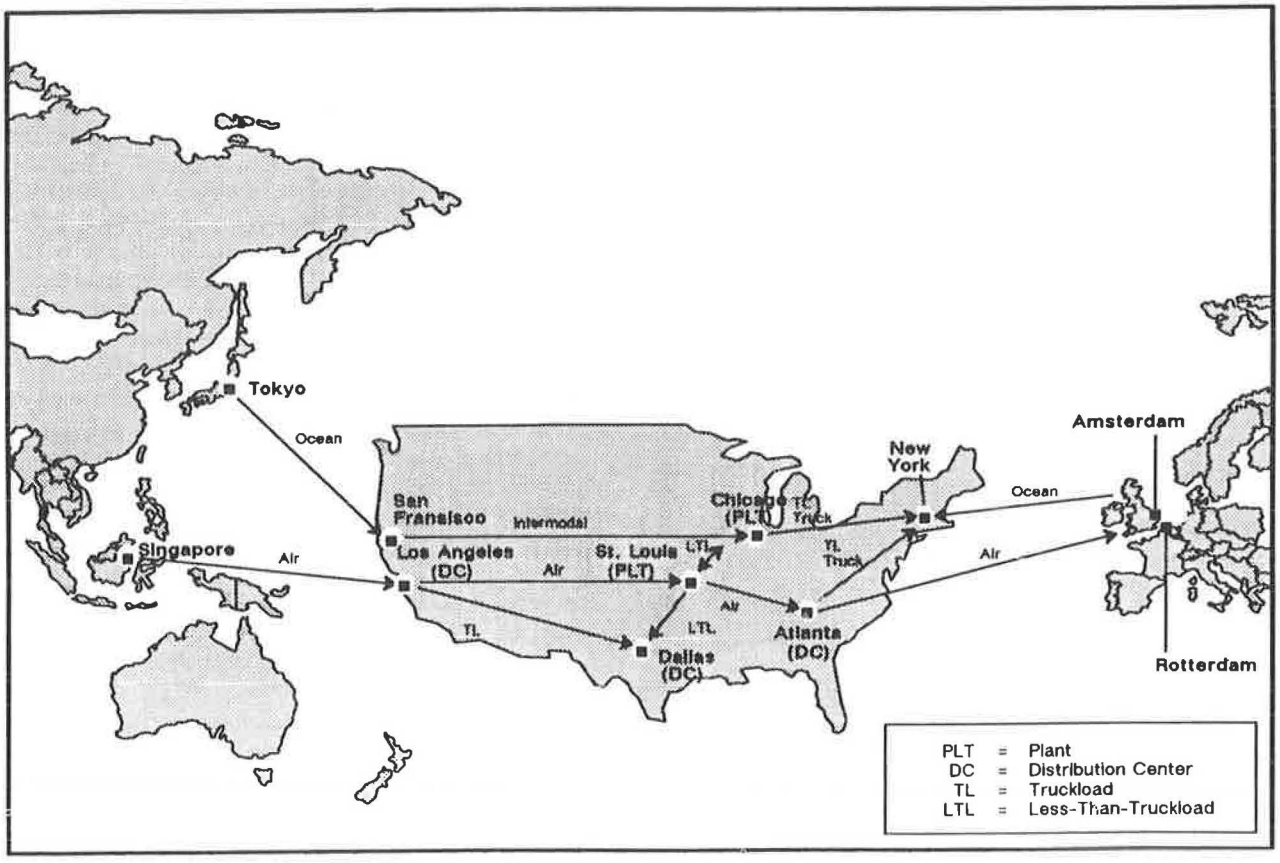

FIGURE 1 U.S. freight movements: shipper perspective.

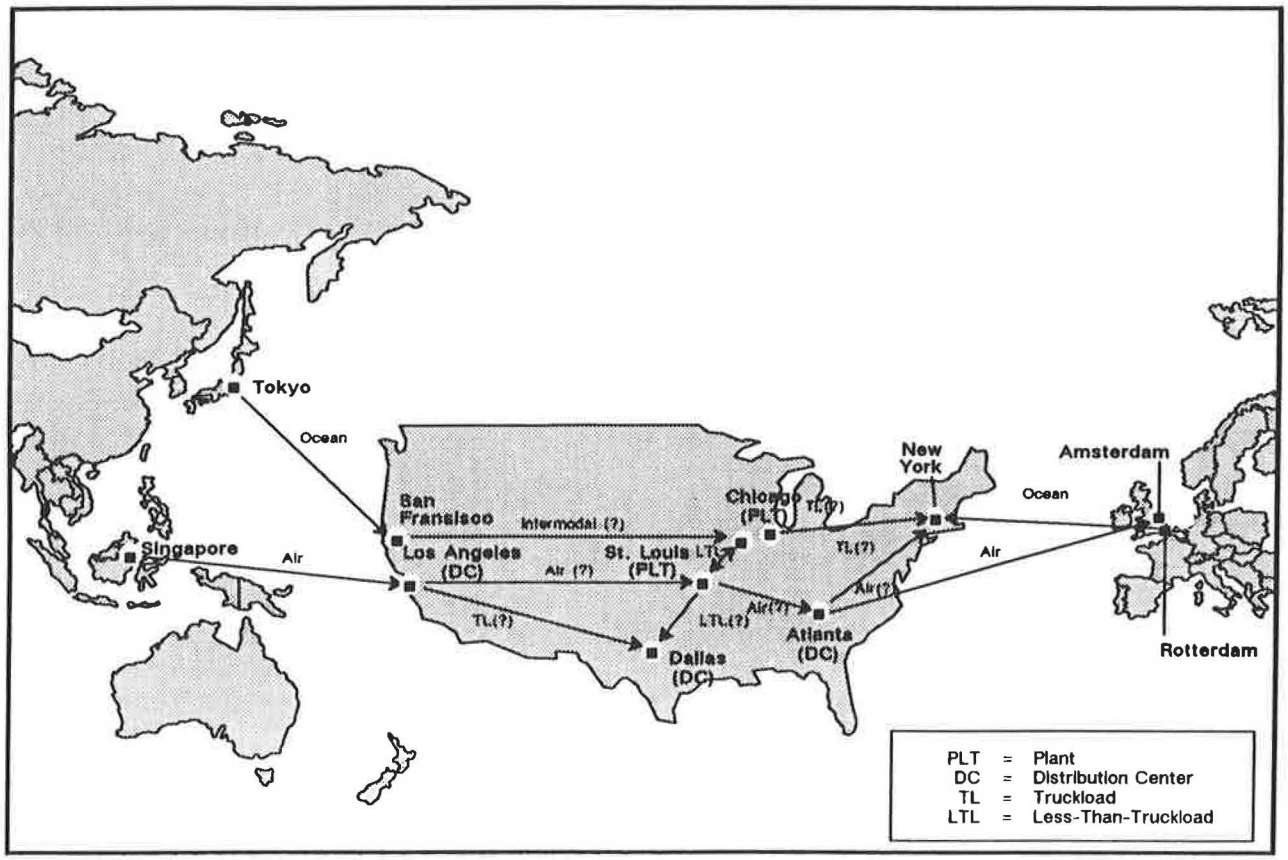

FIGURE 2 U.S. freight movements: public data perspective.

on which to base plans for emerging right-of-way and facility capacity requirements.

Freight transportation is a growing and important contributor to national economic development and global competitiveness. In addition, as Tables 1 and 2 indicate, the fastest modal growth in freight shipments is occurring in areas dependent on public rights-of-way and facilities. Between 1980 and 1988, total truck ton-miles grew by 27 percent and air ton-miles grew by 80 percent, compared with an overall freight ton-mile growth of only 12 percent (see Table 1). In addition, shippers are willing to pay higher truck and air rates to ensure timely shipments. During that same period, highway carrier revenues grew by 55 percent, while air revenues grew by 150 percent, compared with an overall model revenue growth of 47 percent (see Table 2).

The net result is a "planning gap" between the public and private sectors in freight transportation. Private companies are spending more of their information and distribution resources on ensuring the effective and efficient movement of products worldwide, while public agencies are reducing information development commitments for freight transportation right-of-way and facility capacity, safety, and environmental planning.

Continued public agency planning for freight transportation needs is necessary if the United States expects to remain competitive in the global economy. Methods of collecting the data to support these planning activities is the subject of the rest of this paper.

OVERVIEW OF NATIONAL STRATEGIC PLANNING AND POLICY ISSUES IN FREIGHT TRANSPORTATION DATA

A recent U.S. Department of Transportation (DOT) report details a number of major issues facing the intercity and international freight markets, including infrastructure, economic efficiency and performance, competition, safety, and government regulatory roles (*1*).

Three key national planning and policy issues will dominate freight transportation requirements analysis in the 1990s:

1. Ensuring adequacy of right-of-way and facility capacity to reduce congestion and support more rapid growth in freight volumes,
2. Enhancing public safety through closer monitoring of hazardous material flows and freight vehicle design and operation, and
3. Protecting the environment through air quality enhancement programs that include freight transportation impact considerations.

Primary federal government responsibilities for maintaining and expanding rights-of-way and facilities used by freight transportation include

- Interstate and intrastate highways and road/bridge infrastructure;

TABLE 1 U.S. FREIGHT REVENUES BY MODE ($ BILLIONS)

	1980	1985	1988	% Change 1980-1988
Highway	155	209	240	55%
%	73%	76%	77%	
Railroads	28	29	30	7%
%	13%	11%	10%	
Water	15	18	20	33%
%	7%	7%	6%	
Pipeline	7	8	8	14%
%	3%	3%	3%	
Air	4	7	10	150%
%	2%	3%	3%	
Other[1]	3	3	4	25%
Total	212	274	312	47%
% of GNP	7.8%	6.8%	6.4%	

[1] Includes freight forwarder and other shipper costs.

Source: ENO Foundation for Transportation, 1989.

- Air traffic control systems and cargo handling facilities; and
- Coastal, inland, and Great Lakes ports and waterways, including terminal interfaces with other modes.

Currently, the public role in rail and pipeline right-of-way/facility investment is minimal. As stated earlier, shipper trends in modal use imply that highway and air carriers will experience the largest increase in freight traffic during the 1990s. Public agency transportation planning resources will need to focus on enhancing freight haulage right-of-way and facility capacity for these modes.

As both total freight volumes and hazardous material movements increase during this decade, safety issues related to shared passenger/freight rights-of-way and facilities will increase in importance. An improved understanding of freight flow patterns will be required to address these issues, whether they involve real-time hazardous material shipment tracking capabilities or controls over vehicle design and operation.

Finally, environmental considerations, especially air quality, may require rerouting, time-of-day movement restrictions, or banning of certain freight movements. Understanding the role of freight flows in the development of both regional and national economies will be necessary to ensure companies can conform to these potential restrictions.

EVALUATION OF EXISTING INFORMATION SOURCES

Existing freight transportation data sources are characterized by the following trends:

- Data collection activities are continuing to shift to the private sector.
- Data types collected have lagged behind emerging national transportation planning and policy issues.
- Data collection methodologies, especially those related to freight flows, have not kept pace with changing shipper logistics systems or transportation analysis and planning requirements.

During the 1980s, freight transportation data collection activities steadily shifted to private sources. Although DOT, the U.S. Army Corps of Engineers, and the U.S. Department of Commerce have continued to be major sources of certain air, highway, and water-related data, Appendix A indicates that the Association of American Railroads and the Eno Foundation for Transportation (as well as Standard & Poor's and Dun & Bradstreet) have become primary sources for rail data and freight carrier financial information. The possible "sunset" of the Interstate Commerce Commission (ICC) will

TABLE 2 DOMESTIC INTERCITY TON-MILES BY MODE (BILLIONS)

	1980	1985	1988	% Change 1980-1988
Rail	932	895	1031	11%
%	37%	36%	37%	
Truck	555	610	703	27%
%	22%	25%	25%	
Pipeline	588	564	604	3%
%	23%	23%	22%	
Water	407	382	434	7%
%	16%	15%	15%	
Air	5	7	9	80%
%	<1%	<1%	<1%	
Total	2,487	2,458	2,781	12%

Source: ENO Foundation for Transportation, 1989.

cause further reshuffling and reevaluation of their data collection activities, especially in the motor carrier realm. The net result is that private freight transportation data collection will continue to evolve toward information more useful for investors (e.g., carrier financial information) as well as shippers (e.g., freight flows and carrier performance) and less useful for national transportation planning (e.g., right-of-way capacity analysis).

The types of freight transportation data collected have tended to lag behind information needed to address emerging national transportation planning and policy issues. For example, detailed information on hazardous materials flow patterns (which is critical for positioning regional emergency accident response capabilities) is only partially available and is not generally route specific. Similarly, overall freight flow requirements relative to economic growth and development needs are poorly understood, hindering route capacity planning analysis. Priority setting for data collection, especially within DOT and the U.S. Department of Commerce, has favored established information acquisition projects—ones that may not help answer emerging planning and policy issues.

Finally, data collection methodologies, especially those related to freight flows, do not reflect how shippers move goods within the United States. Nonmanufacturers (retailers and distributors, for example) are major U.S. shippers whose activity is not captured by the existing public freight flow data collection process. Similarly, intermodal movements are poorly reflected in existing data sources, making modal linkage analysis (for capacity planning) very difficult. Entirely new freight transportation data collection procedures must be developed to correctly reflect rapidly changing shipper product flow requirements.

Tables 3 through 7 reflect current freight transportation data availability from a national planning and policy analysis perspective. Selected state and local governments often collect detailed information on freight carriers operating within a region, including vehicle activity by route. However, no consistent collection process (either from a data or timing perspective) is used. It is not the purpose of this paper to judge the usefulness of such data for state or local planning, rather it is to address the issue of the role of data in national freight transportation planning capabilities.

Table 3 details the availability of national freight transportation facility data. For public right-of-way information (especially highways, air, and water), the federal government maintains a partial inventory of facilities and some operating characteristics. Railroads maintain their own rights-of-way as well as extensive, though private, data bases on these facilities. No consistent modal network performance data are collected nationwide, which makes congestion- or growth-related capacity enhancement priority setting difficult.

Table 4 details national freight transportation equipment data. Private organizations, primarily the Association of American Railroads (AAR) and Avmark, collect and maintain data on rail and air transportation equipment by type, capacity, and condition. The U.S. Army Corps of Engineers collects some equipment data for waterborne carriage. In addition, the U.S. Department of Defense monitors modal equipment availability for certain modes (primarily rail and air), although these data are not publicly available. Truck

TABLE 3 U.S. FREIGHT TRANSPORTATION FACILITIES

Data / Modes	Right-of-Way/ Network/ Facility Inventory	Ownership	Operating Costs	Capacity	Speed/Transit Times	Condition
Rail	ICC (partial)	ICC (partial)	ICC (partial)	N/A	N/A	N/A
Truck	FHWA (public) N/A (private)	N/A	ICC (partial)	N/A	N/A (truckload) LTL (service days)	N/A
Waterborne	U.S. Army Corps. of Engineers (public)	N/A (private)	N/A	U.S. Army Corps of Engineers (partial)	U.S. Army Corps of Engineers (partial)	N/A
Air	FAA (public-partial) N/A (private)	N/A	FAA (partial)	N/A	N/A	N/A
Pipeline	Dun & Bradstreet (private)	Dun & Bradstreet (private) Federal Energy Regulatory Commission	N/A	Dun & Bradstreet (private)	N/A	N/A

N/A = Not readily available.

equipment availability data are only maintained at the carrier level, although the Truck Inventory and Use Survey provides overall (state-level) information on truck ownership and operating characteristics. In general, freight equipment data (especially vehicle condition data) are most useful in monitoring hazardous materials flows.

Table 5 shows U.S. freight carrier data availability. Although public agencies (such as ICC) still collect some major rail, highway, and air carrier financial/operating data, private sector sources (such as Standard & Poor's or Dun & Bradstreet) have taken over much of the responsibility. Such data collection activity is oriented toward investor analysis rather than national transportation planning. Only minimal operating data (e.g., traffic volumes, costs, and products carried) are generally available, and then only by the major (top 50) carriers by mode.

Table 6 details national freight flow data collection activity. In general, no consistent, timely collection procedures exist to determine what is moving on what routes and through which facilities. The Census of Transportation Commodity Transportation Survey (now discontinued) focused primarily on manufacturer originations of freight traffic and did not effectively sample distribution, retail, and imported product shipments. Overall, insufficient freight flow data exist for right-of-way capacity planning at the regional or national level. In addition, existing data collection activities are biased by incorrect methodologies, leading to potential problems in freight flow analyses (*2*).

Table 7 details available data on U.S. freight shippers. Overall, little information is collected on how shippers (by industry type, size, or operating strategy) choose to move freight to, from, and within the United States.

TABLE 4 U.S. FREIGHT TRANSPORTATION EQUIPMENT

Data / Modes	Type/ Number	Ownership	Miles Traveled	Condition	Operating Costs	Capacity	Speed/ Transit Times
Rail	AAR (Railine)	AAR (Railine)	N/A	AAR (Railine)	AAR (Railine)	AAR (Railine)	N/A
Truck	N/A	N/A	FHWA (aggregate estimates)	N/A	N/A	N/A	N/A
Waterborne	U.S. Army Corps. of Engineers (partial)	N/A	N/A	N/A	N/A	N/A	N/A
Air	Avmark, Inc.	Avmark, Inc.	N/A	N/A	N/A	Avmark, Inc.	N/A
Pipeline	N/A	Federal Energy Regulatory Commission	N/A	N/A	N/A	N/A	N/A

N/A = Not readily available.

ANALYSIS OF INFORMATION GAPS

The following six key information gaps must be filled to meet emerging national freight transportation planning and policy analysis needs:

1. Modal, route, and facility operating performance data;
2. Shipper logistics patterns by industry;
3. Intercity freight flow patterns by selected modes, commodities, and origin-destinations;
4. Hazardous material movement tracking of all modes and all domestic origin-destinations;
5. Intracity freight movement requirements and commodity movements (by route and vehicle type); and
6. Emerging shipper requirements, especially supply channel processing and storage/handling needs.

Understanding current modal, route, and facility (public) operating performance characteristics is a critical first step toward improving freight transportation planning capabilities at the national level. Congestion, especially in urban areas, has consistently been identified by users as a major (and growing) problem in freight transportation. Delays in receiving shipments are particularly troublesome when firms are operating in a just-in-time (JIT) environment. Collection of information such as estimated transit times by route segment and time of day, as well as operating capacity (flights per hour) at airport facilities, needs to be evaluated. Only by understanding where critical modal network constraints exist can workable solutions be developed.

National freight transportation planning and policy analysts need to better understand how shipper logistics strategies by industry determine freight flow patterns in the United States.

TABLE 5 U.S. FREIGHT CARRIERS

Modes \ Data	Finances	Ownership	Market Coverage	Employees	Services Offered	Freight Types/ Volumes
Rail	ICC/AAR (major RRs only)	Moody's (major RRs only)	Moody's (major RRs only)	Moody's (major RRs only)	N/A	N/A
Truck	ICC/States (partial)	Moody's (major carriers only)	N/A	Moody's (major carriers only)	N/A	N/A
Waterborne	Moody's (major carriers only)	Moody's (major carriers only)	N/A	Moody's (major carriers only)	N/A	N/A
Air	Moody's (major carrier only)	Moody's (major carriers only)	Moody's (major carriers only)	Moody's (major carriers only)	N/A	N/A
Pipeline	Dun & Bradstreet	Dun & Bradstreet	Dun & Bradstreet	Dun & Bradstreet	N/A	N/A
Other Third Parties (forwarders, brokers)	Moody's (limited)	Moody's (limited)	N/A	Moody's (limited)	N/A	N/A

N/A = Not readily available.

Data on network development and resultant freight flow requirements can be generated through direct shipper surveys or by reorienting current data collection activities.

Intercity freight flow patterns by product, mode, route, and type of shipper and receiver need to be developed for modes that use public rights-of-way (especially highways and air). Such data are crucial for planning public right-of-way and facility needs. Although state and local governments collect some related data, the national nature of industry freight shipment decisions often precludes effective collection procedures at the regional level.

A hazardous materials monitoring and control system needs to be developed, preferably by the private sector. The system would allow local emergency response teams to deal correctly with hazardous material accident or spill situations.

Intracity freight movement data are sporadically collected by state and local agencies to aid in transportation planning; however, they are a critical input to defining emerging time-of-day (or related) freight traffic restrictions in urban areas. Certain businesses, such as small convenience stores, require multiple daily deliveries because of a lack of storage space. Similarly, service businesses may require frequent deliveries of air express parcels during a working day. Understanding how companies use freight transportation services in an urban environment is critical for setting freight traffic restriction priorities to enhance air quality during the 1990s.

TABLE 6 U.S. FREIGHT FLOWS

Data / Modes	Volume (total)	Volume by Commodity	Volume by O/D and Commodity	Value (total)	Value by Commodity	Value by O/D and Commodity	1977, 1983 Census of Transportation*
Rail	AAR (major RRs only)	AAR (major RRs only)	Federal Rail Administration Rail Waybill Sample (one percent only)	Federal Rail Administration Rail Waybill Sample (one percent only)	Federal Rail Administration Rail Waybill Sample (one percent only)	Federal Rail Administration Rail Waybill Sample (one percent only)	Manufacturer Originations by Mode and Commodity
Truck	Eno Foundation	N/A	N/A	Eno Foundation	N/A	N/A	Manufacturer Originations by Mode and Commodity
Waterborne	U.S. Army Corps of Engineers	U.S. Army Corps of Engineers	U.S. Army Corps of Engineers	N/A	N/A	N/A	Manufacturer Originations by Mode and Commodity
Air	Eno Foundation	N/A	N/A	Eno Foundation	N/A	N/A	Manufacturer Originations by Mode and Commodity
Pipeline	Eno Foundation	U.S. Department of Energy	N/A	Eno Foundation	N/A	N/A	N/A

N/A = Not readily available.
* Private data bases, such as Reebie Associates TRANSEARCH, DRI's FreightScan are also sources of modal commodity flow data.

Finally, shippers are increasingly depending on freight carriers, warehouse owners, and related third-party logistics providers to repackage, assemble, reconfigure, and even further manufacture the product once it leaves a company plant or distribution center. Responsibility for determining the method and timing of freight movements will increasingly shift to carriers and third parties as "contract logistics" becomes more common in the United States during the early 1990s. As a result, freight carriers and warehouses need to be included in the data collection process, both as sources of information and as key decision makers in the freight transportation system.

KEY INFORMATION FINDINGS AND ISSUES

This section examines the freight information development requirements and issues that need to be considered in Phase 2 of the TRB project.

Although adequate information exists on total freight movements in the United States (refer to Tables 1 and 2), a knowledge of what products move where during certain times and by what mode is woefully inadequate for national transportation infrastructure, safety, or environmental quality planning. Certain "private" freight movement data sources, such as FreightScan, the National Motor Truck Data Base, and the TRANSEARCH data base, have been developed to fill these gaps, but they are often inadequate in terms of detail (e.g., data are available only on a state-to-state or comparable basis) and methodology.

Following are suggested methods of collecting data on the six information gaps identified in the previous section:

- A national operating performance data system should be developed that monitors average transit times, time-of-day congestion, and capacity by key highway and air route segment and major urban area and airport. Quarterly reporting to a national clearinghouse from ongoing surveys by state

TABLE 7 U.S. FREIGHT SHIPPERS

Data / Modes	Companies by Industry	Type of Products (I/B)	Types of Products (O/B)	Modes & Equipment Used (I/B)	Modes & Equipment Used (O/B)	Distribution Network	Inventory Policies/ Locations
Rail	Standard & Poors/ Dun Bradstreet (among others)	N/A	N/A	N/A	N/A	N/A	N/A
Truck	Standard & Poors/ Dun Bradstreet (among others)	N/A	N/A	N/A	N/A	N/A	N/A
Waterborne	Standard & Poors/ Dun Bradstreet (among others)	N/A	N/A	N/A	N/A	N/A	N/A
Air	Standard & Poors/ Dun Bradstreet (among others)	N/A	N/A	N/A	N/A	N/A	N/A
Pipeline	Standard & Poors/ Dun Bradstreet (among others)	N/A	N/A	N/A	N/A	N/A	N/A

N/A = Not readily available.

I/B = Inbound

O/B = Outbound

and local governments would be one method for collecting the data.

- Detailed information on how shippers plan to move products, both inbound to and outbound from their operations, should be developed on an industry basis. One option would be to establish a national advisory task force made up of freight shipper representatives in each industry to construct and update a profile of various types of freight logistics operations within an industry sector.
- The Census of Transportation Commodity Transportation Survey should be revived and modified to focus on collecting highway and air freight flows by linked logistics pattern rather than by point-to-point segment. For example, the collection methodology should clearly reflect product movement throughout the vendor-to-customer supply chain. Better representation of distributors and retailers also needs to be considered in the data collection process.
- A hazardous material tracking system must be developed to aid state and local governments in planning for and reacting to hazardous material shipping problems. Private industry, including chemical/petroleum manufacturers and freight carriers, in conjunction with ShipNet, Inc., a Chicago-based third-party logistics management company, is beginning development of such a system. Governments should encourage a private sector, as opposed to a legislated, solution to this problem.
- Intraurban freight flow data collection efforts must be reexamined. The absence of effective information on the type of freight moving within urban areas is seriously hindering the nation's ability to enhance infrastructure and reduce

congestion. One option would be to have state and local governments develop a common methodology and collection process with data sent to a national clearinghouse, allowing improved priority setting for allocating scarce federal funding.

- Finally, freight carriers and third-party logistics providers (who will increasingly influence freight routing and related decisions in the 1990s) need to be included in the effort to improve freight transportation data. One option would be to include them on a national freight transportation data advisory task force.

Procedural recommendations for filling key freight information data gaps are divided into both short-term (1990 to 1995) and long-term (1995 and beyond) categories.

In the short term, collection of freight transportation data by public agencies should be reoriented towards filling the six key information gaps. To accomplish this, consistent, accurate data collection methodologies need to be developed in conjunction with both private and public sector groups. Understanding how shipper logistics strategies determine freight flow patterns by mode and route is an important first step in redefining these collection methodologies. Finally, consistent funding should be appropriated to the collection of necessary transportation planning data.

In the long term, freight transportation data collection should evolve into a joint public/private sector process. Shippers and carriers will begin to realize the importance of sharing freight flow information (from enhanced shipment management data bases currently under development) with public agencies to enable them to better plan right-of-way and facility capacity expansion. Substantial (and consistent) U.S. freight flow information should be readily available to public agencies in the post-1995 period, assuming dialogue begins soon between the public and private sectors on the importance of making the data available.

Key freight information collection issues that remain to be addressed in Phase 2 include the following:

- Willingness of public agencies to change their data collection procedures and methodologies,
- Willingness of the private sector to cooperate with public agencies in freight data collection activities,
- Role of federal, state, and local governments in enhancing freight-related infrastructure development,
- Capability of governmental agencies to enhance freight system capacity through both structural and nonstructural solutions, and
- Willingness of the private sector to accept limitations or logistics operations (e.g., time-of-day movement limits) relative to expected benefits.

REFERENCES

1. *Moving America—New Directions, New Opportunities*. Volume 1: *Building the National Transportation Policy*. U.S. Department of Transportation, 1989.
2. D. Anderson and W. Rennicke. The Contestable Market Defense: Measuring Competition in Freight Transportation. *Transportation Practitioners Journal*, Vol. 54, No. 2, Winter 1987.

APPENDIX A
U.S. Freight Transportation Data Sources

Air Transport Association of America

Air Transport (published annually)

Statistics cover freight ton-miles for U.S. scheduled airlines.

Association of American Railroads

AAR Railroad Cost Indexes (published quarterly)

- Scope of AAR indexes,
- Cost components,
- Index weights,
- Railroad cost recovery (RCR) indexes,
- All-inclusive indexes (AII), and
- Rail cost adjustment factors (RCAF).

AAR Trends (published weekly)

Carloads originated, by commodity group, on major U.S. railroads. Intermodal traffic originated (trailers, containers). Estimated ton-miles (class 1 railroads).

AAR Freight Commodity Statistics (published quarterly and annually since 1980)

National and regional data showing gross freight revenues, tonnage, and carload originations and terminations to the 5-digit standard transportation commodity code (STCC) level for class 1 railroads).

AAR Freight Station Directory (published annually)

Alphabetic and numeric lists of freight stations showing number, name, and state or province, along with standard point location code (SPLC).

Railinc Corporation, Universal Machine Language Equipment Register (UMLER)

Computerized data base of characteristics of all railcars operating in the United States.

NOTE: Other AAR publications on class 1 railroad finances and operating statistics are available by subscription.

Avmark, Inc.

Information on U.S.-operated aircraft by type (passenger, cargo), including specifications/capacity.

Data Resources, Inc.

FREIGHTSCAN (updated annually)

Commodity flows by product and mode and O-D pair (state and Bureau of Economic Analysis [BEA]).

Dun & Bradstreet, Inc.

Moody's Transportation Manual (published annually)

Covers the transportation industry with selected statistical data. Includes railroads as well as other fields of transportation such as airlines, steamship companies, bus and truck lines, oil pipe lines, bridge companies, and automobile and truck leasing and rental companies, covering nearly 1,000 railroads and transportation enterprises. Includes maps of many of the larger railroad systems, route maps of a number of large airline companies, and maps for certain other transportation companies. Facts and figures mostly based on information obtained directly from corporations or stockholders' reports, ICC reports, and Securities and Exchange Commission reports and registrations.

Pipeline Data Base

An on-line data base with information on petroleum and natural gas.

Eno Foundation for Transportation, Inc.

Transportation in America (published annually, with 6-month updates)

- Current transportation traffic indicators,
- Transportation outlays vs. gross national product,
- National economic vs. transport trends,
- Nation's freight bill,
- Nation's passenger bill,
- Domestic intercity ton-miles by mode,
- Domestic intercity tonnage carried by mode,
- Domestic intercity travel by mode,
- Domestic intercity passengers carried,
- Revenues of federally authorized domestic carriers,
- Domestic transportation of petroleum by modes,
- Expenditures for new plants and equipment,
- Federal and state transport user taxes and fees, and
- Transportation vs. total fatalities from accidents.

International Air Transport Association (IATA)

World Air Transport Statistics (published annually)

A digest of world air transport statistics including individual IATA member airlines' fleets, operating and financial statistics, international regional statistics, safety figures, and traffic and capacity data on Atlantic and intra-European routes.

International On-Flight Origin-Destination Statistics (published annually)

Provides air freight traffic performance between regional pairs and subregional pairs.

Freight Traffic Forecasts (published annually)

Total freight traffic forecasts, by O-D pair, 5 years out.

Interstate Commerce Commission, Bureau of Accounts

Transport Statistics in the United States (published annually, 1987 to present)

Detailed data on traffic, operations, equipment, finances, and employment for carriers subject to the Interstate Commerce Act. For example, data on class I freight railroads includes

- Statement of changes in financial position, by district;
- General balance sheet, by district;
- Results of operations and retained income, by district;
- Classification of tracks, by district;
- Railway operating expenses, by district;
- Depreciation of subaccounts, by district;
- Equipment in service, by district;
- Railway operating income, by class of service and by district;
- Railway operating expenses, by class of service and by district; and
- Railway operating statistics, by type of service and by district.

A-300 Wage Statistics of Class I Freight Railroads in the United States (published annually)

Number of employees, service hours, and compensation by occupational group: executive, officials, and staff assistants; professional and administrative; maintenance of way and structures; maintenance of equipment and stores; etc.

Large Class I Motor Carriers of Property Selected Earnings Data (published quarterly)

Operating revenues, net carrier operating income, net income, revenue tons hauled, operating ratio, and rate of return.

Class I Freight Railroads Selected Earnings Data (published quarterly)

Railway operating revenues, net railway operating income, income before extraordinary items, net income, revenue ton-miles of freight, and rate of return.

Large Class I Motor Carriers of Passengers Selected Earnings Data (published quarterly)

Operating revenues, net carrier operating income, net income, revenue passengers carried, operating ratio, and rate of return.

Large Class I Household Goods Carriers Selected Earnings Data (published quarterly)

Operating revenues, net carrier operating income, net income, revenue tons hauled, operating ratio, and rate of return.

M-350 Preliminary Report of Railroad Employment, Class I Line-Haul Railroads (published monthly)

Number of employees at middle of month, group totals.

Journal of Commerce

Port Import-Export Reporting System (PIER)—specific shipper foreign trade statistics including inland origin-destination, overseas destination or origin, commodity, volume shipped, price, etc.

Oil Pipeline Research Institute

Pipeline Carrier Statistics

Federal Energy Regulatory Commission information on finances and performance of domestic pipeline carriers.

Reebie Associates, Inc.

TRANSEARCH data base, including commodity flows by mode and product type (updated annually).

TRAM, Inc.

National Motor Truck Data Base (updated monthly)

Truck commodity flow data base by origin-destination.

U.S. Army Corps of Engineers, Water Resources Support Center (Navigation Data Center)

Waterborne Statistics of the United States (published annually, latest data 1986)

- National summaries;
- Domestic inland traffic—areas of origin and destination of principal commodities; and
- Water carriage ton-miles.

Waterborne Transportation Lines of the United States (published annually)

Contains information on vessel operators and their American flag vessels operating or available for operation in the transportation of freight and passengers. Information includes

- Operators and addresses;
- Type and construction of vessels, net registered tonnage, length, breadth, draft, horsepower, carry capacity, etc.; and
- Description of operations, type of service, principal commodities carrier, and localities served.

Port Series (published irregularly)

Data on port and harbor conditions and facilities, including an index of piers, wharves, and docks, for all principal U.S. land/coastal/Great Lakes ports.

Performance Monitoring System

Provides transit time and related waterway performance data for inland waterways by lock and waterway segment.

U.S. Department of Agriculture, Agricultural Marketing Service

Summary of Fresh Fruit, Vegetable, and Ornamental Crop Movements by Mode and Commodity (published weekly)

Reports origin by state or county, including 23 cities of arrival, and piggyback and export by rail. Piggyback may be reported separately.

Fruit and Vegetable Truck Operating Costs (published monthly)

Lists fixed and variable costs, in cents per mile, of truck fleet operators and owner-operators.

Fruit and Vegetable Truckload Rates Between Growing Areas and Cities (published weekly)

U.S. Department of Commerce, Bureau of Census

Census of Transportation (published every 5 years—1977, 1982, and 1987)

Truck Inventory and Use Survey (TIUS) provides data on the physical and operational characteristics of the nation's truck population.

Nationwide Truck Activity and Commodity Report (NTAC) provides physical characteristics of commodity movements on the nation's highway network (under contract to DOT—results available in 1991).

Commodity Transportation Survey (CTS) provides physical characteristics and geographical distribution commodity shipments from manufacturers along with means of transport. Discontinued (some 1983 data available).

Waterborne Freight (published annually)

Foreign trade from Census-defined merchandise (bonded and export) coming into the United States and collected from customs declarations. U.S. waterborne exports and imports by trade area, district, port, type of services, and U.S. flag.

Modal (Motor, Water, Air, Rail) Carriers of Property (published every 5 years)

Location, number of establishments, revenue, payroll, and employment by carrier.

U.S. Department of Energy

Monthly Petroleum Report

Crude and product movements by pipeline among Petroleum Administrative Districts (PADs).

U.S. Department of Transportation, Federal Aviation Administration

Airport Activity Statistics of Certified Air Carriers (published annually)

Details total air freight tons and ton-miles by carrier and airport.

U.S. Department of Transportation, Federal Highway Administration

Highway Statistics (published annually)

Mileage by characteristics, vehicle registrations, VMT (vehicle miles traveled), truck weight, speed trends, fuel consumption, safety, etc. (to be completed).

Motor Carrier Census, by Carrier (updated daily)

Area of operation, commodities hauled, miles operated, and number of vehicles driven.

U.S. Department of Transportation, Federal Railroad Administration (published annually)

Rail carload waybill statistics, territorial distribution, traffic, and revenue by commodity class for major U.S. railroads.

Statistics presented on carloads, tons, revenues, ton-miles, car-miles, and various ratios.

U.S. Department of Transportation, Office of the Secretary

Operating Statistics by Cargo Air Carrier (annually)

Ton-miles by flight stage, aircraft miles, revenue, and airborne hours.

U.S. Department of Transportation, Research and Special Programs Administration

National Transportation Statistics, Annual Report

A summary of selected national transportation statistics from a wide variety of government and private sources. Features cost, inventory, and performance data describing passenger and cargo operations of the following modes: air carrier, general aviation, automobile, bus, truck, local transit, rail, water, oil pipeline, and natural gas pipeline. Illustrates basic descriptors of U.S. transportation, such as operating revenues and expenses, number of vehicles and employees, vehicle miles and passenger miles, etc. Supplementary sections include Transportation and the Economy: Energy in Transportation, which is divided into Energy Consumption, Energy Intensiveness, Energy Transport, and Energy Supply and Demand. Also includes operating costs of automobiles of different sizes.

Modal Profiles

- Modal profile source references and percent change calculation,
- Air carrier profile,
- General aviation profile,
- Highway profile,
- Automobile profile,
- Bus profile,
- Truck profile,
- Local transit profile,
- Water transport profile,
- Rail profile (A. class I railroads and B. Amtrak),
- Oil pipeline profile, and
- Natural gas pipeline profile.

Selected Passenger and Cargo Performance Indicators by Mode

Transportation Trends

- Section I. Performance,
- Section II. Safety, and
- Section III. Sales and Production.

Supplementary Data

- Section I. Transportation and the Economy; and
- Section II. Energy in Transportation:
  - —Part 1. Energy Consumption,
  - —Part 2. Energy Intensiveness,
  - —Part 3. Energy Transport, and
  - —Part 4. Energy Supply and Demand.

APPENDIX B
Special Conference on Freight Transportation Data—Summary of Discussions

On November 14 and 15, 1989, the Task Force on Freight Transportation, TRB, and the Washington chapter of TRF sponsored a conference to provide an opportunity for input on freight transportation data needs and issues for the DOT National Transportation Policy Study.

First Day

Keynote Address

The conference keynote address was given by Commissioner Karen Phillips of ICC. Commissioner Phillips underscored the ongoing need for freight transportation data collection in the United States, citing continued transportation decision-making requirements, especially in infrastructure development, tax policies, and deregulation impacts. In particular, she focused on the need for data on the performance and financial situation of U.S. transportation industries to monitor ongoing regulatory changes, both at the federal and other government levels. She stated that the government should continue to have a role in data collection (due primarily to data confidentiality issues).

Session 1: Need for Freight Transportation Data in a Deregulated Environment (Part I)

Harvey Levine of the Association of American Railroads stated that railroads continue to be regulated and continue to collect substantial amounts of financial, traffic flow, cost, rate, and performance Class I railroad data, including the only available Class III railroad data base. He believes government should focus on data quality, not quantity, and feels there is a lot of room on the railroad side to consolidate/reduce data required by regulatory groups.

Russell Capelle of the Regulator Common Carrier Conference (RCCC) spoke about the RCCC Motor Carrier Safety Survey (a survey of truck drivers done over the past 4 years). He discussed the American Trucking Associations (ATA)/RCCC petition to ICC to improve the quality of motor carrier financial data, especially for Class III operators, and to improve Class I and II motor carrier data quality/underreporting. He also discussed the University of Michigan Transportation Research Institute's Trucks In Fatal Accidents (TIFA) data base (developed by the Center for National Truck Statistics) and the National Accident Sampling System (NASS).

Kuing Wu Kang of the Port Authority of New York and New Jersey spoke about the data collection efforts for intra- and interurban freight movements involving the New York metropolitan area, including ongoing truck surveys on modal commodity movements. He believes government needs to focus on key data collection needs to avoid wasting energy and money.

Gerald D. Muskin of the Transportation Consulting Group discussed the paradox that, as the ability to manage freight

and the private sector has pushed data collection aside. He feels this is good in some situations (for example, the AAR success story) but bad in others (for example, multi-billion-dollar decisions made with no data). He believes a data collection policy will be generated by DOT, but a lack of support/funds within the agencies may hinder actual collection activities. He stated that the "data hangover" is a real problem (in other words, too much was asked for in the past) and that a new recognition of infrastructure development requirements and resultant data needs is necessary. He cited the AAR model as a good example. He said the ENO Foundation is also supporting transportation data collection, but these efforts must be better coordinated.

The question-and-answer session focused on who has the right to use/resell public data. Many in the audience responded that, when value is added, then reselling is correct. The point was made that collecting and revising data is very expensive and only well-heeled private companies can pay for it.

Second Day

Session V: Review of U.S. Bureau of Census Data Collection Efforts

Chuck Waite of the U.S. Bureau of Census explained that the bureau's highest priority is expanding information in the service industries, including transportation. He reviewed truck use surveys and economic census data (latest 1987) on transportation companies and discussed the bureau's most recent effort: the Nationwide Truck Activity and Commodity Survey (NTACS), which will provide detail on a truck's specific size, weight, materials, and all stops made (beginning in 1991). Other relevant data sources discussed included the Motor Freight Transportation Warehousing Survey: an annual sample of 1,500 for-hire trucking firms (1984–1987 data) regarding revenues, expenses, equipment, and products hauled. Waite also spoke about the 1992 Census of Transportation, which will include all modes. He explained that this census will be the largest expansion in 40 years and will focus more on transportation establishments. He also spoke about how to enhance existing data collection efforts through better federal/state/local cooperation. He discussed the discontinued commodity flow survey, stating that it was too expensive for the bureau to continue and that alternatives were being considered. Finally, he suggested the development of a Center for Transportation Statistics, indicating that the bureau supported the concept, and stated that it should be located in DOT.

Session VI: Institutional Opportunities and Constraints for Data Collection

Linda Morgan, general counsel of the Senate Commerce Committee, stated that real challenges exist in data collection and transportation policy analysis. She said the continuing problems in monitoring deregulation in the rail and air industries (for example, monitoring leveraged buyouts and their impact on carrier safety) imply a need to reconsider the freight data availability issue.

Fritz Kahn, an attorney, reviewed the ICC decision to eliminate unnecessary data collection from carriers. He stated that carriers now want confidentiality with freight transportation data, but the reason is competition, not the laws. He feels laws such as the Sherman Antitrust Act do not apply in these cases.

Paul Bugg of the Office of Management and Budget explored data collection and dissemination issues inside the federal government and at state/local levels. He believes problems exist and that they are important. He thinks a larger data budget would help but is not available, according to OMB.

Edith Page of the Office of Economic Assessment explored reasons why data are needed to answer federal transportation policy questions. The difficulties and costs associated with getting the required data were also discussed. She suggested that local/state groups and industry can help but federal leadership is necessary.

The question-and-answer session focused on data confidentiality problems and inadequate data availability for federal transportation decision making.

APPENDIX C
Select Bibliography on Freight Transportation

NCHRP Report 177: Freight Data Requirements for Statewide Transportation Systems Planning. TRB, National Research Council, Washington, D.C., 1977.

NCHRP Report 260: Application of Statewide Freight Demand Forecasting Techniques. TRB, National Research Council, Washington, D.C., 1983.

Special Report 206: Proceedings of the National Conference on Decennial Census Data for Transportation Planning. TRB, National Research Council, Washington, D.C., 1984.

Transportation Research Board. *Identification of Transportation Data Needs and Measures for Facilitation of Data Flows*. U.S. Department of Transportation, 1981.

transportation data has increased, its availability has shrunk. He believes better freight-related data are needed for safety, public policy, and competitive analysis across all modes. He also noted that private freight-related data are often derived from government data, which are dwindling.

David Licky of the U.S. Army Corps of Engineers, Navigation Data Center, discussed in detail the freight-related data available on inland coastal waterways and ports, especially the waterborne traffic statistics and performance monitoring system. He also indicated that it was the Corp's policy to get data ready within 4 months of year end.

The question-and-answer period focused on the availability of intermodal data and the problems with determining the true origin-destination of commodity flows.

Session II: Need for Freight Transportation Data in a Deregulated Environment (Part II)

Ben Lieberman of the Maryland Port Administration spoke about various data sources used by the ports, including internal data (collected from port tenants on rents, etc.), U.S. Army Corps of Engineers data, the Journal of Commerce Port Import-Export Reporting (PIER) system, and Census Bureau foreign trade statistics. He also discussed the problems with each (for example, the wrong inland origin or destination on some PIERS data).

Jeff Gutterman of the World Bank discussed freight transportation needs in developing countries, growing dissatisfaction with large data-intensive freight modeling activities, and reasons why developed and developing countries need better freight-related data.

Michael Bronzini of Pennsylvania State University stressed the need for developing detailed O-D commodity flow data by mode, traffic density data, accident and incident data, operating costs, performance and rates for planning studies, operational (hazardous materials) analysis, energy policy, new facilities development, and contingency planning. The need for intraurban traffic data was also discussed. Bronzini believes government should collect traffic flow, traffic density, and accident data but that cost/rate data should be collected by the private sector.

The question-and-answer period included a discussion of Eastern Europe, Europe 1992, and Canadian/U.S. free trade and the impact of each on data needs.

Session III: Coverage and Quality Problems with Existing Data Resources for Freight Transportation

David Green of the Oak Ridge National Laboratory evaluated truck freight data for national policy analysis and highway planning. He focused on what is needed—trucks, truck miles, and commodity trips by state and highway class, truck configuration, and carrier type. He noted that there are many sources for the data and spoke about the sampling problems of FHWA data, the Truck Inventory and Use Survey, and the National Truck Activity and Commodity Report Survey.

Paul Roberts of Trans-Mode Consultants stated that it would not be possible to satisfy any of the conference attendees in terms of their freight data needs because their needs are very different. He identified three types of data needed for freight analysis: demand (commodity flows), facilities/equipment, and financial. The demand category requires data on shipment size, packaging, date and time of pickup, origin-destination, carrier, type of service, and cost. Regarding facilities, the types of data needed include the network by mode, a system definition, equipment data, physical attributes, capacity utilization, and condition. For operating entities, carrier financial and performance data are needed. Roberts stated that these data are decreasing in availability, especially intermodal and commodity origin-destination data, and believes the solution is to define what is needed more precisely, then fund the development of these data.

Rolf Schmitt of DOT stated that data quality problems are rampant; for example, no one even knows how many trucks are operating in the United States. He believes this situation will not improve because money is tight for data collection. Schmitt feels the aviation companies did a better job of protecting data under deregulation than the ground transportation industry did. He said paperwork reduction is causing data to disappear and believes the absence of data on the contents of containers is a problem. He feels the role of brokers and potential double-counting of loads is also an issue. He believes new techniques for in-motion weighing will provide more data on volume/trips for trucks.

Frank Smith, a consultant, explained that his approach has been to work with what he has and estimate the remainder. He reviewed the quality of data sources across modes and stated that substantial variation exists in the level, timing, and availability of freight-related data sources.

Session IV: Alternatives to Public Data Sources

Bill Oderwald of ALK Associates discussed the enhancement of the ICC rail waybill sample (ALK adds distances and other codings), discussed data problems found as the waybill file was enhanced, and related the data to actual network linkages. He also stated that ALK maintains complete digitized rail/highway networks on its system and can perform many traffic analyses (e.g., hazardous material routings).

Joe Riker of Reebie Associates spoke about the TRANSEARCH data base—U.S. domestic freight movements among 285 BEA market areas by four-digit STCC commodity and seven modes of transportation, including Canadian traffic. He relies heavily on public information sources and now uses a modeling effort to replace Census of Transportation data. He sees the private sector increasingly taking over the role of data collection but foresees problems (e.g., a proprietary data release by carriers on commodity flows).

Forrest Baker of TRAM spoke about the National Motor Transportation Data Base, which interviews 25,000 long haul truck drivers per year at 20 truckstop locations across the United States. He collects data on trailer type, commodity, origin, and destination (among others) and focuses on the equipment used rather than on commodity flows. He has been gathering data since 1977 and has developed the most complete basic profile of the U.S. trucking industry available.

Alan Pisarski, a consultant, stated that institutions have failed in data collection and that the focus on deregulation

Surface Passenger Transportation Data Needs, Resources, and Issues

ARTHUR B. SOSSLAU

The current and anticipated status of data related to surface passenger transportation is evaluated and improvements are recommended for the purpose of national policy development and decision making. The paper is based on a review of literature, discussions with those involved in current and past national transportation planning efforts and national decision making, and the findings of a TRB conference held in October 1989. The purpose of this meeting of the TRB Transportation Data and Information Systems Committee was to evaluate current data sources, data systems, and applications and to investigate the needs for data in the 1990s. The conference was organized into three areas of concern: urban area data needs, statewide data needs, and national data needs. This paper covers past and current national planning efforts, strategic planning and policy issues, major sources of data, gaps in the data, and recommendations for data improvement. The major data gaps recognized by comparing data needs and available data are data for measurement of congestion; data for system performance monitoring; data on longer trips (over 100 mi) for all modes; data on rural public transportation; data on intercity rail and bus operations, facilities, and infrastructure; data on new roads on new alignments; data on highways by subgeographies such as suburbs and core area; data on local road needs; and data on traveler attitudes and perceptions.

The purpose of this paper is to evaluate the current and anticipated status of data related to surface passenger transportation and to recommend improvements for the purpose of national policy development and decision making. The major focus of the paper is on highways and urban public transportation (bus and rail). Less emphasis is placed on intercity rail and bus, because of the ownership issues.

The types of data addressed in the paper are defined below:

- Equipment inventory, condition, and use;
- Carrier performance and condition;
- Passenger flows;
- Demographics and general economic activity;
- Safety and security; and
- Finance and program administration.

Data needs, availability, and gaps have been evaluated in terms of transportation system condition, performance, and use.

This paper is based on a review of literature, discussions held with those involved in current and past national transportation planning efforts and national decision making, and the findings of a TRB conference held in October 1989. The purpose of this mid-year meeting and conference of the TRB Transportation Data and Information Systems Committee was to evaluate current data sources, data systems, and applications and to investigate the needs for data in the 1990s. The conference was organized into three areas of concern: urban area data needs, statewide data needs, and national data needs. The meeting was oriented to ground transportation with a concentration on highway and public transportation modes. The conclusions of the workshops held on urban, statewide, and national data needs are included, because they provide some direction to the determination of data needs for national planning and decision making. Appendix A is a select bibliography of surface passenger transportation data sources, and Appendix B contains reports of the TRB workshop sessions.

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NATIONAL TRANSPORTATION POLICY STUDIES AND DECISION MAKING

National multimodal policy study and decision making are described for the period since 1966, when the U.S. Department of Transportation (DOT) was established. The nature of these efforts is important to consider when evaluating data needs for the future.

Two types of planning studies can be defined. Policy studies, often brief statements, were required by Congress and rarely developed much data or generated any significant research. Planning activities, the second type, are quantitative, analytical, and comprehensive. These are based on considerable analysis of data and some sort of a modeling process. The data come primarily from either a new data collection effort or secondary sources.

The national studies of interest here are

- 1972 DOT national transportation study
- 1974 DOT national transportation study
- 1976 DOT national transportation study ("Trends and Choices")
- 1978 national transportation policy study (by the National Transportation Policy Study Commission)
- Current DOT National Transportation Policy Team (NTPT) 2020 effort
- Current AASHTO 2020 effort

The 1972 and 1974 DOT national transportation studies and reports were based on special data collection efforts. For the 1974 study, the states and their local jurisdictions were requested to supply detailed information on

- Physical status of the system;
- System demand;

- Performance and level of service;
- Externalities of the system, such as noise and air pollution; and
- Costs of operating and maintaining the system.

The above information was reported by each state for the current situation, a 10-year program, and a 20-year plan.

These data were primarily surveys of state and local expenditure plans, which were very rigorous in definition so as to obtain a consistent and uniform reporting across the nation. A common framework was established with regard to future population, gross national product, and travel demand. Common mechanisms of needs assessment with regard to future inflation rates, interest rates, rates of return, and payback periods were established for all modes.

The national transportation studies produced uniform national reporting for all modes in all areas of the country (by state, major metropolitan area, and urban/rural area). This information included physical inventories with associated levels of service and financial requirements.

The 1976 "Trends and Choices" effort relied heavily on the data collected in the 1972 and 1974 efforts. National networks for all modes were developed and loaded with simulated national trip tables based on secondary source information.

The work of the National Transportation Policy Study Commission (1978) was intensive in a modeling sense, seeking to produce a series of multimodal investment needs responsive to long-range forecasts of passenger and freight travel. Capital investment forecasts were produced for 19 modal categories for two time periods and three alternative growth scenarios.

Even more detailed forecasts were produced, based on scenarios of demography, economy, and lifestyle. These included such statistics as multimodal travel forecasts, energy consumption and flow forecasts by energy type, and export and import trade flows by coastal district.

More than 10 years elapsed between the last big national planning efforts and the current 2020 planning activities. The current activities of DOT and AASHTO are efforts that are partially quantitative and analytical; however, they have also broken new ground by having the general public and transportation system users and providers participate in the planning effort.

By and large, these efforts rely on available data and have not produced new data or research. The surface passenger analyses relied heavily on the FHWA Highway Performance Monitoring System (HPMS) and on UMTA's National Urban Mass Transportation Statistics (Section 15 reporting), as well as on sources such as the Nationwide Personal Transportation Study (NPTS) and the decennial census.

In reviewing the above efforts, some conclusions may be drawn:

- Early national efforts were based on collecting a uniform reporting of information by state, major metropolitan areas, and urban/rural disaggregation. The states and urban areas defined their own 10-year programs and 20-year plans.
- The current efforts of AASHTO and DOT are largely based on the use of secondary sources for data and on a consensus building through input from the general public and system users and suppliers.
- One of the major weaknesses in the efforts reported above is the lack of continuity in the planning efforts. The information and data of the earlier efforts are basically lost.

OVERVIEW OF NATIONAL STRATEGIC PLANNING AND POLICY ISSUES

In "Building the National Transportation Policy," Volume 1 of the report *Moving America—New Directions, New Opportunities*, DOT lists major policy issues. For the intercity passenger market, the issues include meeting travel demand, funding system improvements, safety, and competition within and among modes and intermodal operations. The urban/suburban market issues presented are congestion, infrastructure financing, special transportation needs, the environment, and safety.

The three workshops (urban, statewide, and national) of the mid-year TRB conference on data and information systems further defined national planning data needs. Three major markets were identified:

- Urban/suburban,
- Rural, and
- Intercity.

In the urban/suburban market, the following major policy issues were identified:

- Congestion,
- Operational and management improvement of systems,
- Infrastructure rehabilitation and expansion,
- Funding flexibility and road pricing,
- Transportation and land use linkages,
- Mobility and intermodalism,
- Safety, and
- Investment payoffs (equity, economic development, and environmental impacts).

In the rural market, the following major policy issues were identified:

- Infrastructure preservation,
- Local rural road needs,
- Rail and bus service reduction,
- Mobility, and
- Safety.

With regard to intercity passenger issues, the following issues were identified:

- Access to intermodal facilities (i.e., airports),
- Major corridor congestion,
- Substitution of modes in specific markets,
- New intercity air/rail technology (i.e., MAGLEV),
- Funding flexibility, and
- Safety.

A major problem identified is congestion. Polls sponsored by AASHTO, the media, and government all point to conges-

tion as one of the top issues. All parts of the nation are experiencing the effects of congestion, and there is currently a need for more solid, consistent data to assist in effectively analyzing it.

The questions being asked include the following:

- Are things getting worse as fast as everyone believes?
- Which areas of the country have the biggest problems?
- How bad are the problems?

The weaknesses in the information systems do not, for the most part, stem from lack of monitoring at the local level. Most large metropolitan areas, and many rural areas as well, have continuing counting problems or have scheduled programs that, while not always definitive, do provide a sense of trend. Toll facilities and transit operations keep and publish relatively current data on revenues and operations. Some of this is well covered in the local press, some not. But it rarely makes its way into national attention, unless something dramatic happens. The problem lies at the national level, where local periodic, anecdotal evidence has not been assembled in a useful way. The key weaknesses in this area include

- The failure to assemble data from selected representative points to provide a centralized snapshot of national and subnational trends,
- The failure to assemble data on a timely basis so that "current" (i.e., quarterly and monthly) statistics are made available, and
- The failure to develop a means or measuring congestion that can inform and "move" the press and public officials.

Beyond congestion issues are those issues relating to obtaining a greater capacity and efficiency from existing facilities, including operational and management improvements for highways and transit. The ability to evaluate the effectiveness and consequences of various supply-and-demand "management" schemes is a critical need for the current planning process. The growing need to solve non-work–related travel and congestion emphasizes the need for comprehensive planning rather than simply commuter-related planning.

Safety is an important issue identified for future planning and decision making. Accident data that will support modal decision making in a way that is more meaningful than is currently possible is required. On the highway side, there is the difficulty that law enforcement officials experience in gathering onsite accident data and the difficulty in analyzing such data with regard to cause-and-effect relationships. With a more than doubling of vehicle miles traveled (VMT) expected over the next decades, it is important to obtain and analyze the appropriate data to further reduce the highway death rates.

On the transit side, both safety and security are important issues. In terms of the safety information needed for national strategic planning, although accident and fatality data are being collected under the auspices of Section 15, little national information is available on accident causes and incidents of crime, particularly as related to substance abuse. In addition, there is no consistency between the data collected for Section 15 and that available from other federal accident and safety reporting systems, such as NHTSA's Fatal Accident Reporting System (FARS) and National Accident Sampling System (NASS).

Without a more comprehensive set of data on accidents and their causes and crime against transit passengers, personnel, and property, it is difficult to properly identify important safety and security problems, formulate potential responses at the federal (and other) levels, and evaluate them. The first attempt at improving this situation will be a redesign of the safety-related data being collected for Section 15 purposes. A semiannual drug program reporting system is also being established under UMTA's new drug rule.

Mobility planning, as opposed to planning for individual modes, will become increasingly important. In urban areas, effective monitoring is basic to analyzing mobility needs. In the intercity market, data are needed, for example, to evaluate intermodal concepts such as substitution of high-speed rail for air or auto travel in trips under 400 mi. FRA is evaluating MAGLEV for this market and finds that, in obtaining trip information for city-to-city movements, origin-destination (O-D) data can be obtained for air and rail but is lacking for the highway mode, both for automobile and bus travel.

Rehabilitation and replacement will become increasingly important across all modes. In the wake of the great wave of public takeovers of private transit operators in the late 1960s and early 1970s, a large number of new maintenance and operating facilities were constructed for all modes. In the mid- to late 1970s and on into the 1980s, a large number of new rail systems began operation. Beginning with the first gasoline crisis in 1973 and accelerating after the second in 1979, transit fleets were expanded. Applying any set of rules or standards on facility updating and equipment and vehicle replacement to the transit systems whose history is briefly noted above suggests that the 1990s will mark the beginning of a significant period of transit rehabilitation and replacement. The precise implications for federal transportation programs are somewhat unclear.

Rail transit modernization requirements were examined as part of a congressionally directed rail modernization study, which was completed in 1987. However, the basic thrust of that study was to determine the cost of bringing the nation's then existing rail transit systems, most of which had originally been built decades earlier with nonfederal funds, to modern standards.

To assess the magnitude of future rehabilitation and replacement activities for all modes and how they will be distributed in time and by geography requires a significant amount of system condition data. Unfortunately, these data are not now routinely collected at the national level and much of it may not even be available locally.

MAJOR SOURCES OF SURFACE TRANSPORTATION DATA

The major sources of available information found most useful by those involved in the current national planning efforts of DOT and AASHTO are

- *For highways*: HPMS (FHWA),
- *For transit*: Section 15 reporting (UMTA),

- *For passenger travel*: NPTS (FHWA), and
- *For demographics*: census reporting.

These data sources have the following common characteristics:

- They are collected on a recurring basis.
- They are standard among reporting units (transit operators, states, etc.).
- They are national in scope.
- They are collected mainly for purposes other than national multimodal planning.

As background, a short description will be provided for each of the above.

HPMS

HPMS was established by FHWA in 1978 in response to a series of one-time special national studies requested earlier by Congress. The system was established as an ongoing and continually updated statistical data base and has many uses. One primary use is to provide basic information for the biennial reports to Congress titled *The Status of the Nation's Highways and Bridges*. Another use is a source for the annual mileage and travel tables for the publication *Highway Statistics*. A report, *Fatal and Injury Accident Rates on Public Roads in the United States*, was also prepared using HPMS data. Before the HPMS was established, each congressionally mandated study required the collection of massive amounts of data for one point in time. It was difficult to develop any trend data from these studies because definitions, categories, standards, and geographical detail were different in each of the studies. Routine statistical reports were out of date and lacked correlation among the many data items. It was determined that a continuous, comprehensive, and comparable data system was necessary.

The HPMS provides basic information on all roadway mileage in the nation, such as extent, functional classification, jurisdictional responsibility, and the like. Detailed information concerning extent, performance, operating characteristics, usage, pavement type, composition, and condition is obtained for a sample of about 102,000 arterial and collector roadway sections. Additional information is reported by the states in the form of areawide summary data, which includes fatal and injury accident data and a mileage and daily travel summary. HPMS data is reported by all states and is stratified into three substate components: rural, small urban, and urbanized. Six functional systems within each substate component are sampled separately. HPMS provides consistent and accurate information for national purposes. It can and has been supplemented for substate areas in a number of states.

In addition to information on the physical highway system, FHWA collects truck weight, vehicle classification, and traffic count data. Each month, the states provide information on traffic volumes by hour of the day, day of the week, and month of the year from over 3,500 permanent traffic counters throughout the United States. Annually, the states provide information on the vehicle classes and the weight of the trucks using the nation's highways.

Section 15 Reporting

The Section 15 data set, collected by UMTA, includes, for each transit operator in the country, data describing the size and composition of the vehicle fleet, the extent of fixed guideway facilities, levels of service provided, accidents and fatalities, operating and maintenance costs, ridership and revenue, subsidies, and employment. These data can be stratified in a number of ways, such as by operator size and mode.

Information is provided by metropolitan planning organizations (MPOs) and transit operators. MPO-provided information, for example, includes linked trips. The transit operator's system generates information for internal use in managing their operation as well as input to the Section 15 reporting system.

The Section 15 data have been used successfully for the past 9 years for national analyses of transit productivity, efficiency, and effectiveness. Many of these studies were used in preparation of the biannual reports to Congress on the current performance and condition of public mass transportation systems required by Section 308 of the Urban Mass Transportation Act.

The analytical categories of Section 15 information are as follows:

- Facilities and equipment levels;
- Resource utilization: vehicles, manpower, and energy;
- Financial structure and condition: capital expenditures, operating expenditures, and revenues;
- Service supplied;
- Passenger use of service;
- Operating performance: efficiency, relationship of passenger use to service, relationship of operating costs to passenger use, revenue generation capability, safety, and maintenance.

NPTS

The NPTS is a nationwide inventory of households to determine the residents' travel characteristics on a typical day. The travel characteristics collected include all person-trips for all lengths by all modes. However, since long trips over 100 mi represent only 0.7 percent of all trips, they are not well represented in the NPTS. The sample, distributed over each day of the week for a full 12-month period, also contains an inventory of the motor vehicles available to the households and their use in the previous year. Various other socioeconomic and demographic data related to the travel characteristics are also obtained. The NPTS is the only nationwide continuing and comprehensive survey of personal travel, and it is used by researchers, policy development staff of various organizations, national associations, other federal agencies, state and local governments, students, and private sector organizations concerned with the relationship of travel to demographics. It is an excellent source of current personal travel characteristics and, because of its relative consistency and

similarity from survey to survey, it is a valuable tool for assessing trends in these travel characteristics over time.

The next survey is expected to commence in February 1990, with data collection involving 20,000 households spread over a 12-month period. All household members age 14 and above will be personally interviewed by telephone, with proxy interviews for household members 5 to 13 years of age.

Previous surveys in 1969, 1977, and 1983 were conducted by the U.S. Bureau of the Census through personal interviews in the home. Two significant changes were introduced for the 1990 survey. The survey will be conducted by a private contractor, and a computer-assisted telephone interview technique known as CATI will be used.

Census Data: Demographics and Journey to Work

The decennial census provides considerable information regarding population and housing that is of use in national planning activities. Information on the journey to work is also collected. A special transportation planning package has been made available for the past several decennial censuses, providing data for urbanized areas. This package will be available for all urban areas and on a statewide basis for the 1990 census and should, as such, be of expanded use for national planning purposes. Data items include the number of work trips, work location, work trip time and departure time, mode traveled, carpool used, auto occupancy, and vehicle type.

The decennial census provides the longest time series of U.S. demographic data. It was first taken in 1790 and was broadened in 1810 to include other subjects. In 1960, the format was changed so that the majority of the population had only to answer a limited set of questions (short form), and a sample of the population had to answer a more detailed set of questions (long form). Journey-to-work and other transportation questions are included on the long form.

Other Data Sources

In addition to the above major data sources, numerous other data sources have played a lesser role in national planning. The Highway User and Finance System collects comprehensive data on the economics of the highway system; these data have been reported by the states and are published in the annual *Highway Statistics*. Highway finance data encompass complete and comprehensive information on receipts and disbursements for highways by all units of government. This includes 43 years of data and provides a continuing baseline of information for state and national policy deliberations. Other data in the highway user component of this series include motor fuel, vehicle registrations, and licensed drivers. Motor fuel data, reported monthly, are used for many purposes including estimates of federal Highway Trust Fund receipts attributable to each state.

The Annual Housing Survey (AHS) consists of a national sample of approximately 75,000 households and a metropolitan area sample of about 140,000 households spread over 20 standard metropolitan statistical areas (SMSAs). These 20 SMSAs constitute one-third of a list of 60 SMSAs that are sampled on a 3-year cycle, so that about 420,000 metropolitan households are surveyed in a 3-year period. The AHS includes questions that provide detailed information on journey-to-work trips.

The Eno Foundation publishes *Transportation in America*, a summary statistical analysis of transportation in the United States. This has been published every year since 1980. The report summarizes transportation traffic indicators, transportation outlays, the nation's transportation bill, intercity travel, fatalities, and user taxes and fees. These data are provided for all modes.

Although no national data bases have been developed for the intercity rail and bus modes, there is some information on these operations, such as that reported in the Amtrak and Greyhound annual reports. Likewise, O-D information can be obtained for rail through ticket sale information. The ability to obtain such information in a readily used format, however, is questionable.

NASS is based on a sampling of all highway accidents by accident investigation teams under contractual agreement with NHTSA. These investigators visit the accident scene, locate the vehicles involved, interview drivers and others involved, and procure appropriate records. This information is coded on NASS forms and provides annual files available to the public. FARS gathers data on all fatal highway accidents. FARS analysts gather, interpret, codify, and transmit data on all fatal accidents using police, medical examiner/coroner, and emergency medical services reports as well as state vehicle registration, driver licensing, highway department files, vital statistic documents, and death certificates.

The last source described here is data collected for local and statewide planning that can provide characteristics useful to national planning. These include O-D surveys, traffic counts, classification studies, speed studies, forecasts of demographic and travel characteristics, etc. A good summary of such characteristics is contained in *Characteristics of Urban Transportation Demand*, available from DOT. The basic problem with much of the data collected locally is the lack of consistency in definitions between areas.

GAPS IN DATA AVAILABILITY

The material in this section has been developed through conversations with those involved in DOT and AASHTO national planning efforts, staff involved in the collection of national data sources such as the HPMS, and, most important, the October 1989 conference of the TRB Transportation Data and Information Systems Committee.

The results of three workshops held at the conference on urban, statewide, and national transportation data needs provide a good framework for discussing data requirements for national planning and decision making. The findings are reported herein, along with material from the other sources mentioned.

Data Gaps

In evaluating data gaps, it may be worthwhile to array the current data sources (previously described) by market and by

TABLE 1 MAJOR DATA SOURCES SUMMARY

Market	Sources
Urban/suburban	
Highway	HPMS; FARS/NASS; HUFS
Public transport	Section 15
All modes	Census; AHS; NPTS
Rural	
Highway	HPMS; FARS/NASS; HUFS
Public transport	—
All modes	Census; AHS; NPTS
Intercity	
Highway	NPTS; HPMS
Rail	NPTS; Ticket Data Amtrak
Bus	NPTS; Ticket Data Greyhound
All modes	Census

NOTES: HPMS = Highway Performance Monitoring System (FHWA); FARS = Fatal Accident Reporting System (NHTSA); NASS = National Accident Sampling System (NHTSA); HUFS = Highway User and Finance System (FHWA); Section 15 = Urban Mass Transportation Industry Uniform System of Accounts and Records and Reporting System (UMTA); Census = Decennial Census (Bureau of the Census); AHS = Annual Housing Survey (Bureau of the Census); and NPTS = Nationwide Personal Transportation Study (FHWA).

mode. This is shown in Table 1. The major data gaps recognized by comparing data needs and available data are summarized below:

- Data for measurement of congestion;
- Data for system performance monitoring;
- Data on longer trips (over 100 mi) for all modes;
- Data on rural public transportation;
- Data on intercity rail and bus operations, facilities, and infrastructure;
- Data on new roads on new alignments;
- Data on highways by subgeographies such as suburbs and core area;
- Data on local road needs; and
- Data on traveler attitudes and perceptions.

Filling the Data Gaps

The following activities are suggested as ways to fill the data gaps discussed above:

1. A national congestion monitoring data set providing public information on trends in major U.S. cities is identified as a needed and useful undertaking to support national policy making and comparative analyses in individual metropolitan areas.

The goal of the plan would be to assemble on a quarterly basis a set of travel trend measures representative of all of the nation's metropolitan areas with a population of over a million. One important task would be to develop appropriate means for measuring and reporting congestion.

A major emphasis would be on change in congestion. That might mean an emphasis on peak period measurements at major facilities, with percentage changes between one month/quarter and that of the past year. One approach would be to obtain only a limited number of "representative" points per metropolitan area, drawn from existing monitoring points, toll booths, bridges, transit counts, etc. There is no presumption that these areawide measures will be properly statistically weighted, unless such a system is in place in a given area and readily available. Preferably, downtown-oriented and suburban trends for each area would be separately monitored.

2. Consideration should be given to a continuing performance measurement process for metropolitan areas. The data set developed in a TRB study of performance measurement needs in 1976 (see Table 2) should form the basis for such a reevaluation. An NCHRP synthesis of effective practice in this area is warranted. Along this line, the mandated requirement for a continuing process of monitoring and reporting transportation trends in urban areas, which was rescinded in 1983, needs to be reconsidered. The utility of such a process is agreed to by many, but it is not clear that federal mandates must be the answer to achieving it.

3. There is a lack of data on longer trips. Data is required to evaluate intermodal concepts such as substitution of high-speed rail or vertical takeoff aircraft for travel under 400 mi. The national travel survey that was part of the NPTS data collection used to capture long trips on all modes has not been conducted since 1977. Consideration should be given to reinstating this collection effort. The US Travel Data Center currently collects data called the National Travel Survey. It is oriented toward tourism, but it does provide other useful information on longer trips. For specific city pair markets, however, special surveys to collect O-D movements by all modes may still be necessary.

4. An authoritative review of the relationship between transportation investment and economic development, productivity, and competitiveness, and the data required to support such analysis, should be undertaken.

5. Consideration should be given to the establishment of a national data collection effort and reporting of information for the passenger rail and intercity bus market, similar to that being accomplished for highways (by the HPMS) and urban public transit (by Section 15). Currently, such information may be available from Amtrak and Greyhound but is not easily obtainable in a consistent format.

6. Not a single consistent source of data was found for transit operations. UMTA collects data on urbanized transit operations, including some financial information. These data, however, do not cover rural areas. This may be covered in a separate Section 18 data process. Section 15 does not provide sufficient information on transit facilities and infrastructure. Specifically, information on terminal and maintenance facilities is not included with data on condition, needs, etc.

A national transit system condition data set, comparable to that used by the HPMS, would describe the number, size, and condition of fixed transit facilities, as well as all vehicles and significant ancillary equipment. Acquisition and/or operation initiation dates would be collected, along with the expected dates for major overhauls and/or replacements, based on consistently applied standards. Estimates of the costs associated with rehabilitation and replacement might also be included.

Care would have to be exercised to ensure that the data collected were not more detailed than was necessary to support national-scale planning and policy analysis. This could be ensured by using a sampling procedure similar in concept to that used by the HPMS, collecting the data on a periodic

TABLE 2 SUMMARY OF PROPOSED DATA ELEMENTS

Data Element and Classification	Reporting Interval (years)	MPOs Affected	Implementation Phase
Highway data			
Road miles			
By functional classification	2	All	1
By geographic area	2	All[a]	1
Lane miles of arterials during peak period	2	All	1
By functional classification of arterials			
By number of lanes			
By geographical area			
By 1-way or 2-way direction			
Miles of reversible lanes	2	All	1
Vehicle miles of travel			
By functional classification[b]	2	All	1
By geographic area	2	All[a]	1
By vehicle type	4	—[c]	2
Passenger occupancy	4	—[c]	2
By vehicle type			
By geographic area			
CBD cordon measurement	4	—[d]	2
Passenger occupancy			
Vehicle type			
Traffic volume and congestion[e]	4	—[f]	2
Public transit data			
Land area within ¼ mile of weekday transit service (population within band will be determined when census data become available)			
By number of boardable vehicles per 24 hour period	4	All	1
By geographic area	4	All[a]	1
Transit user survey	4	—[d]	2
Number of linked passenger trips			
Average linked trip distance			
Average linked trip time			
Trip purpose			
Rider characteristics			
Age			
Sex			
Income			
Whether handicapped			
Automobile availability			
Limited transit user survey	4	—[g]	1
Unlinked passenger trips			
Unlinked passenger miles or average unlinked trip distance			
Average unlinked trip time			
Rider characteristics			
Age			
Sex			
Race			
Handicapped			
Selected data from transit operators (classified by mode)	2	All	1
Annual unlinked passenger trips			
Annual revenue passengers			
Annual vehicle miles			
Annual revenue vehicle miles			
Number of revenue vehicles			
Age distribution of revenue vehicles			
Average age of revenue vehicles			
Demographic data			
Population			
By geographic area	2	All[a]	1
Dwelling units			
By geographic area	2	All[a]	1
Employment	2	All[a]	1
By geographic area			
By CBD			
Passenger vehicle registrations	2	All	1
By county located in or containing urbanized area			
By vehicle type			
Land areas	2	All	1
By urbanized area			
By central city			
By central business district			
By federal-aid system boundaries			
Measurement of system performance			
Highway system: land area and dwelling units within travel time contours[h]			
From CBD	2	—[f]	1
From airport	4	—[f]	2
From major non-CBD employment center	4	—[f]	2
From major non-CBD shopping center	4	—[f]	2
Transit system: land area and dwelling units within travel time contours[h]			
From CBD	2	—[f]	1

[a]Areas with populations between 50,000 and 200,000 report only for urbanized areas.
[b]In phase 1, functional classifications are combined into 3 groups: Interstate, freeways, and expressways; principal and minor arterials; and collectors and locals. In phase 2, only the first 2 groups are used; collectors and locals are excluded.
[c]Only areas with population of 200,000 or more; a systemwide sampling method will be used.
[d]Only areas with population of 750,000 or more.
[e]Under consideration by FHWA.
[f]Only areas with population of 200,000 or more.
[g]Only areas with population of 200,000 to 750,000.
[h]After census figures become available, dwelling units and population within contours will be calculated on a 4-year cycle.

basis but not every year. The triennial reviews required by Section 9 of the Urban Mass Transportation Act might provide a good opportunity to keep such a national system condition data base current.

7. Although the HPMS provides a wealth of information for national planning and decision making, a number of recommendations should be considered for the future:

- Congestion measures should be included in the HPMS. Some possible improvements being considered by FHWA include sampling individual urbanized areas rather than sampling them collectively statewide; adding data items, if necessary, to allow calculation and reporting of congestion indices; and reviewing sample adequacy to allow calculation of congestion indexes for subareas of metropolitan areas.
- Coding should be included within the HPMS to allow identification and reporting for subgeography, such as suburbs and core areas. This would allow identifying area types with problems, such as the current suburban congestion.
- Data should be obtained on an aggregate measure of local road needs, which are not now obtained in the HPMS. This reporting should be by some method other than segment sampling. While good data on the condition of the Interstate system are available from the HPMS, the data are weaker for primary and secondary highways and of limited use for local systems, mainly because of progressively weaker statistical sampling.
- Since the HPMS is based on statistical sampling of existing highways and roads and is designed to consider improvements to these, it does not deal with new roads on new alignments. New routes that have been constructed since sample selection should be included as quickly as possible. Consideration should be given to including descriptive information for future new routes when the facility is programmed.
- Encouragement should be given to urban boundary consistency between data sources. FHWA uses a federal-aid boundary definition in the HPMS, which may differ from those used by urban area planning agencies. Generally, boundaries should be larger than captured by the HPMS to include areas of growth such as those anticipated in 20-year forecasts.

8. Changes in highway finance data series should focus on improving the completeness and accuracy of information on local government capital outlay by functional system. Some states have not developed the capacity to report this information on a continuing basis, even though the data series was established 10 years ago. Improvements are needed to better serve the needs of the transportation community.

9. The NPTS is a valuable source of trend information and travel characteristics for all modes. However, the sampling rate has been decreasing over the years because of budgetary limitations, and the reporting of specific area characteristics has been restrained because of Census Bureau disclosure procedures. Much of this has been overcome by current plans to increase sample size through telephone interviews and the use of a private firm for collection. This collection effort, planned for 1990, should be funded and accomplished as planned.

10. The decennial census provides most of the demographic data used for national planning and decision making. Likewise, it provides the most complete information on commuting (the journey to work). Since effective national planning relies heavily on available information from all areas of the nation, the current plan to produce the Census Transportation Planning Package (CTPP, formerly the UTPP) for all urbanized areas and states should be implemented.

11. Another area of data need is "felt" problems and trends with regard to the transportation system and service at the traveler level. This would relate to areas such as congestion, mobility, payoff of public expenditures, safety, costs versus benefits, and quality of life. This area of consumer attitude and perception is one that should be considered, because it is a major data gap on a national level.

12. Regarding data collected by individual states and urban areas, some attention needs to be directed toward making these more useful for national planning and decision making. Collections such as O-D surveys (internal and external), classification and count activities, and speed and delay surveys would be greatly enhanced for national planning purposes through some standardization, if only in the area of definition of terms (e.g., what is a trip) and stratifications used (e.g., modes and trip purposes) for some defined portion of each collection effort.

CONCLUSIONS/RECOMMENDATIONS

The purpose of this section is to present the key questions that should be considered in Phase 2 of this TRB project and beyond.

As described earlier in this paper, three data levels have been used in past national planning studies. At one level, broad policy issues are addressed with available data from existing sources, mostly in report form, with little new manipulation of the basic data sources and without analysis or modeling based on the original data sources. At another level, described for the 1974 DOT efforts, a new data reporting activity is defined and requested/required of the states and metropolitan areas. This effort results in considerable analytical and modeling-based activities. Depending on the detail requested, the costs can be quite high. A data collection and analysis function like that carried out in 1974 might cost in the range of $10,000,000 today.

Current planning efforts have been based on available sources of information with some analysis and modeling. In some instances, the basic data files have been manipulated to provide required information. This approach is benefited today by the data bases that have been defined and collected on a regular basis, but originally designed for other purposes. These include, among others, the HPMS, Section 15, the NPTS, and the decennial census. Depending on the nature of future policy and planning efforts, any one or a combination of the above approaches may be appropriate.

In this paper, the focus has been on surface passenger data needs, available data sources, and data gaps. It will be left to others, and work in Phase 2, to further define the overall data approach.

A concern expressed by Francis Francois at the mid-year TRB Transportation Data and Information Systems Committee meeting should be stated here, even though it applies to all modes and market segments. Francois agrees that more effective ways to collect and analyze data and information must be found, but he warns that the challenge is to avoid information gridlock, being deluged with data and given high-

speed computers capable of whirling out more information than transportation professionals can digest and utilize. Hence, data gaps must be evaluated and filled only with data that can be efficiently and effectively used to fill important information needs.

Before the conclusions and recommendations specifically related to surface passenger data, a short summary is provided of comments and suggestions made at the mid-year conference that are appropriate for all transportation data.

First, consideration should be given to the establishment of a national data center for strategic planning and decision making. There is currently no central repository of data used for past national efforts—no corporate history. A considerable amount of data is now collected regularly, so there is something of a "national data base." This base could be further enhanced by having the modal administrations work toward standardizing as much as possible with regard to geography, definition of terms, travel and performance measures, years collected, computer systems, adaption of uniform Geographic Information Systems (GISs), and data management systems. Data integration may well be achieved through GISs.

Second, this industry must learn to speak to the various receptors of transportation information in their language. Data should be collected, analyzed, and reported in terms understandable to the press, the public at large, government decision makers, and industry heads. A major focus should be on taxpayer/consumer interests. With regard to providing such information, it would be useful to develop and publish an annual state-of-the-system and service report across all modes and transportation markets.

Third, a renegotiation of data partnerships—who collects what data for whom—should be investigated. National planning should capitalize on all useful existing data sources, such as state and metropolitan area collections. Such data usefulness for national planning suffers from a lack of standardized definitions for items such as modes, purposes, and geography. Local efforts are not consistent. The question to be answered is, can local data be aggregated for national use? At the moment, the most useful data comes from specially designed collections (such as the HPMS and Section 15). As much as possible federal reporting should be an incidental by-product of local data, or at least be based on data useful at the state and local levels.

Finally, time series data are very important. The problem is that those responsible for data collection efforts often do not wish to change collection procedures, data items, and definitions because of the interest in trends. This must be somehow balanced against a need to develop more consistent information between collection efforts and data more in tune with current and foreseen issues.

Regarding surface passenger data and data gaps, the following is desired based on the investigations made for this paper:

- A data system is needed to measure and monitor congestion, system performance, and mobility across all modes.
- Data are required to measure and evaluate "felt" consumer/traveler problems and trends in terms of attitudes and perceptions.
- Information for all modes is required on longer trips (those over 100 mi) to provide for the study of new technologies and substitutions between modes.
- A data system for intercity rail and bus systems needs to be developed. The data collected by the carriers should be a prime point of investigation.
- For highways, the HPMS is the best data source. FHWA is currently considering improvements related to pavement data, traffic data, and urban boundary considerations. Other specific recommendations include obtaining data on new facilities or new alignments; inclusion of congestion measures; a level of geography improvements, such as identifying individual urbanized areas and subgeographies such as the suburbs; and gathering at least aggregate information on local roads.
- For public transit, Section 15 reporting has been the most useful source. This source does not cover rural areas. It provides good data on operations and financial aspects. Data should be considered relative to safety and security; obtaining a better handle on systems conditions; financial requirements related to rehabilitation and replacement; and fixed facilities, vehicles, and significant ancillary equipment.
- The NPTS should be conducted in 1990. It provides considerable trend information for all modes. Mechanisms should be continuously investigated for increasing sample size and the reporting of information for specific geographic areas (such as individual urbanized areas and portions of urbanized areas). Additionally, definitions of terms and geography should be evaluated to provide consistency with other data sources, such as the decennial census.
- With regard to the decennial census and the CTPP, it is recommended that the plan to consider a consolidated purchase of the 1990 package be implemented. Having this data on a national basis would be extremely useful. Likewise, the statewide package currently being considered should be implemented along with the traditional urban package.

APPENDIX A
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APPENDIX B
Summary of Mid-year Meeting and Conference Workshop Sessions

The program for the mid-year meeting and conference of the TRB Transportation Data and Information Systems Committee held in October 1989 included three concurrent workshops. These workshops on urban, statewide, and national data and information system needs resulted in the development of a number of recommendations. The chairperson of each workshop summarized the findings, which have been compiled and edited as appropriate for this paper.

Urban Workshop Report by Alan Pisarski

Strategic Planning/Policy Issues

The urban workshop began with an assessment of current trends and issues in the urban planning process and their relationship to data requirements.

First, it was concluded that the pendulum is swinging back toward longer-range thinking, to supplement rather than replace the recent short-range focus of planning. The future emphasis will be on both factors, rather than on one or the other. Highway operations planning is an example of the short-term focus; land use planning is an example of the focus on the longer term. Second, the scale of activities is again balanced between broad regional efforts and highly localized troubleshooting activities. All of these trends will place extensive information burdens on the planning process.

Dramatic changes in the demographic, economic, and spatial character of metropolitan centers have challenged local planning capabilities. The lack of adequate financial resources and supporting programs to produce adequate data has retarded the effectiveness of metropolitan planning.

The prime issue is highway congestion, in both urban and suburban areas. Parts of the congestion concern include the relating of existing facilities and services to the new circumferential patterns of contemporary commuting. Although most critical in high-growth areas, congestion effects are being felt in all parts of the nation. The adequacy of current planning tools and data to forecast and assess prospective demand and evaluate alternative responses is in serious question.

Beyond congestion issues are those issues relating to obtaining greater capacity and efficiency in the use of existing facilities, including operational and management improvements for highways and transit. The ability to evaluate the effectiveness and consequences of various supply-and-demand

"management" schemes is a critical need for the current planning process. The growing issue of non-work-related travel and congestion emphasizes the need for comprehensive planning rather than simply commuter-related planning.

A final set of issues relates to the linkage of transportation to overall land use concerns, access to low-cost housing, and the problems of dealing with rapid growth.

Conclusions/Recommendations

- The mandated requirement for a continuing process of monitoring and reporting transportation trends in urban areas that was rescinded in 1983 needs to be reconsidered. The utility of such a process is agreed to by all, but it is not clear that federal mandates must be the answer to achieving it.
- The program to produce the special journey-to-work package—the CTPP—is the single highest priority for meeting urban data requirements and should be fully supported by local governments, MPOs, states, and federal agencies.
- UMTA and FHWA should undertake programs that encourage and support collateral data collection activities in the 1990s to complement the decennial census data collection effort. These collateral activities should include surveying of nonwork trips, urban freight data needs, and external travel, particularly in small metropolitan areas.
- Consideration should be given to a continuing performance measurement process for metropolitan areas. The data set developed in a study of performance measurement needs in 1976 should form the basis for such a reevaluation. An NCHRP synthesis of effective practice in this area is warranted.
- A national congestion monitoring data set providing public information on traffic trends in major U.S. cities was identified as a needed and useful undertaking to inform national policy makers and support comparative analyses in individual metropolitan areas.
- A condition and performance monitoring capability for transit, akin to the HPMS on highways, is needed, particularly to gain knowledge of capital reconstruction needs for fixed transit facilities. A parallel highway program related to UMTA Section 15 reporting would be desirable.

Statewide Workshop Report by Michael Meyer

Strategic Planning/Policy Issues

- Facility maintenance, rehabilitation, condition, and performance;
- Intermodalism;
- Safety;
- Congestion;
- Mobility planning (need good definition);
- Payoffs of investment in terms of equity, economic development, and environmental impacts;
- Non-federal-aid system;
- Trucking/commercial travel;
- Noncapital strategies;
- Corridor preservation;
- Road pricing; and
- Fund apportionment.

Gaps in the Data

- Trucking;
- New roads on new alignments;
- Transit data;
- Access to intermodal facilities such as airports and ports;
- Performance measures;
- Before-and-after data to measure results of improvements;
- Nonwork, non-home-based work trips;
- Cost/benefit information;
- Traveler attitudes; and
- Usefulness of GIS technology.

Conclusions/Recommendations

- There needs to be greater coordination between data bases that state DOTs use, such as pavement management systems and the HPMS. FHWA should take the lead in fostering coordination and implementation of standards in terminology.
- GIS technology should facilitate the above coordination. Steps need to be taken to disseminate information on availability and uses of GISs with emphasis on keeping it simple to foster quicker implementation.
- Further research and implementation of the results of collection of data on trucks, such as automated vehicle detection and crescent study procedures, are needed.
- Data are needed for evaluating intermodal concepts, such as substitution of high-speed rail for air in trips under 400 mi, better access between highways and ports, and cost allocation between modes.
- User benefits are important measures. What do they mean to other parts of society and the economy, such as economic development and the environment?
- An authoritative review should be made of the relationship between transportation investment and economic development, productivity, and competitiveness, along with a determination of the data required.
- Performance/level-of-service data are required. The HPMS should be modified to include such a measure, if possible.
- Sufficient data on rural and nonurban areas have already been collected. Complete data bases across each state are needed to allow consistency in planning between urban and rural areas.
- A strategy should be established for collecting state transit facility condition data.
- At least 2 percent of all federal transportation aid to metropolitan areas and states should go to transportation planning and research, with data collection, data management, and analysis a major part of a transportation research and planning effort.
- Consistency is needed in aviation data and analysis to relate national airspace planning to physical plans at airports.
- Better information on fuel consumption and evasion of taxes is needed, as this is important for use in the allocation of funds.
- The 1990 census should be used to see how the models and forecasts might be improved.
- To avoid information gridlock, a review of data collection management strategies should be made. The TRB Transportation Data and Information Systems Committee should do a prototypical study of what a good data management system should be.

Recommendations for National Data by Gary Maring

This workshop considered five markets: urban/suburban, rural, intercity passenger, intercity freight, and international.

Strategic Planning/Policy Issues

- Urban/suburban
  - —congestion,
  - —System management,
  - —Infrastructure rehabilitation/expansion,
  - —Land use/transportation integration, and
  - —Funding flexibility.
- Rural
  - —Infrastructure preservation,
  - —Local rural road needs,
  - —Rail branch line abandonment, and
  - —Rural mobility problems.
- Intercity passenger
  - —Airport/airway congestion,
  - —Major highway corridor congestion,
  - —New intercity air/rail technology, and
  - —Funding flexibility.
- Intercity freight
  - —Truck size and weight,
  - —User fee equity,
  - —Economic deregulation,
  - —Tax/registration uniformity, and
  - —Safety/hazardous materials.
- International
  - —Competitiveness,
  - —Port connections, and
  - —Container standards and weights.

Gaps in the Data

- Urban/suburban
  - —Consistency in urban boundary definition,
  - —Measurement of congestion, and
  - —Geographic specificity.
- Rural
  - —Rural public transportation and
  - —Local road needs.
- Intercity passenger—lack of national travel survey for long trips.
- Intercity freight
  - —Commodity transportation survey,
  - —Intermodal movements, and
  - —Air cargo.
- International—domestic leg of foreign commerce.

Conclusions/Recommendations

- Urban
  - —Consistency between data bases should be encouraged for urban boundaries of metropolitan areas. FHWA uses a Federal aid boundary definition, which may be different from those used by urban area studies. The urban boundary should be larger than that captured in the HPMS. The boundaries should be extended to include areas of growth (20-year forecasts).
  - —Uniform measures of congestion should be developed. One recommendation would be lane miles at some level of service (e.g., LOS D). Data items should be included in the HPMS, if they are not now included, to calculate congestion.
  - —The HPMS should include some coding to allow identification of subarea geography, such as the suburbs. This would allow identifying area types with problems, such as the current suburban congestion.
  - —Develop means within the HPMS for measuring trip length to aid in activities such as functional classification and determining systems of national significance. More than volume is required. A measure such as trip length is probably necessary.
  - —The Section 15 data base should be expanded to provide condition data on fixed plants.
- Rural
  - —Data not obtained in the HPMS are needed on an aggregate measure of local road needs. These data should be gathered by some method other than segment sampling.
  - —For short-line railroads, some measure of the abandonment impact on local roads and the agricultural economy is required. Financial and flow data would be desirable.
- Intercity Passenger
  - —There is a lack of data on longer trips. The National Travel Survey used to capture long trips on all modes. This is especially important when considering new technology and proposals for activities such as substitution of high-speed rail for intermediate length trips (100 to 400 mi), tilt engine vertical take-off aircraft, etc. There is a need to collect information on longer trips by all modes.
  - —There is a need for information on intercity buses and rural bus service, including financial and flow data.
- Intercity Freight
  - —There is a lack of commodity O-D data. The last Commodity Transportation Survey was done in 1977. The impact of changes since then due to deregulation and changes in sizes and weights is not clear. Better data across modes are required.
  - —There is a need for better truck safety data by truck configuration and a way to relate accident data to exposure data.
- International
  - —Better data and analysis on international flows should be obtained. Data are collected, but they are not well reported and compiled. For example, the impact of containers on the road system must be measured.
- Other
  - —Relative to all modes and markets, the GIS concept provides the mechanism to coordinate data bases on a common basis, especially as related to networks and flows.
  - —There should be a reevaluation of partnerships in data collection at three levels:

1. Between federal agencies: Agriculture, DOT, Energy, Census, etc.;
2. Between federal, state, and local agencies; and
3. In government: Private relative to deregulation, privatization, etc.

Scenic Byways Data Needs, Resources, and Issues

BOB L. SMITH

Three national policy issues are suggested for consideration by those concerned with making informed policy decisions in transportation, particularly in the area of scenic byways: Should there be a national scenic byways program? Should there be a nationally identified scenic byways system? Should scenic byways be eligible for increased federal funding or a special category of federal funding? Whether the answers to these policy issues are "yes" or "no," certain data are needed if the states are to continue or begin scenic byways programs. Specific data and sources are suggested for use by those charged with scenic byways marketing, selection/designation, corridor protection/enhancement, and maintenance. Economic impact data are of legitimate interest to all levels of government as well as the private sector. Data needs and sources are suggested in this paper. Because there is virtually no information available on the economic impact of scenic byways, it is recommended that economic impact data be gathered for several years and a series of economic impact models be developed and refined as the data become available.

The following national policy issues should be considered by those concerned with making informed policy decisions in transportation, particularly in the area of scenic byways:

1. Should there be a national scenic byways program?
2. Should there be a nationally identified scenic byways system?
3. Should scenic byways be eligible for increased federal funding or a special category of federal funding?
   - The basis for such funding would logically require some minimum level of usage by scenic byways recreationists as well as some minimum criteria for scenic byways designation.
   - There could also be some "system requirement" (i.e., the enhancement or completion of a nationwide, regional, or state scenic byways system).
   - A minimum level of positive economic impact (benefits) on the region could be estimated or perhaps a benefit/cost (B/C) ratio greater than 1.0 could be required.
   - An estimate of the positive economic impact on a region could also spark regional (state or local) public and private investment in the protection/enhancement of the byway corridor.
   - Another basis for such funding could be a documented need for preserving/enhancing the byway corridors to increase the enjoyment and use of the corridors, as well as to avoid adverse safety and environmental consequences.
   - Federal funding or other assistance could be used in the coordination of efforts, collection of data, and preparation/dissemination and periodic updating of a document, *Scenic Byways: Status and Statistics.*

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Whether the answers to these three policy issues are "yes" or "no," the following information is needed if states are to continue (or begin) scenic byways programs.

GENERAL INFORMATION

Factors that are important to the scenic byways user (recreationist) in the selection or rejection of a given route need to be identified. This information should provide insight regarding the importance of protecting/enhancing a scenic corridor.

In order to travel scenic byways, the public must be able to determine

- Where the byways are located;
- The level of scenic quality and the location and types of recreational, historic, and cultural sites;
- Whether the route is all-weather and what the type of roadway surface is; and
- Whether the route is suitable for only limited sizes and types of vehicles (e.g., only four-wheel drive vehicles).

There should be some system of informing the public of the above through maps, booklets, or brochures prepared by national, regional, and state organizations.

SPECIFIC SCENIC BYWAYS DATA NEEDS

The following specific scenic byways data are needed:

1. Location of byways (for a national registry, maps, etc.).
2. Criteria used in byway selection (enhances the chances that designated scenic byways will consistently "deliver as promised").
3. Physical characteristics such as surface type, right-of-way, and roadway width; number of lanes; functional classification; geometrics; minimum desirable design standards or criteria; and a description of specific techniques, such as commentary driving, that were used to conduct a safety analysis of the road (useful in byway safety evaluations).
4. Physical condition of roadway surface, drainage, etc., i.e., a sort of scenic byways "sufficiency rating" (useful in byway safety evaluations).
5. Traffic information such as volumes; count of recreationist users (for use in economic/impact studies); level of service; types of recreation vehicles prohibited, e.g., tour buses;

weather problems that warrant road closure to recreationists; and speeds (to determine whether speeds on scenic byways are different from speeds on similar but nonscenic roads).

6. Accident experience of all users and of recreationists only (to determine whether "scenic roads" are safer than "nonscenic" roads).

7. History of "tort claims" lawsuits, judgments, and settlements (to help answer the concern that enticing the public to scenic byways will result in greater tort claims losses).

8. Jurisdiction with control over the byway (where to direct questions about the byway).

9. Maintenance/upgrading of road: whose responsibility, dollars spent, and sources of funds (to determine costs for B/C ratios in economic impact studies).

10. Protection/enhancement of byway corridors (for economic impact studies and as a guide for others): (a) What, if anything, was done? (b) How was it done, i.e., scenic easements, purchase, zoning, other? (c) What were the costs and who made the payments, i.e., federal, state, or local government, or private funds?

11. Marketing campaign: description of campaign, responsibility, and origin of funds—public or private (for economic impact studies and as a guide for others).

12. Location/type/amount of recreation and historic sites in the scenic corridor and in the area directly impacting the byway (for economic impact studies and estimation of future scenic byways recreationist traffic).

Some of the above data are currently being collected, but they are not available in a central location, organized by byway and state. State DOTs usually collect these data in states that have roads designated as byways. In other states, it is unlikely that the state DOT collects the information.

ECONOMIC IMPACT DATA

The economic impact of scenic byways is an important area of concern for all levels of government, as well as the private sector. However, virtually no information is available on this subject.

Scenic byways can be viewed as an addition to a region's tourist attractions. To measure the economic impact of this addition, the increase in tourist trips and expenditures attributable directly to the scenic byways programs must be determined. In addition to the total spending, the types of expenditures and where those expenditures occurred should be identified.

After the tourist expenditures data are obtained, input-output (I-O) models for the states in each region would be required. These models measure the income, sales, and employment impacts of scenic byways programs through the computation of multipliers that measure the impact of tourist expenditures.

An I-O model has been proposed for evaluating the economic impact of scenic byways in Iowa, Kansas, Missouri, and Nebraska. The I-O model for Kansas will be based on *The Kansas Input-Output Model: A Study in Economic Linkages* (*1*). Iowa, Nebraska, and Missouri will use models that have adapted national data to these states' economic structure. It is suggested that survey-based I-O models be developed in those states desiring to use this technique in scenic byways economic impact studies.

Since it is not possible to know the increase in tourist expenditures attributable to scenic byways before their designation and operation, large amounts of data are required to obtain some indirect estimates. A variety of baseline data about the region is necessary. The following data, currently available from the sources listed, should be included:

- Population by age, sex, and race: Bureau of the Census (*2*);
- Per capita and personal income: *Survey of Current Business* (U.S. Department of Commerce);
- Employment by industry: *Employment and Earnings* (Bureau of Labor Statistics);
- Employment in the tourism industry: *Employment and Earnings* (Bureau of Labor Statistics);
- Automobile ownership: *Motor Vehicle Facts and Figures* (Motor Vehicle Manufacturers Association) and state statistical abstracts;
- List of tourist attractions and population within 100 mi of each: state statistical abstracts (perhaps state departments of tourism);
- Locations of potential scenic byways relative to other regional tourist attractions and population centers: state DOTs;
- Attendance at state parks, historical sites, and recreation areas and at national parks, monuments, and recreation areas: state statistical abstracts, state departments of tourism, national park statistical abstracts (U.S. National Park Service);
- State park and recreational income: state statistical abstracts;
- Recreational facilities at regional tourist attractions (i.e., camping, hiking, fishing, hunting, boating, swimming, and lodging): state statistical abstracts and state departments of tourism;
- Traffic counts on potential scenic byways: state DOTs; and
- Origins and destinations of nonresident visitors to the region: US Travel Data Center.

As much as possible needs to be known about the characteristics of byway recreationists. At a minimum, information should be collected on the types of expenditures they make (i.e., gasoline, hotels/motels, meals and refreshments, groceries, souvenirs, and admissions to tourist attractions). This data is important because different types of expenditures result in different income and employment effects. Possible data sources for this are the US Travel Data Center in Washington, D.C., and state departments of tourism.

In addition to the types and amounts of byway recreationist expenditure, the following data are needed:

- Purpose of the trip,
- Type of trip (weekend or vacation),
- Number of nights away from home,
- Number in the travel party,
- Types of lodging used,
- Mode of transport,
- Types of recreational activity, and
- Repeat trips.

This data may be available from the US Travel Data Center. Otherwise, a sample of the recreationist population could be

interviewed/surveyed. Some data are also available from *Southern Living* and *Better Homes and Gardens* magazines.

A great deal of demographic data on tourists, such as age, sex, race, income, occupation, and education, are also required. This information can be compared to the region's demographics to determine whether regional tourism activity will match or exceed national norms.

To gather the above types of information on tourists, survey studies should be conducted on the economic and demographic characteristics of tourists. This type of information could be gathered through interviews or questionnaire surveys at state parks, recreation areas, historical sites, hotels/motels, and visitor centers.

To obtain an estimate of increased use, traffic counts should be conducted on potential scenic byways, followed by traffic counts in the years following their designation. In order to do this, the traffic due to scenic byways recreationists must be identifiable.

BENEFIT/COST DATA NEEDS

The costs to tourists are primarily the types of expenditures identified above. Data on costs to the states should be gathered in the future (see items 9–11 of the specific scenic byway data needs listed above). The costs to states include

- Signs and other safety measures;
- Maintenance;
- Maps, brochures, and marketing campaigns; and
- Corridor enhancement and protection, including construction of byway turnouts, parking areas, etc.

The increased use of scenic byways, identified by traffic count surveys, can be multiplied by an average benefit per person to obtain total benefits, which can then be compared with public and private costs.

RECOMMENDATION

To develop definitive models of the economic impacts of scenic byways, it is suggested that a number of byways be selected and the previously described needed data be gathered for several years. A series of economic impact models should be developed and refined as the data become available.

REFERENCES

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2. *Projection of the Population of the United States by Age, Sex and Race: 1988–2010.* Current Population Reports, Series P-25, No. 1017, Bureau of the Census, U.S. Department of Commerce, 1989.

Recreational Travel and Tourism Data Needs, Resources, and Issues

SUZANNE D. COOK

Data needs, resources, and issues of the travel and tourism industry, a major industry in the United States that depends heavily on the existence of a safe and efficient transportation system, are covered. The paper provides an overview of the U.S. travel and tourism industry, as well as current data sources and statistics. A variety of information sources are reviewed including federal government agencies (i.e., U.S. Departments of Commerce, Transportation, and Labor) and various offices within these agencies, state government agencies, as well as private sector sources (i.e., US Travel Data Center and Eno Foundation for Transportation). The focus of this paper is on identifying gaps and problems in existing data systems and on recommended improvements. It considers the transportation data needs (specifically related to travel and tourism) of the federal government in formulating policy, as well as the data needs of the travel and tourism industry. The gaps and problems identified revolve around four major categories: research orientation/priorities, research methodologies, data coverage, and data products. A variety of recommendations for improvements are included in this paper. Travel and tourism, the nation's third largest retail industry and its second largest employer, needs to become a priority industry for statistical coverage in future federal agency and other programs. This will require increased funding for travel-related data collection at the federal level as well as through public-private partnerships, and improved communications among researchers, data users, and the various organizations involved. The top priority of the travel and tourism community is the reinstatement of the large-scale National Travel Survey formerly conducted by the Bureau of the Census but terminated after the last survey in 1977. Recommendations involving research methodologies include the use of larger samples, production of ongoing time series data, and standardization of definitions and methodologies. Data coverage recommendations include improvements to the SIC code system and related data collection efforts, more frequent data, greater coverage of other aspects of travel (i.e., rail, bus), production of more marketing-oriented information, as well as greater attention to regional needs and collection of data to support the development of the scenic byways program. Finally, recommendations related to data products include more timely release of data, improved analysis and dissemination of results, greater support for a few specified survey programs, and establishment of a clearing house.

An overview is given of the data resources, issues, and problems related to recreational travel and tourism. The paper actually goes beyond this to consider all travel away from home, and outside the home community, by American residents and foreign visitors.

Over the years, there has been considerable discussion of the appropriate definition of recreational travel. After careful study of alternative definitions, the US Travel Data Center, the national nonprofit center for travel and tourism research, has adopted the following definition of "domestic traveler":

> any resident of the United States regardless of nationality who travels to a place 100 miles or more away from home within the United States or who stays away from home one or more nights in paid accommodations and who returns home within twelve months, except commuting to and from work or attending school.

This definition closely follows that recommended by the World Tourism Organization (WTO) for domestic travel. The Data Center has also adopted the WTO definition of "international traveler":

> any person visiting a country other than that in which he (she) has his (her) usual place of resident, for not more than one year, and whose primary purpose of visit is other than following an occupation remunerated from within the country visited, staying at least 24 hours, but not more than one year in the country visited.

Thus, although the purpose of the trip is important to whether or not it is included under these definitions of travel, the mileage threshold results in significant overlap with intercity passenger travel in transportation-related research and statistics. Given the frequent lack of data, travel and tourism professionals often use intercity passenger data as a proxy when analyzing travel and tourism trends and patterns. Although travel and tourism is a subset of intercity passenger travel, it requires special consideration because of its growing importance and unique characteristics.

This paper provides a descriptive overview of the U.S. travel and tourism industry, data sources and statistics that are currently used, gaps in existing data systems, and recommended improvements. It considers the transportation data needs of the federal government in formulating policy specifically related to travel and tourism, as well as the data needs of the travel and tourism industry.

A draft of this paper was presented at the Scenic Byways Conference on November 6, 1989, in Arlington, Va., at which additional input was obtained. Several other TRB meetings during 1989 provided the forum for presentations of other resource papers and initial discussion of issues related to transportation data needs, collection, and usage. Written summaries of these meetings have been reviewed, as well as a variety of other materials, as listed in the appendix to this paper. In addition, discussions with a number of individuals knowledgeable about both transportation data systems and their applicability to the topic of travel and tourism were held in preparation of this paper.

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TRAVEL AND TOURISM IN THE UNITED STATES

Travel as an Economic Activity

Travel has become an integral part of the American way of life. The ongoing National Travel Survey conducted by the US Travel Data Center indicates that two-thirds of the U.S. population of nearly 250 million people takes at least one trip of a minimum of 100 miles away from home each year, producing approximately 1.2 billion person-trips (one person taking one trip away from home) in the process.

Approximately three-quarters of all U.S. resident travel (as defined above) is taken for pleasure or leisure-related purposes. In 1988, 35 percent of all travel (430 million person-trips) was taken to visit friends and relatives, while 40 percent (490 million person-trips) occurred for other pleasure purposes including sightseeing, outdoor recreation, and entertainment. Another 8 percent of U.S. resident travel was for personal business reasons, leaving 17 percent of all person-trips taken to conduct business or attend a meeting or convention.

The vast majority of travel in this country is by personal motor vehicle. The National Travel Survey indicates that, in 1988, 77 percent of all U.S. resident person-trips were taken by automobile, truck, or recreational vehicle, generating an estimated 625 billion passenger-miles, 42 percent of the nearly 1.5 trillion intercity passenger-miles posted on the nation's highways, railways, and skyways. In addition, air travel generated another 342 billion and intercity rail and bus a total of 29 billion intercity passenger-miles in that year.

The US Travel Data Center estimates that travelers in the United States spent a total of nearly $323 billion in 1988. This includes $294 billion by Americans on domestic travel, as well as an estimated $29 billion (not including international passenger fares) by 14.1 million foreign visitors who traveled within the United States. Fourteen percent of these dollars were spent on automobile transportation and 25 percent on public transportation. Therefore, transportation accounts for 39 percent of all money spent by travelers in the United States.

In terms of employment, travel and tourism in the United States directly generated 5.65 million jobs in 1988, more than 5 percent of total nonagricultural employment and a combined payroll of $67.8 billion. This ranks travel and tourism as a leading private employer, second only to health services.

It can be argued that the most critical of these four divisions is the carrier sector. Without transportation, suppliers have no customers, intermediaries have nothing to retail, and destination marketing organizations cannot attract visitors.

Moreover, transportation companies comprise important components of the supplier sector as well. These include car rental companies, taxicabs and airport limousine services, ocean cruise liners, local land and water sightseeing companies, and river and lake water passenger transportation carriers. These companies help attract and serve travelers, work with other components of the industry to market their products, and contribute economic benefits to the nation, regions, and states.

Finally, intercity travel by personal motor vehicle produces more passenger-miles than all of the carriers and transportation suppliers combined. Many destinations are virtually inaccessible except by automobile, truck, or recreational vehicle. The industry has a vested interest in the characteristics of the nation's highway system and the service levels of businesses such as gasoline service stations and auto repair garages.

Because the travel industry is a composite of a large number and varied set of activities in the economy, it does not fit the traditional industry definitions used by federal agencies in collecting data. However, it is possible to identify those businesses that service the traveler using the Standard Industrial Classification (SIC) system. A list of SIC codes that comprise the travel and tourism industry is provided in Table 1.

Data Needs

Suppliers, intermediaries, and destination marketing organizations, as well as the carriers themselves, continually seek comprehensive, current, and accurate information on the conditions, service levels, performance, and economic characteristics of the carriers. This information is used for a variety of purposes, including measuring usage of transportation systems and adjusting service levels, forecasting future demand and planning for expansion, preparing for contingencies such as congestion and system failures, preparing economic development programs, and developing beneficial public policies. In addition to these industry-type data, these groups also seek data on trip and traveler characteristics, which are used to develop marketing programs and monitor the results, as well as to seek cooperative marketing partners.

Travel spending also generated a combined total of $39.5 billion in federal, state, and local tax revenue in 1988. The travel and tourism industry (including its transportation component) has played a substantial and dynamic role in the long-term growth of the American economy. Increasingly, government at all levels is recognizing the significance of this industry to economic development strategies and its value as an economic tool for revitalizing rural communities and small businesses. This recognition is generating additional need for specific information, essential to the development of public policy, which will foster travel's continued growth.

The outlook for travel and tourism in the coming decade and beyond is generally positive. Even in the slow growth economy some predict for the 1990s, demand for travel and, thus, transportation is likely to continue to expand. Government estimates suggest that airline travel growth should be approximately 5 percent and intercity automobile traffic about 2 to 4 percent annually in the years ahead. Moreover, increased global interdependence is expected to generate additional business and leisure travel to and from the United States.

U.S. Travel and Tourism Industry

The US Travel Data Center has adopted the following definition for the travel industry:

> an inter-related amalgamation of those businesses and agencies which totally or in part provide the means of transport, goods, services, accommodations, and other facilities for travel out of the home community for any purpose not related to local day-to-day activity.

The travel and tourism industry can be broken down into four primary sectors: (a) suppliers, (b) carriers, (c) intermediaries, and (d) destination marketing organizations.

TABLE 1 SIC CODES USED TO DEFINE THE U.S. TRAVEL INDUSTRY

Travel Category	Type of Business (SIC code*)
Transportation	
1. Air	Transportation by Air (45)
2. Taxicab/Limousine	Local and Suburban Passenger Transportation and Taxicab Companies (411-412)
3. Automotive Operation	Gasoline Service Stations (554)
4. Automotive Ownership	Automotive Dealers (55 except 554 + 555)
5. Auto Rental	Passenger Car and Recreational Vehicle Rental (7514 + 7519)
6. Bus/Motorcoach	Intercity and Rural Bus Transportation and Bus Charter Service, Except Local (413 + 4142)
7. Rail	Amtrak
8. Cruise	**
Lodging	
9. Hotel/Motels	Hotels and Motels (701)
10. Camping	Recreational Vehicle Parks and Campsites (703)
11. Own Second Home	Building Materials, Hardware, Garden Supply, and Mobile Home Dealers (52)
Other	
12. Entertainment/Recreation	Amusement and Recreation Services (79)
13. Meals	Eating and Drinking Places (58)
14. Incidental Purchases	General Merchandise and Miscellaneous Retail Stores (53, 59)
15. ***	Arrangement of Passenger Transportation (472)

* Standard Industrial Classification codes, as established by the U.S. Office of Management and Budget, 1987.
** The impact of this spending in the average state is included in arrangement of passenger transportation (472).
*** No separate expenditures are identified with this category, since they are included in others, such as air transportation, cruise transportation, and hotel/motel lodging.

Source: US Travel Data Center

Suppliers provide the hospitality, entertainment, and recreation services that travelers seek. Carriers provide transportation to and from the destination. These include airlines, intercity bus companies, and Amtrak. Intermediaries, usually travel agents and tour operators/wholesalers, package and sell supplier and carrier services to consumers. Destination marketing organizations are usually government or nonprofit agencies that promote their areas to consumers. The U.S. Travel and Tourism Administration (a federal agency), the Maryland Office of Tourism Development (a state agency), and the Washington, D.C. Convention and Visitors Association (a nonprofit association) are representative of these organizations.

It is virtually impossible to distinguish the travel and tourism information needs of the private sector from those of the public agencies. The state and city travel development agencies depend on the services of suppliers, carriers, and intermediaries to stimulate economic development, prevent supply distortions, and generate tax revenue. Such agencies also need data to educate state legislators and departments of transportation on the economic significance of the travel industry in their geographic area. They also require information to evaluate proposals from the private sector regarding transportation systems. For example, Florida, Ohio, Texas, and Nevada all have funded studies on the potential of high-speed rail.

Consequently, these agencies work closely with private sector travel and tourism interests to obtain, analyze, and learn from research on America's transportation system. In short, better information on intercity passenger transportation is good public policy no matter who the initial data user is.

NATIONAL STRATEGIC PLANNING AND POLICY ISSUES

Major strategic and policy issues related to transportation data to be considered in the development of a national transportation policy include

1. What should be the role of the U.S. Department of Transportation (DOT) and other federal agencies in transportation data collection and dissemination?
2. What do federal and state officials need to know to formulate appropriate public policies?
3. What does the travel industry's private sector, as well as states and other destinations, need to know to efficiently service its existing traveler market and attract additional visitors?

DOT focused on issues related to these questions in its report, *Moving America—New Directions, New Opportunities. Volume 1: Building the National Transportation Policy.* This report and others identify the need for transportation data to

- Forecast and assess prospective demand and evaluate alternative responses to plan and operate an efficient and safe transportation system;
- Determine the level of investment needed in infrastructure and identify possible funding sources;
- Provide for the study of new technologies and substitutions between modes, for example, intercity air and rail technology (e.g., maglev); and
- Make informed and fair energy, tax, and regulatory policy decisions with regard to transportation.

More specific to travel and tourism, data are required to

- Increase recognition that transportation serves multiple purposes and markets, and to emphasize the need for comprehensive transportation planning rather than simply commuter-related planning;
- Recognize and understand the difference between business and leisure travelers regarding what they will pay for and what type of services they require;
- Understand the uniqueness of markets and that different transportation solutions will be required;
- Realize and encourage the benefits of travel-related economic development;
- Facilitate the continued growth in international arrivals (which contribute significantly to the balance of trade) and the development of a transportation system that can bring them to the United States efficiently and at a competitive price; and
- Support the scenic byways concept and rural tourism.

Three workshops on urban, statewide, and national data and information needs held during the October 1989 TRB conference, as well as a series of cluster groups, all identified the need for a strong government role in support of transportation research, development, demonstration, and deployment of alternative solutions that would extend into the 21st century. The major objectives of the national transportation policy now being developed are economic growth and enhanced quality of life for U.S. citizens. Travel and tourism will continue to contribute significantly to the achievement of these two objectives. The data resources needs of the travel industry should, therefore, be carefully considered in the development of this policy.

INFORMATION SOURCES

Federal Government Sources

The travel and tourism industry relies heavily on federal transportation data collection efforts. Beyond the national transportation policy and planning studies identified elsewhere in this Record in the paper on surface passenger transportation, there are a number of other national transportation-related information resources of particular value to the travel and tourism industry. Recent inventories have identified several federal agencies, as well as other organizations, now providing such data. These data are of two basic types: (a) industry-level data covering measures of company condition, performance, and passenger volume and (b) user characteristics. The most important of these data sources to travel industry officials follows.

Industry-Level Data

U.S. Department of Commerce *Bureau of the Census: Census of Retail Trade, Establishment, and Firm Size and Census of Service Industries, Establishment, and Firm Size* Conducted every 5 years, these economic census reports provide extensive industry and geographic detail on the number of establishments, business receipts, and employees for all organizations in the United States. Separate reports are also generated for state and metropolitan areas with detail provided by retail and service components, including a number of particular interest to the travel and tourism community. Unfortunately, data are not readily available on all travel industry sectors.

Bureau of the Census: Monthly and Annual Retail Trade and Service Reports These reports provide monthly and annual receipt data for a number, but not all, of the SIC codes included in the travel and tourism industry.

Bureau of Economic Analysis (BEA): Survey of Current Business This comprehensive monthly summary of national economic statistics includes a number of series of interest to the travel and tourism community. The July issue report contains the international travel and passenger fare series, recently revised to incorporate results from the U.S. Travel and Tourism Administration (USTTA) Survey of International Air Travelers.

U.S. Department of Transportation *FHWA: Highway Statistics* This annual report provides a compilation of statistics on vehicle-miles, passenger-miles, and energy consumption data covering personal passenger car, motorcycle, truck, and water transportation. It is used by state highway agencies and DOTs, local planners in metropolitan planning organizations, as well as the travel industry.

Research & Special Programs Administration (RSPA): Domestic Air Passenger Origin-Destination (O-D) Statistics With coverage since 1939, this detailed file contains 10 percent of

all passenger tickets on scheduled U.S. certificated carriers for all trips within the United States. The large data file permits detailed tabulation of point-to-point air travel counts and extensive indication of passenger demand patterns between city pairs. These data are useful for air system planning and detailed domestic carrier market planning.

RSPA: Airport Activity Statistics of Certificated Route Air Carriers This annual report contains statistics on the volume of revenue passenger traffic handled by the nation's large certificated route air carriers by each airport. Aircraft departure statistics are also included. Data are compiled from information reported quarterly to DOT by carriers using RSPA Form 41.

RSPA: Air Carrier Traffic Statistics and Air Carrier Financial Statistics These reports provide aircraft revenue miles and total operating revenue data for scheduled and nonscheduled airlines.

RSPA: U.S. International Air Passenger Statistics Conducted since 1976, this program provides country-to-country flows of air and sea passengers for U.S. citizens and noncitizens as identified on trip manifests (Form I-92) required by the Immigration & Naturalization Service. The manifest identifies date, carrier, ports of origin and destination, and counts of passengers by U.S. citizens and others. These data are useful in bilateral negotiations and other international policy functions.

RSPA (Transportation Systems Center): National Transportation Statistics Annual Report This report is a summary of selected national transportation statistics from a variety of government and private sources. Featured are cost, inventory, and performance data describing passenger operations of air carriers, general aviation, automobile, bus, rail, and water transportation. Descriptive data such as operating revenues and expenses and vehicle and passenger miles are included, as well as discussion of transportation-related trends. Data on transportation related to the economy and energy supply and demand are also included. Although these data are available in other reports, this is a comprehensive and convenient source for travel industry officials interested in transportation.

International/Territorial Air Passenger O-D Statistics Since 1947, this program has provided a detailed file of 10 percent of all passenger tickets on scheduled U.S. certificated carriers for all trips in which one or more points in the trip occur outside the 50 states. Similar to the domestic O-D system, this large file permits detailed tabulation of point-to-point air travel counts and is used for air system, airport, and aircraft planning, as well as for treaty and policy analysis.

U.S. Department of Labor *Bureau of Labor Statistics (BLS): Employment and Earnings Report* This monthly report provides employment and earnings data by detailed SIC code, including nearly all industries significant to travel and tourism. State and metropolitan level data are provided at lower levels of SIC detail.

BLS: ES202 Employment and Payroll Data Payroll and employment data are reported quarterly and annually for industry sectors at the two-, three-, and four-digit SIC code level, covering most sectors of interest to the travel industry. Data are available nationally and for each state.

Intercity Rail and Bus Data No national data bases currently exist covering intercity rail and bus. Information is available from Amtrak and Greyhound, but it may be hard to access.

Scenic Byways Data Two new bills focus on information and data needs as they relate to scenic byways. The Tourism Policy and Export Promotion Act of 1989 is designed to revamp federal tourism policy to increase inbound travel and give the industry a higher standing on the U.S. trade agenda. Part of this bill would require the study of the economic impact of scenic byways. In addition, the bill calls for more frequent publication of tourism statistics.

The Scenic Byways Study Act of 1989, to be completed in one year at a cost of $1 million, has four major parts:

1. An updated inventory of scenic byways,
2. Guidelines for a national scenic byways program,
3. An analysis of the safety and environmental implications of scenic byways designations, and
4. Case studies of the economic impact of scenic byways.

The Government Accounting Office (GAO) is also conducting its own investigation of scenic byways and will collect data on scenic road programs in 14 states. Finally, a major new study is being underwritten by Kansas, Missouri, Iowa, and Nebraska. The economic benefits of scenic byways is one of the areas being studied, along with their selection, designation, protection, and safety. The study is being conducted by Kansas State University in cooperation with the four states' transportation agencies and is discussed in more detail elsewhere in this Record in the paper on scenic byways.

User Characteristics Data

In addition to industry-level data, there are a few federally funded surveys that provide useful information on the users of transportation regarding the purposes of travel and the characteristics of the trips.

U.S. Department of Commerce *Bureau of the Census: National Travel Survey* First conducted in 1958, this survey obtained information on long-distance travel from sample U.S. households and permitted description of travel by mode of transportation, purpose of trip, and characteristics of the

traveler for broad geographic areas including a number of larger metropolitan areas, states, and regions.

Results from the last survey, conducted in 1977, were used extensively by travel industry firms and state travel marketing and promotion agencies, as well as by state transportation planners. The sample, although large enough at 20,000 households to provide fairly reliable state-level data, was still too small to allow route analysis, service planning, or other activities requiring detailed flow data. Unfortunately, and at a great loss to travel and tourism officials and analysts, the National Travel Survey was cancelled abruptly just before commencement of the 1982 survey.

USTTA: Survey of International Air Travelers (Inflight Survey) Started in 1983, this program surveys both outbound foreign visitors regarding their travel activities and expenditures while in the United States and outbound U.S. travelers regarding their anticipated activities and expenditures while abroad. These data support marketing and analysis programs of USTTA and other agencies and are also used for international trade statistics in the national accounts.

Further, the data set is frequently used by state and local travel development agencies, as well as the private sector, for market analysis. Using data from this survey and its Travel Economic Impact Model, the US Travel Data Center has estimated foreign visitor expenditures and economic impact by state and industry sector (including transportation) for 1983 and 1985–86. A similar analysis is now being prepared for 1987.

U.S. Department of Transportation The Nationwide Personal Transportation Survey (NPTS), conducted by FHWA, is a national household travel survey covering all trips made by U.S. households for local and long-distance purposes by all modes of transportation. Given the demise of the Census Bureau's National Travel Survey, the NPTS is now the only continuing national survey of personal travel at the federal level.

Conducted in 1969, 1977, and 1983–84, the next survey is scheduled to begin in early 1990 and will include telephone interviews with 20,000 households. The emphasis of this survey, however, is on short-distance trips with only a limited long-distance travel component. Further, because of budget constraints, the long-distance component may be reduced more significantly than originally intended. These data are used by researchers and policy development staffs at the local, state, and federal level, as well as by the private sector, to analyze travel patterns over time.

U.S. Department of Labor The BLS Consumer Expenditure Survey is a continuing survey of a national sample of U.S. households designed to collect information on all expenditures. Currently, the survey includes approximately 4,800 interviews per quarter and 10,000 weekly diaries from 5,000 household units. Long-distance nonbusiness travel is covered in the survey, and extensive information on travel and expenditures away from home is collected. The data collected from this survey, particularly the trip data, have not been adequately tabulated or analyzed. The potential of this survey as a source of travel consumption behavior data, however, is substantial.

Table 2 summarizes the key data elements describing trip and traveler characteristics included in the four surveys previously described.

State Government Sources

Major sources of data provided by state DOTs are covered in other papers in this Record, such as those on surface passenger transportation and scenic byways.

State travel offices are another state government data source that is of particular value to the travel and tourism industry. The governments in the 50 states and U.S. territories fund agencies responsible for travel promotion and development. Although the responsibilities, structure, and resources of these offices vary and focus primarily on marketing their destinations, most have some ongoing research efforts. With total budgets ranging from $1.4 million to $22.5 million and averaging $6.8 million per state in 1989–90, state travel offices now spend an average of $129,000 on research, or only about 2 percent of their total budgets.

The 1989–90 edition of the *Survey of State Travel Offices*, conducted by the US Travel Data Center, indicates that most states now have ongoing travel data gathering programs that include transportation-related information. These programs generally involve highway traffic counts, counts and surveys of highway welcome center visitors, monitoring of airline arrivals, and systems to track attendance at state facilities and private attractions.

In addition, a number of states conduct research to determine visitor profiles describing trip and traveler characteristics (including origin and demographics), to measure advertising effectiveness, and to collect economic impact-related data such as traveler expenditures and state and county travel-industry related tax revenues (i.e., lodging), as well as estimates of employment, payroll, and tax revenue generated through travel and tourism to and within the state. The table below lists the types of research most frequently conducted by state travel offices in 1989–90:

Type of Study Conducted	*Number of States*
Advertising effectiveness/conversion study	34
Economic impact	31
State visitor profile	21
Consumer attitude/awareness/image studies	20

State travel office research is most often conducted by state universities or private sector research firms. In some cases, the research is conducted by other state agencies.

Other Data Sources

US Travel Data Center

Probably the best source of national-level travel data (including coverage of transportation-related issues) is the US Travel

TABLE 2 DATA ELEMENTS IN THE DOMAIN OF TRAVEL AWAY FROM HOME

	Federal Surveys			
	CES	NPTS	SIAT	NTS
Measures of volume				
Travel (travel parties)	—	X	X	X
Person-trips	—	X	X	X
Person-nights	—	X	X	X
Person-miles	—	X	—	X
Measures of incidence				
Number of households taking one or more trips				
In a year	—	X	—	X
In a multiyear period	—	—	—	X
Number of residents taking one or more trips				
In a year	—	X	—	X
In a multiyear period	—	—	X	—
Trip characteristics				
Transport mode	—	X	X	X
Purpose				
Primary	—	X	X	X
Secondary	—	X	—	—
Type of lodging	—	X	X	X
Distance				
Straight-line	—	X	—	X
Circuity	—	X	—	—
Duration				
Total	—	X	X	X
At destination	—	—	X	X
By lodging	—	—	X	X
By state	—	—	X	X
Destination				
Country				
U.S.	—	X	X	X
Foreign	—	X	X	X
State	—	—	X	X
Multistate region	—	—	X	X
Metropolitan statistical area	—	—	X	X
City	—	—	X	—
County	—	—	—	—
Travel party				
Size	—	X	X	X
Composition	—	X	X	X
Booked through travel agent	—	—	X	X
Rented automobile/truck/RV	—	X	X	X
Package tour	—	—	X	X
Timing				
Day/month trip began	—	X	—	—
Day/month trip ended	—	X	—	X
Occasion				
Weekend	—	X	—	X
Vacation	—	X	X	X
Activities				
Recreation	—	—	X	X
Places visited	—	—	X	X
Brand purchased	—	—	X	—
Expenditures				
Total	—	—	X	—
By item	—	—	X	—
Traveler characteristics				
Relating to household				
Income	X	X	X	X
Size	X	X	—	X
Family structure	X	X	—	X
Housing tenure	X	X	—	X
Number of wage earners	X	X	—	X
Credit card ownership	X	—	—	X
Residence				
Multistate region	X	—	X	X
State	X	—	X	X
Metropolitan statistical area	—	—	X	X
City	—	—	X	X

TABLE 2 (*continued on next page*)

TABLE 2 (*continued*)

	Federal Surveys			
	CES	NPTS	SIAT	NTS
Relating to traveler				
Age	—	X	X	X
Gender	—	X	X	X
Race	—	X	—	—
Occupation/employment status	—	X	X	X
Education	—	X	—	X
Marital status	—	X	—	X
Subjective characteristics				
Of travelers' intentions to travel	—	—	—	X
Toward destinations and services (satisfaction)	—	—	X	—

NOTE: X = data available; CES = Consumer Expenditure Survey, Bureau of Labor Statistics; NPTS = Nationwide Personal Transportation Survey, U.S. Department of Transportation; SIAT = Survey of International Air Travelers, U.S. Travel and Tourism Administration; NTS = National Travel Survey, Bureau of the Census. Much of the trip data listed above are collected by the CES but are unavailable to users.

Data Center. The Data Center was established by public and private industry organizations in 1973 to improve information available on travel and tourism to, from, and within the United States.

Following are some of the Data Center's major programs most useful to the travel and tourism community and of potential use to transportation policy analysts.

National Travel Survey (NTS) The US Travel Data Center's NTS was first implemented in 1979 to provide more current data between administrations of the Census Bureau's much larger National Travel Survey. Conducted by telephone to monthly national probability samples of 1,500 U.S. adults, the survey collects data on trip characteristics including mode, purpose, accommodations, distances, and durations for all travel 100 miles or more away from home, as well as traveler demographics. The Data Center's NTS has been used extensively by state travel offices, city convention and visitor bureaus, and the private sector to develop descriptive profile and marketing data through reports, special tabulations, and the addition of proprietary questions.

Travel Economic Impact Model (TEIM) The TEIM is a disaggregated model built upon estimates of 18 types of travel expenditures; their impact on 14 types of travel-related businesses (including transportation) at the retail level; and the resulting business receipts, employment, payroll, and tax receipts. Developed by the Data Center in 1975, it provides the only consistent, comprehensive, annual estimate of travel spending and its contribution to local, state, and national economies. Since its development, the TEIM has been used by the Data Center to prepare more than 175 studies for a total of 34 states, covering over 2,600 counties and cities. The model is currently being revised under contract with USTTA to improve the estimates, incorporate international visitor impact, measure the indirect effects of tourism spending, and provide forecasts of travel expenditures for states and regions.

Travel Price Index The Travel Price Index (TPI) was developed by the Data Center to measure changes in the cost of travel away from home for U.S. consumers. It is based on U.S. Department of Labor price data collected for the monthly Consumer Price Index (CPI). The CPI is a measure of the average change in prices paid by urban consumers for a fixed collection of goods and services. It is representative of the buying habits of about 80 percent of the noninstitutional population of the United States. Since it is based on the CPI series incorporating a fixed set of weights, the TPI does not necessarily represent changes in the average fares, rates, and other prices travelers actually pay. Further, only national data are available.

Other

One other useful source of transportation-related data used by the travel industry is the Eno Foundation for Transportation's *Transportation in America.* Published since 1980, this statistical analysis of transportation in the United States is a compilation of data from other sources and includes estimates for unavailable data. The report includes data on intercity travel by mode, intercity passengers carried, and intercity transportation mileage.

DATA GAPS AND PROBLEMS

Despite the large number of data sources regarding transportation and travel/tourism, a number of gaps and problems have been identified by both the providers and users of this information. These fall under four major categories: (a) research orientation and priorities, (b) research methodologies, (c) data coverage, and (d) data products. Each of these is discussed in greater detail below.

Research Orientation/Priorities

Travel and Tourism Not a Priority Issue

Data systems useful in describing and monitoring travel away from home in the United States are inadequate, especially

considering the significant contribution made by this industry to the U.S. economy. Other industries, such as agriculture, are fortunate to have more comprehensive data, despite their smaller size. The general weakness of data on the service sector of the U.S. economy exacerbates this problem in that statistics on many of the SIC codes considered a part of the travel industry are not collected and published regularly.

Moreover, much of the data useful to the study of travel, especially at the federal level, are collected as either a by-product of an administrative program, for system financing or planning, or for regulatory reasons. Thus, the specific informational needs of the travel industry are not usually considered and are often not met. Many observers and analysts, including participants in the cluster groups, have noted the general lack of data on long trips.

Limitations/Reductions in Data Collection

While significant transportation data resources do exist within the federal system, there are substantial weaknesses in data covering travel and tourism. In particular, data are lacking that go beyond the descriptive and into the levels of detail needed for more sophisticated analysis and marketing purposes.

Deregulation has changed both the structure of transportation industries and the statistical reporting system used to measure them. In the past, regulatory agencies have provided aggregate statistics for major components of the transportation industry. Under deregulation, many data collection programs have been reduced or discontinued. Deregulation has also made it increasingly important, yet difficult, to maintain establishment level, revenue, and pricing data.

There has also been a deemphasis on data collection at the federal level as a result of policy changes created by budgetary restraints and the goal of reducing the reporting burden. Many programs generating travel and tourism information have been affected.

These changes in federal data collection efforts resulted in a marked decline in U.S. travel statistics at the federal level during the 1980s. The Census Bureau's National Travel Survey has been cancelled indefinitely, the National Recreation Survey was cancelled for 1987, and the NPTS has been cut in design and delayed in planning.

Cancellation of the National Travel Survey

The greatest loss in the collection of data of direct value to measuring and monitoring travel and tourism was the cancellation of the National Travel Survey conducted by the Census Bureau. As previously described, this survey provided the only source of travel volume and characteristics data comparable across all states and consistent across time; it was of vital importance to the travel and tourism community.

Although the US Travel Data Center's NTS is similar in purpose and designed to replicate as closely as possible the definitions, question areas, and methodology of the Census Bureau survey, it was never intended to replace it. Rather, it was intended to provide more timely information between the conduct of the larger sample benchmark surveys of the Census Bureau.

Lack of Exchange Between Transportation and Tourism Industries/Lack of User Input

Although improvements have been noted recently, there has been a serious lack of communication between providers and users of data in the transportation and travel communities. This helps explain the weakness in transportation-related data regarding travel and tourism and is an area where attention to the problem could generate substantial positive results at minimal cost.

Lack of Integration Among Various Agencies

Lack of communication and integration among the myriad agencies now producing transportation data has also been frequently noted. Duplication of effort and unfilled data gaps have been the result.

Research Methodologies

Small Sample Sizes

Given the time and expense involved, sample surveys are often too small for their intended purpose. Although the sample sizes for surveys dealing with travel, such as the Census Bureau National Travel Survey and the NPTS, appear quite large and able to provide reliable results at the national level, they are often too small to allow for the specific geographic and sector segmentation required for federal and state policy formulation or to be of value to the travel industry.

Quality of Data

Regulatory agencies' data collection tends to be of high quality. Deregulation has resulted in greater dependence on other data providers such as trade associations and private organizations. The quality of these data varies depending on the level of skill and resources available.

High quality data are essential to adequately describe both transportation and travel. Just last year, it was learned that international travelers are spending substantially more money (an additional $12.4 billion) in the United States than previously estimated. The travel deficit is now calculated to be $2.9 billion, versus $7.6 billion using the previous method. This change, of course, also improves the current account balance. These new estimates were computed by BEA based on the USTTA Survey of International Air Travelers. Previously, estimates were based on a less accurate survey. This situation is a good example of the negative effects of inadequate travel/tourism data.

Lack of Time Series/Lack of Continuity

Time series data are essential to track transportation and travel trends, as well as to keep data collection systems responsive to current and anticipated issues and informational needs. Travel-related data systems have not fared well in this

regard, as evidenced by the cancellation of the National Travel Survey and rather sporadic conduct of other surveys of key importance. To address emerging data needs, data collection efforts must balance the need for consistency with the need for flexibility in modifying methods, questionnaire content, etc.

Lack of Standardization

There has been a lack of standardization of terms, statistics, and categories used to measure transportation usage and travel. This is reflected in the lack of coordination of state data collection efforts in both the more traditional DOT-type programs and those dealing specifically with travel.

Since its establishment, the US Travel Data Center has concentrated on the development of standard definitions and research methodologies for use in travel-related research and has encouraged their adoption. Yet, despite the acceptance of this standardization by many private sector and state government travel entities, there continues to be a fairly large number of studies that depart from this standardization, making it difficult to compare travel-related statistics across localities or industry sectors.

Confidentiality Constraints

Because of confidentiality constraints on the publication of federal statistics, data are often unavailable for specific geographic areas. Although the detailed type of flow analysis data required for transportation planning are usually available, it is often impossible to obtain demographic data describing travelers by specific origin and destination. This type of information is crucial for state and local tourism officials.

Studies Often Mode-Specific

Federally sponsored studies are often confined to a single mode of transportation. Intermodal and multimodal alternatives often cannot be investigated through such research. At a time when alternate solutions to transportation infrastructural problems (i.e., high-speed rail) are being seriously investigated, this emphasis on mode-specific research is both inadequate and inappropriate.

Data Coverage

Unmet Data Needs

Table 3 presents a matrix indicating the current state of information available on various characteristics of passenger transportation modes most likely to be frequented by travelers away from home. This matrix was developed from the US Travel Data Center's perspective in working with public tourism development agencies and private carriers, suppliers, and intermediaries.

The unmet information needs at state and local levels tend to be greater than at the national level, yet the value of data

TABLE 3 TRAVEL AND TOURISM TRANSPORTATION DATA NEEDS MATRIX

Transport Mode	Company Condition[a]	Performance[b]	Passenger Volume[c]	User Characteristics[d]	Comments
Commercial airlines	+	+	+	0	Form 41 data comprehensive at national level
General aviation	—	0	—	0	Very little known about activity
Intercity rail	+	+	+	+	Amtrak gathers complete data
Ocean cruise lines	—	—	—	—	Trade association gathers some information
Rental cars, trucks, RVs	0	0	—	—	Some information from Census of Business
Rivers/lakes water passenger transportation	—	—	—	—	No consistent information available
Scheduled intercity bus	0	0	0	—	ICC reports on Class I carriers only
Sightseeing services	—	—	—	—	No consistent information available
Taxicabs/airport limousines	—	—	—	—	No information available
Tour operators	0	0	—	—	
Tour/charter bus	—	—	—	—	No reliable information available
Travel agents/tour operators	0	+	0	0	Some Census of Business data, airline reports, industry surveys

NOTE: + = ample information available at least annually; 0 = some information available periodically; — = little or no reliable information available.

[a]Includes revenue, expenses, employment, payroll, taxes paid.

[b]Includes revenue per passenger-mile, cost per passenger-mile, cities served, weekly service, productivity, load factors, capacity.

[c]Includes passenger-miles, origin-destination flows, passengers.

[d]Includes volume, demographics, and other characteristics of personal users and business users.

to rational economic development and industry planning is no less. As international travel to and from the United States continues to grow more rapidly than domestic tourism, understanding of the conditions, characteristics, and performance of the carriers serving these travelers, as well as the characteristics of the travelers themselves, needs to be improved. This matrix of information needs is submitted for serious consideration in the current national transportation policy study.

Weaknesses in the SIC Code System and Related Data Collection and Reporting

Despite the 1987 revision of the SIC code system, which generally improved coverage of the travel industry, weaknesses still remain. Many of the improvements were based on recommendations made by data users in the travel industry, including the US Travel Data Center. Yet, other improvements are still needed that were recommended but not made in the last revision.

In addition, industry-level data on numbers of establishments, business receipts, payroll, and employment for many components of the travel industry are still lacking. The following industries, for example, are not covered in the censuses of retail trade and service industries:

- Group 412: taxicabs;
- Group 413: intercity highway passenger transportation;
- Industry 4142: passenger transportation charter service, except local;
- Industry 4481: deep sea transportation of passengers, except by ferry;
- Industry 4489: water transportation of passengers, not elsewhere classified (airboats, excursion boats, sightseeing boats, water taxis, and passenger water transportation on rivers and canals);
- Group 451: air transportation (scheduled) and air courier services;
- Group 452: air transportation (nonscheduled);
- Group 458: airports, fields, and terminal services;
- Group 472: arrangement of passenger transportation;
- Industry 4624: travel agencies;
- Industry 4725: tour operators; and
- Industry 4729: arrangement of passenger transportation, not elsewhere classified.

Publication of these data by state, as well as by county and metropolitan statistical area, would be most useful to the travel and tourism community and those who study it.

Further, data collected through the economic censuses and other sources do not cover firms without employees. In an industry such as travel, which is dominated by small businesses, this is a significant data weakness resulting in underreporting of its economic significance.

Frequency of Certain Data

Annual sales/receipts data are currently not available for a number of SIC codes covering major components of the travel industry. These include water transportation (SIC 44), railroad transportation (SIC 40), and nonscheduled air transportation (SIC 452).

Weakness of Rail and Bus Data

There is a lack of national data collection and reporting of information for the passenger rail and intercity bus industries. Although data are available from Amtrak, and more recently from Greyhound, they are not integrated into the federal data collection systems and are not easily accessible.

Lack of Information on Other Aspects of Travel

Both the federal government and the travel industry require data beyond counts and flows to facilitate planning and ensure a safe and efficient transportation system in the future. Travel industry firms and destination promotion agencies also require additional information to better market their products and services and satisfy the traveling public. For example, more comprehensive national and geographically specific data are required on traveler characteristics, decision making, consumer attitudes, perceptions, travel expectations, and satisfaction. Research is also lacking on how travel and transportation usage affect other parts of the nation's economy, the environment, and society as a whole, in terms of both benefits and costs.

Lack of Data Regarding Scenic Byways

The development of scenic byways in the United States has become a top priority, as reflected in the Scenic Byways Study Act of 1989. FHWA Executive Director Richard Morgan testified in support of this act saying, "Scenic byways and recreational travel are important to an overall transportation planning process, and we support their consideration." To date, however, there are little or no data available to either quantify the number of recreational users of scenic byways or estimate their economic impact.

Data Products

Publication Lags

Delays in publication of data (often by as much as 2 years) significantly reduce their relevance, both to federal agencies involved in policy formulation and to the various components of the travel industry. This may result in a seeming lack of interest in available data products.

Lack of Analysis and Dissemination

Many federal agencies lack the financial support to engage in in-depth data analysis and to produce the variety of data products necessary to serve the multiple and often different needs of the various levels of government interested in transportation and the travel community. In addition, inadequate

staff and lack of funding often make it difficult to obtain special tabulations of existing data sets.

No Coordinated Central Source of Data

There is no coordinated central source of federally produced, transportation-related travel data. Given the large number of federal agencies producing data and the lack of communication among these agencies and among data producers and users, a coordinated central source would be a most welcomed service.

RECOMMENDATIONS

The following recommendations are based on an assessment of the gaps and problems related to transportation travel data. In addition, recommendations made by members of the cluster groups have been incorporated. Many of these recommendations reflect an implicit understanding of the importance of travel (as defined in this paper) to transportation issues and a recognition of the data needs of the travel and tourism industry.

Research Orientation/Priorities

Travel and Tourism a Priority Issue

Travel and tourism, the nation's third largest retail industry and its second largest private employer, needs to become a priority industry for statistical coverage in future federal agency programs. Now that travel and tourism is recognized as the largest export business in the United States, it behooves the entire federal establishment to take the industry more seriously. The national transportation policy should acknowledge the importance of the movement of people, not just that of vehicles. In keeping with one of its major objectives—that it be market driven—the policy should promote research not only on technology but on travel characteristics and patterns.

Increased Funding

In these times of high budget deficits, it may be difficult to obtain additional funding for federal data collection efforts related to travel and tourism. However, when additional funding is sought, the travel industry could again be mobilized to support funding requests for research efforts at the federal level.

Other funding sources should also be considered. For example, federal agencies should encourage public/private partnerships and investigate the possibility of the private sector providing "seed money" for transportation and travel-related research. Higher data user fees might also be considered as a means of financing collection and dissemination efforts.

Methods for making the most efficient use of research funding should also be addressed. For example, federal agencies should investigate whether data collection efforts can be more cost-effectively undertaken by the private sector, as is now being done with the NPTS. In addition, existing, ongoing research programs in the private sector or academia that could be expanded and modified to meet federal data needs should be identified and considered as possible research vehicles. This would serve not only to stretch limited federal funds but to help ensure the data are applicable to the needs of the transportation and travel community.

National Travel Survey

The top priority of the travel and tourism community, with regard to federal research programs, is the reinstatement of the Census Bureau's large-scale National Travel Survey. If, as has been suggested, the long-distance component of the NPTS is cut, the National Travel Survey will be more critical than ever.

Reinstatement of the National Travel Survey is supported by a number of key national travel industry groups, including the Travel Industry Association of America, the US Travel Data Center, the Travel and Tourism Government Affairs Council, the National Council of State Travel Directors, the Congressional Travel and Tourism Caucus, and the Travel and Tourism Research Association, as well as several regional, state, and local groups.

Transportation/Tourism Exchange

Improvements in communication among researchers and data users in transportation and travel should be encouraged. Attendance at major travel research meetings, such as those held by the Travel and Tourism Research Association and the US Travel Data Center, by those responsible for transportation data collection would be appropriate and useful. Similarly, travel researchers and data users should consider attending major transportation-related meetings such as those sponsored by TRB.

Interagency Working Group(s)

Interagency working groups comprised of those responsible for various transportation data collection efforts should be established and encouraged. This will help ensure that data programs are not artificially constrained by any particular program area, alleviate duplication of effort, fill current data gaps, and support multimodal transportation development efforts. One suggestion would be to have OMB head up an interagency working group that would meet on a regular basis.

User Groups

DOT and other federal agencies should establish industry advisory boards/user groups for research efforts on all transportation modes (including representatives from the travel industry). The value of current data resources could be considerably enhanced by the involvement of data users who are more knowledgeable about the needs of the transportation and travel industries. A survey of such users, similar to one

conducted by TRB in 1981, might also be useful. Meetings of these user groups with interagency working groups would also be appropriate and beneficial.

University Research Efforts

The federal government should consider providing greater support to universities for transportation-related travel research. In addition to research, universities will produce tomorrow's research professionals. Further, the base of researchers in the field should be expanded to avoid dominance of a few players and to bring in other disciplines that can make significant contributions to this area.

Research Methodologies

Increased Sample Sizes

The value of the previously discussed surveys to both transportation and travel officials would be considerably enhanced by larger samples. Because this may be costly, alternative methodologies should be considered and tested. It would also be helpful to the research community at large if the results of such experimentation with new methodologies were shared with other transportation and travel researchers.

Time Series Data

As previously discussed, time series data are critical to tracking transportation and travel trends and are critical to provide program continuity over an extended timeframe. Further, data collection systems must be flexible enough to respond to emerging transportation and travel industry needs. An appropriate balance of consistent data series and flexibility should be sought in all data collection efforts.

Standardization

Standardization of definitions and research methodologies should be encouraged at all levels of government, as well as within the private sector. The interagency working groups and user groups could help considerably in achieving this objective.

Confidentiality Constraints

Although the need for confidentiality in the release of data is clearly understood, consideration should be given to ways in which these constraints might be relaxed to provide more complete dissemination of existing data to users.

Multimodal Research

Federally sponsored studies should include simultaneous investigations of all modes of transportation. Given the increasing interest in alternative transportation systems to help alleviate traffic congestion, such as high-speed rail, the need for such multimodal studies will no doubt increase rapidly in the near future.

Data Coverage

Improvements to the SIC Code System and Related Data Collection Efforts

From the travel and tourism industry perspective, there are two general principles that should guide any additional improvements to the SIC code system. These include

1. Establishments primarily providing passenger transportation and related services should be distinguished from those primarily providing comity transportation and warehousing.
2. Establishments primarily providing intercity passenger transportation and related services should be distinguished from those primarily providing local transportation.

Specifically, those components of the travel industry not currently covered in the previously discussed economic censuses should be included in 1992. Further, data on firms that have no employees should also be collected.

Frequency of Data

Annual state and monthly national data covering business receipts of intercity bus companies, travel agencies, taxicab and airport limousine services, ocean cruise liners, and rental car companies should be provided.

Rail and Bus Data

A system to collect national data on passenger rail and intercity bus networks, similar to that collected for highway travel, should be considered.

Greater Coverage of Other Aspects of Travel

The national transportation policy should promote areas of research other than those that are solely technology oriented or that just produce counts and flows. In keeping with its objective to be market driven, additional data should be collected on traveler demographics and psychographics, as well as on transportation's and travel's relationship to the nation's economy, environment, and quality of life.

Regional Needs

Greater attention should be given to the collection of data to meet regional and state needs. Regional studies would contribute much to investigation of the usage of intercity corridors, as well as being useful in encouraging private sector investment. State and local travel officials should be involved to provide input about their unique data needs. At the same time, to relate to national planning and policy needs, such research must be tied to national system priorities.

Scenic Byways

Current or planned research on the use and economic impact of scenic byways will assist those responsible for developing and monitoring the scenic byways system. These recent efforts are likely to increase recognition of the need for better data describing travel and tourism. For example, when introducing the Scenic Byways Study Act in June 1989, Senator Rockefeller testified, "The desire to hit the road has made travel and tourism the fastest growing industry in the country." Other proponents of the act have made similar statements.

Additional research efforts will obviously be needed as this system is implemented. Consideration should be given to utilizing current methodologies, such as the US Travel Data Center's TEIM, in monitoring this effort. Besides being cost effective, such a strategy would help ensure comparability of results across geographic areas and consistency over time.

Data Products

More Timely Release of Data

Improving the timeliness of government data should be a top priority. This would help enhance both their relevance to and their use by transportation and travel researchers.

Improved Analysis and Dissemination of Results

It is unfortunate and wasteful that much of the data collected remain relatively underused because of inadequate analysis, lack of dissemination, and the unwillingness of many agencies to respond to requests for special tabulations. For example, a series of special reports prepared a few years ago based on data from the USTTA Survey of International Air Travelers and covering foreign visitors has not been updated. Further, given today's PC-based office environment, all data resources should be available in an easy-to-use format on diskette.

Greater Support for the Consumer Expenditure Survey

The Consumer Expenditure Survey offers high potential as a source of data for the travel industry. The program should be maintained as currently designed but should be adequately funded to provide access to the long-distance trip data collected, as well as the more in-depth tabulations and analyses required to enhance its usefulness. Even in these times of budgetary constraints, it makes little sense to spend large amounts of money funding the conduct of research without making adequate financial provisions for full utilization of the results.

Greater Support for the Survey of International Air Travelers

Greater financial support should be given to the USTTA's program of research. Given the significant increase in international visitation to the United States and its tremendous potential, data on this sector are in great demand. Efforts to make this information more readily available to those involved in planning efforts and in marketing the travel product to the foreign market have been thwarted by inadequate staff and financial resources.

Establishment of a Clearing House

The paper on surface passenger transportation in this Record recommends the establishment of a national data center for strategic planning and decision making. Such a center would provide for the standardization of geography, definitions of terms, travel and performance measures, and computer systems. It is further recommended that data needs of the travel industry be considered when establishing such a center.

The center should also provide training in the use of federal data systems as they apply to transportation and, specifically, travel and tourism, perhaps through seminars at tourism-related conferences. In addition, existing inventories of federally produced data products should receive much wider dissemination.

At the July 1989 conference at the National Academy of Sciences, William Johnston of the Hudson Institute stated, "The national transportation policy must understand the need to collect sufficient data to document and quantify the scale and scope of transportation needs. Typically, what gets measured gets fixed."

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Safety Data Needs, Resources, and Issues

RICHARD M. MICHAELS

Two concepts of safety in transportation are presented. One is termed the "system design" definition and the other is the "casualty" definition. A discussion of accident statistics is provided, along with a look at the conceptual structure of safety data systems. Accident mitigation efforts are analyzed, and safety data needs are discussed. It is concluded that safety is an essential criterion of the effectiveness of all transportation modes. A more consistent and coherent safety policy would require more sophisticated data bases than are currently used. However, if they were employed, limited resources could be allocated more effectively and all modes could be measurably improved.

Data are required for safety policy purposes to achieve three objectives:

1. Safety investment decision making,
2. Safety program evaluation, and
3. Rationalization of regulatory policy.

The first objective is concerned with program initiatives necessary to improve the safety performance of the mode. What data are essential for the Office of the Secretary of Transportation (OST) to evaluate proposed initiatives and the resources required to implement cost-effective safety programs?

The second is concerned with the data required to evaluate the performance of the modes and their safety programs. What data, functional and economic, are essential to determine the cost effectiveness of such programs after implementation?

The third is concerned with the role of the U.S. Department of Transportation (DOT) in regulating transportation modes to increase or ensure safe performance. What data are needed to rationalize and justify imposition, relaxation, or extension of the safety design or operational regulations of the various modes?

At present, a wide range of data has been collected by the modal agencies within DOT and other public and private agencies with a stake in transportation safety. Relatively little of the safety data is useful for policy purposes as defined here. This is true because there has been and continues to be a basic confusion of definitions of safety and a basic unwillingness at the policy level to confront the measurement problems inherent in those definitions. Both have led to frequent misallocation of resources and an inability to evaluate the cost effectiveness of safety programs.

The purpose of this paper is to review the definitions of safety and develop an operational framework from which the data required to satisfy the policy goals outlined above may be derived. The paper is divided into three sections. One is devoted to safety constructs. A second is devoted to the operational priorities deriving from those constructs. The third is the information required for policy making and analysis.

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ALTERNATIVE CONCEPTS OF SAFETY IN TRANSPORTATION

The concept of safety in transportation has had a long history. It has had two levels of meaning, one reactive and the other rational. The first reflects the response to a real or perceived threat in the interaction between mechanical systems and users or operators. The threat derives in part from the uncertainty about the systems and their potential for harm, in part from their scale relative to users, and in part from direct and vicarious experience with those systems. People thus respond with the same variety of emotions that they exhibit for natural events that are or appear to be beyond their control.

The rational meaning has emerged as a response to system design and its economic consequences. The driving force has been to create mechanical systems that produced wealth for producers and consumers. Engineering, theoretical or empirical, was the vehicle for generating the systems that produced this wealth. The limitations of design engineering, however, produced systems that were frequently unreliable and often poorly adapted to user capabilities and limitations, physical and psychological. Inherent, then, in the design of systems was a willingness to accept a risk of failure, including harm to users and operators.

One of the consequences of this evolutionary engineering was that it led to an externality in which the reactive and rational converged to create a unique definition of safety. This has been tort law and the concept of negligence. In the occurrence of harm to users and operators of mechanical systems, who is responsible and who must recompense a "victim"? This is an issue that has come to be a hallmark of industrial societies. Liability insurance, the legal profession, and the courts have become the subculture responsible for managing the resolution of damages done by transportation engineering.

For this social mechanism to function, it must focus on a specific event that has been the "accident." It must determine the "cause" of accidents as a basis for adjudicating negligence. It has accomplished this through accident investigation, reconstruction, and analysis. It has, as a consequence, defined safety as a casualty event.

Out of this history have arisen two different definitions of safety, which have consistently been confused. One comes from the systems engineering tradition, which defines safety

as the performance accuracy and reliability of the system and its component elements. Its focus is on component and systemic performance and the analyses of their modes of failure.

In this frame of reference, safety is part of a continuum of system behavior. Damage to persons or property is derivative. The accident as casualty is the unpredictable outcome of random failure in the Baysian sense. Knowing the characteristics of the components of a system, it is possible to estimate the probability of failure. It is equally possible to evaluate the random variations inherent in system performance and estimate the probability of deviations from ideal. The system design approach thus deals not with any discrete event (e.g., accident) but with the continuum of system behavior and its performance. Failure analysis is one well-developed method for evaluating system design. Unfortunately, the more complex the system and the more empirical its design, the less reliable is failure analysis.

The second view of safety is that of a casualty event. Its focus is on the damage resulting from "accidents." This approach has developed both a conceptual structure and a methodology for evaluating accidents and developing hypotheses, structural and institutional, for reducing the effects of accidents. It has also used accident analysis as a means of determining causality. In very simple systems or those very rationally designed (e.g., aircraft), investigation of accidents has been useful in identifying component and system failures as a basis of engineering modification. In less rationally designed systems (e.g., highways), the approach has been less successful.

In sum, there are two different definitions of safety. One is the system design definition and the other is the casualty definition. Each leads to radically different analysis, data, and policy requirements. Each also leads to radically different measures for policy purposes. Both safety definitions are essential for determining programmatic effectiveness and conducting policy analysis, but they need to be treated separately for policy purposes.

ACCIDENT STATISTICS

In almost all modes of transportation, the casualty approach has been the dominant, socially acceptable frame of reference for safety. Consequently, all transportation agencies use accidents as the safety criterion. The counting of accidents provides the dominant data of safety. FHWA uses accident rates to measure each state's safety program effectiveness. NHTSA uses accident data as a basis for automotive safety standards.

Accidents as the definition of safety and the criterion for system performance leads to a series of measure issues that need to be clearly recognized. These issues are (a) data acquisition, (b) data normalization, (c) interpretation for policy implementation, and (d) evaluation of policy initiatives. Fundamentally, unless the accident measures used are rational, mathematically determinate, and reliable, they are useless for policy purposes.

The first consideration is the accuracy of the definition of accidents in the transportation system. Practically, an accident is defined in every mode of transportation by the magnitude of damage and casualty. For commercial carriers, either all accidents are reported, as in aviation, or all those over a certain dollar amount (e.g., $7,500 in rail transportation, if damage is restricted to railroad property). In all commercial carriers, significant injuries and fatalities are reported and are subject to investigation, hence such accidents are accurately counted whether they involve carrier labor or system users. Such accident data bases also allow a reasonably accurate estimation of the direct costs of the event in terms of repair and replacement. Accuracy of cost estimation drops rapidly when either indirect effects, such as time and administrative costs, or the life cycle costs of victims are considered.

In highway transportation, even the counting of accidents becomes a far more difficult problem. Only a small fraction of all accidents are reported, much less investigated. Those that are investigated are the responsibility of the criminal justice system. (This is in marked contrast to aviation, rail, and transit accidents, for which at least the carrier, and in major accidents the federal government, has technical specialists assigned to investigate and analyze such events.) The level of sophistication in accident analysis is low, as is evident in the accident report forms used. There is no medical evaluation of the victims, little evaluation of the structural damage to the vehicles, and no cost analyses. These evaluations are almost always left to the legal system and the insurance industry. Little of that process becomes part of any accident data base, especially at the federal level. Through its claims process, the insurance industry probably has more data on highway accidents and their costs than any public agency. However, these do not appear to be accessible in any form useful for policy purposes.

In sum, in highway transportation especially, accident data are unreliable and incomplete. More fundamental, however, is the fact that accidents are rare events in all modes of transportation. To describe them statistically requires the use of complex distribution functions, that is, statically as compound Poisson or dynamically as Markov processes. In essence, accident occurrence is rarely the consequence of a single event. In almost all cases, regardless of mode, several factors operating in time and space conjoin to produce the event. In most situations, these factors are unique and cannot be generalized.

Further, the occurrence of a serious injury or fatality may bear little or no relation to the cause of the accident. What happens after the initiation of the sequence that causes a vehicle to become "out of control" may not be predictable. It should be recognized that the process occurring after the event is a different operational regime, the transition describable at best by chaos theory. To use fatalities as a criterion for safety in almost any mode of transportation, either as a measure of safety or as a basis of policy, is largely futile.

Beyond the complexities of accident accounting and the temporal and spatial relations involved in their occurrence, another fundamental issue exists: exposure. In all modes of transportation, accident frequencies need to be normalized to obtain a measure of performance or risk. Three global measures of exposure have been used: (a) vehicle or passenger miles of travel, (b) population, and (c) vehicle volume. The implicit assumption behind exposure is that the probability of an accident is directly related to the amount of time spent on the system. The validity of this assumption has never been proven for any mode of transportation, certainly in the aggregate sense and especially using vehicle or passenger miles of travel. In the case of aviation, 75 percent of all accidents occur

on takeoff and landing. Passenger miles of travel clearly are no measure of this class of event. Accidents per flight operation are more relevant but obviously must be weighted by aircraft size and/or passenger load, to say nothing of airport operations and environment. On the basis of passenger miles of travel, general aviation could be expected to have a far greater accident rate than commercial aviation, even if the probability of accidents was the same. This is true simply because the number of passengers per operation is much greater on commercial flights than in general aviation, although the number of operations in general aviation is much greater.

In highway transportation, the issue is even more complicated. If exposure is really defined by time, then the vehicle miles of travel (VMT) will be in error at least by an amount equal to travel speed on any highway segment. If a trip is made using three equal roadway segments—arterial, primary, and freeway—and the travel speeds on each segment are in a ratio of 30, 45, and 60 mph and the likelihood of an accident is simply a function of time, then an accident rate using VMT should be 1.3 on the primary and 2 on the arterial relative to the freeway. This is less than observed fatality rates on the VMT basis, but considering the previous discussion, the difference is not that great.

Even if VMT is considered a legitimate exposure measure for highway and bus transportation, measurement accuracy is a problem. This is not an issue in aviation, because of federal requirements for aircraft maintenance and management. The hours flown by each aircraft are documented, even if passenger load is not. Similar but less precise data are available for railroad and transit. In highway transportation, however, VMT is estimated as an aggregate or by highway system (e.g., volume × gasoline consumption × average miles per gallon per vehicle; in special studies, average daily travel (ADT) is determined for a given highway segment). Each of these are stochastic variables, each with a different distribution function. However, each is a derived value (i.e., an annual average). No variance is defined for the product, so the reliability of the measure is indeterminate. Examining the characteristics of the individual distributions leads to the inescapable conclusion that VMT is unreliable as a measure of exposure in highway transportation. More sophisticated types of statistical analysis can be used to measure accident probabilities in specific design situations reliably. These are complex and are not currently used at the policy level.

From a policy standpoint, aggregate measures of accident rates are arbitrary and inherently unreliable when commonly used. Little evidence suggests that any of the global measures of accident rates are useful for policy purposes. There are vitally important reasons for conducting accident analyses and collecting accident data. However, attempts to measure transportation system safety on an aggregate basis, as is current practice, are highly suspect and unproductive for policy purposes. On the contrary, they may be major deflections from more operational means of improving the safety of transportation.

SAFETY: A CONCEPTUAL STRUCTURE

It was suggested earlier that there are two different domains that must be kept distinct in any discussion of safety. One concerns the engineering performance of the mode. The other concerns accidents. Each requires a different analysis framework and a different policy data base. The objectives of the two domains may be defined as follows:

- The engineering mode (the design and operation of any transportation system) is to minimize the probability of failure in its performance.
- Accident analysis is to minimize the consequences of a failure event to humans and materiel involved.

Safety inheres in the design of a transportation system insofar as the behavior of that system is predictable. There are three basic means of determining system predictability. One is through the development and application of verifiable design theory. The second is through failure analysis. The third is through understanding the higher order interactions of the components that make the system operational. In surface transportation especially, and in highway transportation in particular, none of these three requirements for the design of a safe system is met. In many of the attributes of highway transport, the failure modes are well known but cannot be eliminated cost effectively. Contrast, for example, aviation and highways under conditions of ice and snow. Significant decreases in the coefficient of friction will close airport operations, but highways close only in the most extreme situations. Yet reducing frictional contact places the controller (the driver) in the position of having to operate without knowledge of the change in vehicle response. The consequences for system performance and safety are well known.

This, of course, is an obvious example of a well-recognized failure mode. There are much more basic and subtle examples, which are not well understood or even recognized, especially in highway transportation. To a significant degree these relate to vehicular and system control, which in all modes are largely left to human operators. Since the detailed mechanisms of human control of the automobile, train, bus, or aircraft are not understood, the range of reliable performance of these systems is not predictable. This is the case partly because these systems have not been designed to match the capabilities and limitations of the human operator. In commercial aviation, compensatory and redundant mechanisms minimize the uncertainties in pilot performance. This is far less developed in the surface modes.

It is interesting to compare failure mode analysis for the command and control component of transportation systems with that for the structural and mechanical components of the systems. It is inherent in the design of every mechanical element of transportation vehicles that comprehensive failure analysis is undertaken from the design stage through test and evaluation. Airworthiness certification involves detailed failure mode evaluation. All contracts for rail transit vehicles require similar analysis as part of the procurement. Automotive engineering involves comprehensive component and structural evaluation for vehicles of any size and use. It inheres in the engineering.

To determine the safety of any mode of transportation, there must be an identification of how the system does and may fail. This is not usually a discrete event but a continuum of performance under different ranges of operating conditions. What uncertainties occur under what static and dynamic

situations? What conflicts arise in the interaction among vehicles (e.g., weaving sections of freeways)? As a basic data set, it would be worthwhile to have each transportation administration define and prioritize the failure modes. This would allow a far more rational basis for safety investment than is currently followed.

If failure analysis were used as a basis of safety policy, it should be recognized that within the current state of knowledge it would be incomplete (as in the failure of the Nimitz freeway structure). On the one hand, none of the modes has sufficient theoretical understanding to identify all the failure modes. On the other, data on system operations are too limited to allow reliable failure analysis. This is one reason that failure investigation is useful. Where system performance is not fully understood, operational failures can identify design problems. Clear air turbulence and wind shear are two examples where unpredicted behavior of the medium as reported by pilots (to a lesser degree through accident investigation) led to the modeling of the phenomena. This, in turn, led to design and operational modifications that sharply reduced the threat to system stability. In highway transportation, the Europeans have been much more active than the Americans in using conflict analysis for identifying potential failure modes. For safety investment and evaluation, for policy purposes, such analyses would provide a policy-sensitive safety data base.

What is increasingly clear is that new technologies holding tremendous promise for reducing operational failure and conflict are emerging in the 1990s. Viewed from this perspective, collision avoidance technology is becoming an important means of reducing failure probabilities in all modes. Automated warning and override control systems are well within the state of the art for surface transportation modes and are, of course, well advanced in aviation. The underlying issue over the next decade will not be the transfer of this technology but rather the determination of the performance dimensions for which that technology will offer the highest safety returns. Without a detailed understanding of the failure modes, it will be impossible to evaluate the return on collision avoidance or safety technology. Equally, without an understanding of the underlying performance mechanisms, it will be impossible to design such safety technologies.

An example of a new technology that reduces one failure mode is antilock brakes. Basically, this system responds to a particular braking system failure caused by drivers who have no way of knowing the relation between brake pedal pressure and brake lock-up. It does not prevent skidding or loss of steering control under very low friction conditions. It does resolve a narrow range of that set of failures in highway transportation, just as it has in aviation for years.

Automated headway control has recently been proposed for highway transportation, not only to reduce rear-end conflicts but also to increase highway capacity. Such control has been an integral part of aviation and rail transport; however, it has developed in both these modes as part of a superordinate control system. The pilot or engineer is given instructions either symbolically or verbally of the "safe" space coordinates and is expected to navigate within those assigned spaces. In the highway transportation proposal, the concept is based on maintaining continuous control over separation of individual vehicles.

There is an implicit assumption in such a proposal that separation of automobiles is a nonrational driver behavior. Yet there is considerable research to indicate that headways are dictated by both desired relative speed control and steering control. Without understanding the driver control modes, superimposed systems may degrade rather than improve system safety performance. Without understanding control dynamics of any transportation system, it is impossible to design technology that will predictably improve system safety.

In the end, technological changes in system design must be based on an understanding of how the system performs. Without that data base, it is not possible to define safe design. In most modes of transportation, aviation perhaps less than surface, the current understanding is not sufficient to ensure development of standards for or design of safety. The issue is not one of technology—mechanical, electronic, or structural—but rather understanding the basis of system failure.

Collision avoidance technology may be viewed as inherent in the design of the transportation mode or superimposed on its current structure and performance characteristics. The former derives from design theory and may be either evolutionary or revolutionary, depending upon the state of engineering knowledge. There is little question that in all modes the evolution of engineering knowledge has led to design, standards, and regulatory changes that have produced safer transportation systems. Similarly, failure mode analysis has been an integral part of aviation system design and in rail transit is a requirement for railcar procurement. The level of sophistication clearly varies for the different modes, but failure mode analysis is a recognizable function in vehicle and structural design, at least. It does, however, need to be integrated into the operational analysis of transportation to a far greater degree than currently practiced. From a policy standpoint, a knowledge of where and under what conditions the system and its components fail would provide a far better safety data base than current practices.

In the operational domain in all modes, but especially highway transportation, conflict analysis has emerged as a potentially productive tool for evaluating operational safety. The techniques are well developed but lack consistent application in the field. However, FHWA has now produced a manual for the states on making effective use of conflict analysis. Again, a systematic collection of conflict data would be most useful for safety policy objectives.

Data of the type discussed in this paper have been and are collected largely under the rubric of research. Much is known about design and operational failures and conflicts. Much of this knowledge has not been systematized in ways that can be used for policy purposes. It is certain that if the modal agencies were asked to provide such data for policy purposes they could do so. Certainly FAA collects incident data that can, properly analyzed, provide a significant policy data base. Its current program to develop an integrated safety data system is an attempt to do this.

ACCIDENT MITIGATION

It will never be possible to eliminate harm to users or damage to property in any transportation system. As part of the evo-

lutionary engineering design process, the probability of failure will continue to be reduced. However, the underlying design theory will never be sufficient to eliminate all sources of operational failure that directly or indirectly lead to property damage, injury, and fatalities. This will be true, in part, simply because every mode will be used to its structural, organizational, and operational limits to extract the maximum benefit, economic or social.

Given that, the question becomes one of mitigating the consequences of such events. This leads to the separate domain of accident analysis. In essence, regardless of any antecedents in the operation of the system, accidents require analysis with the objective, as previously stated, of minimizing their effects. This whole domain requires both a frame of reference for its analysis and a body of data for setting priorities for modification and regulation of the system. Such data constitute the basis for accident mitigation policy making.

Any accident mitigation effort divides naturally into three component elements:

1. Analysis of crash dynamics,
2. Engineering of damage reducing systems, and
3. Minimization of the consequences of accidents to occupants.

In any mode of transportation, the forces to which the occupants are subjected, the time rate of application of those forces, and the locus of their application to the occupant are major determinants of the extent of damage. Because of their complexity, these processes in real accident events are extremely difficult to analyze and model. In aviation, FAA has been involved in such research for years and has developed an understanding of some of the processes occurring in aircraft accidents. The work in fire propagation is especially noteworthy, as it has led to major design and materials changes. Whether these changes have led to reductions in aviation injuries and fatalities is probably indeterminate, but they do provide a rational basis for accident mitigation.

In highway transportation, accident analyses have led to a recognition that a significant proportion of serious injuries and fatalities are the consequence of ejection from the vehicle. Much of the accident minimization attributed to seatbelts is because they reduce ejection. It becomes much more difficult to evaluate modifications internal to the vehicle. This is due in part to the complex interaction of the motions of a body in an accident and in part to the interactions between the different body structures and the vehicle interior. The biomechanics are inadequately understood to model the consequences for all but the simplest force dynamics. This makes it extremely difficult to reliably specify the elements of the vehicle interior that are the source of the trauma or whether their modification would significantly reduce injury or fatality. Consequently, any regulatory policy must be compromised and it is difficult, if not impossible, to evaluate the cost effectiveness of such proposed regulations.

This issue is most salient in highway transportation, where the numbers of accidents are so large and distributed so randomly. Compounding this difficulty is the way in which accident data are collected. Highway accident investigation is done by police for purposes other than accident mitigation. The nature of the information is largely superficial and cannot be used to evaluate the sources of trauma or damage and certainly not the crash dynamics. Beyond that, there is little coordination and cooperation between the health care system and the accident investigator. For a variety of reasons, it is almost impossible to obtain hospital records of accident victims to precisely identify the locus and severity of injuries or the consequences of treatment on the time of recovery or the enduring effects of the accident. Without such data, it is impossible to evaluate the accident and obtain the knowledge to improve the design of the system. Further, without such cooperative efforts, data on even the direct costs of accidents will remain unreliable.

These limitations are well recognized in the field, and NHTSA has, over the years, supported intensive and expert accident investigation. Although much has been learned from such programs, they have a fundamental limitation: ex post facto analysis cannot reconstruct the dynamics and hence cannot reliably determine the cause of trauma. The result is that, on the operating system level, only the occurrence of the trauma and, at best, its gross source can be reported. Finally, most investigation has focused on fatality accidents, which may provide far less useful understanding of crash dynamics than injury accidents.

These limitations have led to the use of alternative means of analyzing crash dynamics. Some have involved analysis of the force dynamics of vehicles in controlled crashes. Others have involved animal and human cadavers, but most have employed anthropometric dummies in controlled impacts. Dummies, unfortunately, are crude representations of the human body and do not reflect most of the complex interactions of skeletal and soft tissue structures. Although crash dynamics research has developed considerably over the past three or four decades, it is far from precise or scientific. As long as this is the case, accident mitigation policy will be compromised.

It is obvious that the purpose of crash dynamics research and analysis is to provide the basis for design changes in the vehicle. If fatalities are to be reduced to injuries and injuries reduced to structural damage, then vehicle design, structural as well as interior, is the means to achieve that end. Seatbelts and air bags are appurtenances whose cost effectiveness has to be evaluated relative to design changes. Good policy requires data whose accuracy and reliability allow rational choices among these alternatives. At present, such data are far less complete than is needed. As a result, most accident policy making concerning design standards or regulations is at least controversial if not unjustifiable. This is especially true for highway transportation.

If rational accident mitigation policy is to be developed, far more sophisticated crash dynamics and trauma analyses will be required than are presently available. Two classes of data appear essential. One is on the crash dynamics itself. In aviation, flight recorders have been used to define the forces to which the aircraft have been subjected. They have been most useful in providing critical data on how the system failed and hence providing significant data for design as well as operations and training. No other mode has used this technology. It would appear to be an especially valuable tool in highway crash dynamics analysis, in which it could provide detailed

data on the forces to which occupants are subjected. Certainly, such recorders would add significantly to the understanding of the forces occurring in actual collision events. Supplementing the current efforts to model the motion dynamics of vehicles in crashes, they could provide a more effective evaluation of injury and fatality accidents in highway transportation than is currently possible. Such data should lead to more rational policy making on both structural design and restraint technology.

The analysis of crash dynamics without detailed evaluation of trauma experienced in crashes will not provide data for sound policy. Detailed medical analysis of injuries is a parallel activity that must support crash dynamics. Some cooperative efforts between NHTSA and hospitals and doctors, through the Health and Human Services Administration, seem essential. Such a program, which does not now exist, would provide a flow of data that would allow far more rational and cost-effective accident mitigation policy making than is now possible.

The last element of accident mitigation concerns the response of the health care system to trauma events in transportation. It is well recognized that rapid response to and emergency treatment of accident victims have the potential for saving more lives than any other single action. Certainly in surface transportation, where accidents occur unpredictably in time and space and yet most of the traumas suffered are not immediately fatal, medical response within the first 20 min could prevent over half the fatalities now experienced in highway transportation. Most studies on health care response to transportation accidents indicate that the cost of such systems would have a high return on investment, directly through reduced medical costs and indirectly through a reduction in public and private losses (e.g., wages and taxes).

SAFETY DATA NEEDS

The previous discussion reflects an attempt to define the two domains that determine the safety of transportation systems. Essentially, the framework adopted defines safety in terms of system performance. Accident analysis is defined in terms of mitigation of the effects of system performance failure. Such a dichotomization leads to radically different data needs. In this section, the specific classes of data needed for each domain are detailed. The objective is to develop a framework within which existing and new data may be combined to provide a basis for safety policy making.

Transportation System Safety

Failure Mode Analysis

It has been suggested that the basic data required for system safety derives from failure mode analysis and, in interactive systems, conflict analysis. In all modes of transportation there are at least four dimensions of failure analysis that bear on system safety:

1. Medium,
2. Vehicle,
3. Control, and
4. Command.

This is a first-order generic list. It is assumed that a comprehensive analysis would be developed within each mode for each of the dimensions and their interactions, determining, for example, the probability and consequences of failure, the requirements to reduce failure, the cost to reduce the number of accidents, and the return on investment. It is anticipated that this taxonomy would become very detailed.

Estimate Failure Probability

Given the modes of failure (or sources of conflict within systems or groups of vehicles in their operating environment), an estimate of the probability of each failure mode may be made. The objective is to provide a realistic estimate of the frequency of failure. How that probability is measured will vary with the system and the nature of the interactions of its elements. In most transportation systems, it should be possible to estimate both component failure rates and aggregate system failure using classical statistical methods.

Estimate Risk Probability

It is equally important to estimate the significance or risk associated with the failure. A bridge failure may have a low probability of occurrence, but such a failure could have catastrophic consequences (e.g., the Connecticut Turnpike structure or the Nimitz Freeway). Further, the failure probability may be dependent on the location of the element in its life cycle (e.g., fatigue of aircraft structure). Thus, the objective of the data sets is to define the probability of failure or conflict in some priority order of consequence to safe system performance.

What derives from this class of analysis is a "safety" surface. It would define the importance of failure in terms of its effects on system performance. Again, the objective is to allow setting rational priorities for efforts to improve the safety of each mode.

Policy Analysis

If the above analyses are carried out, it should be possible to develop a safety policy analysis. Given both failure mode probabilities and risk assessment, priorities are defined for safety improvements or evaluation. This leads to safety program development: what investments in which elements, structural or operating, would have the highest safety return? That is, what are the technological, operational, organizational, or regulatory requirements for reducing the failure probability to any desired level?

It is assumed that the safety program will define the resource requirements to accomplish the reduction (i.e., the time, manpower, money, and research and development required to achieve the desired reduction in failure or conflict probability). Given the resource requirements, a straightforward rate of return analysis can be performed. Such analysis would allow

the Office of the Secretary to determine the short- and long-term gains of alternative safety program proposals and provide a rational basis for selection. Within resource constraints, this process should allow DOT to make allocation decisions that would improve the likelihood of cost-effective safety improvements. It would also provide a rational basis for evaluating proposed safety programs, because they could be located within a common strategic framework. Finally, this process would lead to multiyear budgeting for programs with explicit and measurable safety results.

The general framework for the analysis discussed is shown below:

1. Medium
   a. Designed
   b. Natural
2. Vehicle
   a. Structural stability
   b. Component reliability
   c. Performance stability
   d. System reliability
3. Vehicle control
   a. Data acquisition reliability
   b. Communication reliability
   c. Data processing reliability
   d. Human control reliability
4. Command structure
   a. Data acquisition
   b. System architecture
   c. Communications
   d. Human performance
   e. System management
5. Interactions
   a. Vehicle—medium
   b. Vehicle—vehicle
   c. Operator—vehicle
   d. Operator—medium

Clearly, this framework has been oversimplified. In many modes, the levels of understanding of the dimensions of failure are unknown. The capacity to carry out risk assessment is also limited. This suggests a need for greater investment in technical support in most, if not all, modal administrations to begin to generate the quality and quantity of data that failure mode analysis requires.

Accident Mitigation

The second dimension of safety policy is accident mitigation. Transportation injuries and fatalities are an indirect consequence of system failure. Although such failures are rare in all modes, they are inevitable. The policy objective becomes one of reducing the magnitude of such trauma when these events occur.

Crash Dynamics Data

A detailed understanding of crash dynamics and the forces to which humans and materials in the vehicle are subjected is required. Out of such an analysis, the nature of the trauma may be defined and its sources within the vehicle determined. Such data should provide a rational basis for vehicle "packaging" design, as well as for restraint and regulatory policy.

Such analyses require not only crash research with surrogate bodies but also more detailed data on crashes in the operational transportation environment. At best, crash research has been cross-sectional rather than longitudinal. Both are essential for a comprehensive analysis of accident effects. One way this can be accomplished is by installing the equivalent of flight recorders in the surface modes of transportation. Installed in, for example, the federal auto and truck fleet, the wealth of basic crash force data would provide an essential flow of information on the whole range of deceleration forces to which occupants are exposed. Such data, added to controlled crash tests, should permit a more precise prediction of trauma risk than is currently possible. Further, these kinds of data may be used to evaluate structural and interior design proposals for accident mitigation.

Trauma Data

A second requirement is to increase the flow of data on the nature of the trauma experienced in transportation accidents. At present, the data are inadequate, which compromises the ability to relate the crash dynamics to their physiological consequences. This is especially significant in injury-producing accidents, which may be significantly more amenable to mitigation efforts than fatalities. Further, the social as well as economic costs of injury accidents are so high that their mitigation would appear to be of highest priority. It is recommended that a joint effort be undertaken with the health care system to provide a comprehensive injury data base, including treatment regimes, practices, and costs. It may also be worthwhile to enlist the insurance industry, which also obtains detailed accident damage and trauma data.

Trauma Recovery

Considerable evidence suggests that the sooner treatment is begun, the higher the prognosis for survival. Most evidence suggests that getting the victim into treatment within 20 min would save upwards of 50 percent of the lives currently lost in highway accidents. The accomplishment of this objective requires a sophisticated effort at the local level involving communications, location, equipment, and manpower. There are varying programs for trauma management among the states, as well as varying investments. Data on such programs would provide a means of evaluating the range of effectiveness of trauma management and provide a basis for resource allocation to states.

Policy Analysis

If the flow of data discussed was available, it would be possible to evaluate investments in accident mitigation programs. The basic process would be the same as that regarding safety programs. It is reasonable in the policy process to ask where

investments in the accident mitigation domain would have the highest return. It is certainly reasonable to ask which programs and proposals within program elements will have the highest return. Strategically, this is the only way to make investment decisions for reducing the consequences of accidents with limited resources.

SUMMARY AND CONCLUSIONS

Safety policy is the process of investment in and evaluation of programs designed to reduce the risk of failure in the performance of the transportation function. The ultimate question for policy purposes is, What is the most cost-effective way of reducing the current probability of system failure? From this follows the question, What data must be available to allow resource investment decisions to be made?

It is a major proposition that any of the global measures of safety, especially those defined in terms of accidents or accident rates, are unreliable and in most cases invalid. They may have political, vis-à-vis policy, attractiveness. However, if the objective is to invest in programs that will reduce the risk of system failure and its consequent costs, a more analytic approach is necessary.

Two different paths of analysis appear essential. One is failure analysis directed at the mechanical, electronic, structural, and human elements of the system. In addition, it includes the analysis of the vehicular and superordinate command and control functions, as well as the interactions with the physical and human environment. The purpose of a formal program of this type would be to provide a flow of data that identifies and prioritizes the importance of failure modes and provides a rational risk assessment. This, in turn, would provide the transportation policy maker a means of identifying safety investments that have a high probability of reducing risk to users. Such investments might include operational, structural, and technological changes in the ways transportation systems are designed, operated, and managed.

The second is accident mitigation, which requires analysis of the chaotic regime occurring after failure of the system. Data on how trauma occurs and the dynamics that determine its magnitude are basic to developing cost-effective structural, operational, and organizational programs that will reduce the effects of accidents.

Every modal agency within DOT has a safety responsibility. Every agency has a unit and personnel responsible for collecting, analyzing, and reporting safety data. With the exception of FAA, the focus has been on casualty data rather than safety, as defined in this paper. The safety analysis programs in FHWA and the approach to safety in the Bureau of Motor Carriers are examples. Transit safety has been largely accident oriented, and the data have been embedded in the Section 15 data base. Conversely, the new FAA program to develop a comprehensive safety data base that would provide a method for assessing and identifying aviation safety issues reflects the recognition of the safety as well as accident dimensions. It is well worth review by the other modes.

Finally, although it should be recognized that all modes of transportation are safety systems considering their scale and use, their safety is an essential criterion of their effectiveness. It is unfortunate that poor measures are often used as a basis for policy making at higher levels of safety policy. The result is often superficial and conflicting policy. There is little need for this to be the case. However, moving to a more consistent and coherent safety policy will require more sophisticated and scientific data bases than are currently being used. If they were employed, limited resources could be allocated more effectively and the safety of all modes of transportation could be measurably improved.

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A series of workshops were held through TRB, in November 1989. Each covered a different mode; aviation, rail, highway, and transit. The participants were all responsible for safety or safety data analyses in their organizations at the local, state, and private levels. These workshops provided essential insights into safety programs, methods of analysis, and problems in safety planning, programming, and evaluation. Many, if not most, of the issues raised in this paper derived from that expertise. The paper could never have been completed without the continuing support of Richard Pain of TRB. As a liaison officer, he made this work possible.

APPENDIX A
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Information for Transportation Decision Making: Institutional Challenges

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To initiate a discussion of the appropriate institutional forms that a comprehensive transportation information program might take, the purpose and scope of such a discussion are delineated, some of the institutional forms and types now operating in this sphere are surveyed, and the functions that these institutions will have to perform in order to be effective are examined. First, an overview of the scope and character of national transportation data development is given. Second, the major transportation data-collecting institutions—federal, state, local, and private—are examined, with particular emphasis on those federal entities within the U.S. Department of Transportation. Third, the institutional functions to be performed in the development of a National Transportation Statistical System (NTSS), including assembly of data needs, program design, funding, program coordination, and product delivery, become the focus. In a brief concluding section preliminary observations are presented, not to draw definitive final conclusions and recommendations but rather to help guide further discussion. Fundamentally these observations examine the argument that the present national transportation data program needs new institutions and institutional arrangements to give structure to the scope and scale of its activities.

This paper is part of an overall effort to assess the capabilities and needs of a transportation information program to support better transportation decision making, in general, and the U.S. Department of Transportation's (DOT's) policy planning requirements, in particular. The study was undertaken because the Secretary's Strategic Policy Study discovered, early in its activities, that there was a serious lack of effective information to support the policy planning effort. Although it was not possible in this study to develop the information in time to meet the needs of the Secretary's initiative, it was decided to begin the process of forming an effective transportation information program to facilitate future applications. This is appropriate to the conception of the policy planning effort as a continuing activity. Perhaps more significant, the programs and policies proposed as part of the new policy are data intensive compared with past policies. Emphases on strategic assessment and system monitoring, policy evaluation, etc. will demand more of the national transportation data system than it is presently capable of delivering.

OVERVIEW OF A COMPREHENSIVE TRANSPORTATION DATA PROGRAM

Institutional Framework for an Information Program

The components of a comprehensive transportation information program are varied and complex. They include (a) the technical skills required to design, assemble, and produce information; (b) the software and hardware and other logistical capabilities to collate, store, and manipulate data; and (c) the financial resources to support ongoing activities.

This description neglects the more intangible elements that are often the main ingredients of success for a large-scale public activity program. These elements include the public and institutional support that ratifies a public program and substitutes for the market success that justifies a private endeavor, and the public and private institutions that design, manage, ratify, and sustain the program over time. This paper focuses on these elements and their role in the success of transportation information programs.

The following elements are crucial to a workable transportation information program:

- Technical skills must be assembled and organized.
- Effective program designs must be created or adopted.
- Financial and other resources must be acquired.
- Public support must be developed and sustained.

All of these elements must be assembled, focused, and managed for a program to be launched successfully and to sustain itself over time. The history of transportation information programs has shown otherwise. Technical skills have not been lacking, program designs have been generally responsive, and resources and support have been weak but usually adequate. Rather, it has been the lack of an institutional framework to give permanence to the ad-hoc efforts that has precluded the prospect for long-term effectiveness.

An effective transportation information program must focus primarily on the development of continuing data series—monitoring trends in supply, demand, and system performance rather than squandering resources in ad-hoc projects and responses to perennial "fire drills." Continuing programs require the application of common definitions and procedures employed uniformly over time. Although it could be argued that it is possible to accomplish this definitional permanence with different organizational entities coming and going, the most likely opportunity for success will be produced by a permanent institution that can operate and sustain a continuing process over time, particularly one with a resource base that does not fluctuate erratically.

Scope of Data Coverage

It is appropriate to be more specific about the nature and scope of the data activities to be included in this assessment. First, it should be clearly recognized that there is no definitive

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delineation of the data set that is the object of such an undertaking. This is not to criticize the current effort; rather, it is to establish that there has been a need for such delineation since the inception of national programs of transportation information development. The only serious effort at explicit delineation is *The Red Book* (*1*). Although never receiving formal support from DOT or Congress, this document has served as the informal bounding of the appropriate scope of a national transportation information program for 20 years (*2*).

The general focus of the types of data programs of interest are those engaged in meeting data requirements for policy and planning. Of course, this can be interpreted broadly to include almost every activity of DOT, other public agencies, and the entire transportation industry. For this paper, it is more narrowly defined to include data that permit a broad assessment of the current and prospective supply, demand, and performance characteristics of the transportation system. The Canadian program in transport statistics refers to this data set as statistics "in support of policy, legislative, planning, regulatory, forecasting and monitoring functions" (*3*). A key concept in defining the scope of this data set is that its focus is most often on the relationship of transportation to broader economic and social factors in the nation.

To help establish the scope of the data of interest, more generic criteria include general purpose statistical data on transportation, i.e., information applicable to more than one program and more than one application. This typically focuses on the development of a recurring data series that provides time series trend information as opposed to one-time, ad-hoc issue coverage. More specifically, it includes

- Facility inventory, condition, and performance data;
- Equipment inventory, condition, and use data;
- Carrier performance and condition data;
- Passenger and freight flows data;
- Demographics and general economic activity data;
- Safety and security data; and
- Finance and program administration data.

It is useful to define certain data and related activities out of the scope of interest of this assessment. These areas include (a) engineering data on structures, facilities, and vehicles; (b) administrative data on departmental, state, local, and private firm operating accounts and personnel matters generally characterized by the label of Management Information Systems; and (c) regulatory data that support day-to-day departmental, state, and local regulatory functions such as licensing and inspections. There are occasions when these sources are valuable in meeting the information needs of the policy planning process, but fundamentally they represent secondary applications.

The defining concept regarding the data set that is the goal of these efforts concerns whether the data are those necessary for DOT to meet its internal needs and support its mandated programs, or whether the data needs should be extended to meet the needs of DOT and other agencies linked to DOT programmatically, such as states and localities. Further, should the data needs be extended to meet general policy needs regarding all of the transport industry, and yet additionally extended to meet industry needs for marketing and competitive analyses? How DOT and Congress construe the requirement will be crucial for program development.

GENERIC INSTITUTIONAL TYPES

The array of institutions and institutional arrangements associated with transportation information is formidable. It is appropriate for the purposes of this assessment to review those institutions and arrangements, not with the intent to inventory every entity in the transportation data field but to identify the generic institutional types that are involved. Thus, it is a typology of institutions, functions, and activities that is intended rather than a comprehensive listing.

Federal Institutions

The federal system for the production of all statistics, not just transportation statistics, is a decentralized system. Many agencies engage in the production, use, and dissemination of statistics. There have been numerous discussions about the merits of shifting to a more centralized system (*4*). In some other countries, such operations are more centralized with a single ministry or statistical office managing the nation's statistical efforts. In that ministry, there would typically be a Transportation Division that is the recognized center of national transportation statistics. Staffing would consist of people knowledgeable in all areas of transportation. Most, if not all, appropriations for statistical activities would go to that division, which would have charge of delineating the national transportation information program. The Canadian approach is somewhat of a hybrid between a centralized system and the far more decentralized U.S. approach. The Transport Division of Statistics in Canada is the source of most of the significant national statistical transport measures. However, while 60 percent of its funding is directly appropriated, the remainder is cost shared with other federal agencies and provincial governments. A memorandum of understanding between agencies structures these arrangements.

In the United States, a multipurpose system with multiple masters is responsible for the production and dissemination of national transportation statistics. Generally, the national system contains at least three elements:

1. A System of National Accounts (SNA),
2. A regulatory system, and
3. A transport system.

This is paralleled in other countries as well. A synoptic description of these elements follows.

The System of National Accounts basically amounts to the accounting "books" of the nation—the accounting of goods and services produced and received, the gross national product system, and the foreign trade statistics. The indexes of prices and the statistics of employment can also be considered part of this system for functional purposes. In the United States, as in other countries, these statistics are the most rigorously defined and formal, and they usually have the longest continuous history. These systems are planned and managed by the Bureau of Economic Analysis (BEA) and the

Bureau of Labor Statistics (BLS), and data collection is predominantly conducted by the Bureau of the Census from major funding provided by the using agencies. In support of these programs, "nation defining" statistical systems such as the Standard Industrial Classification and the Classifications of Occupations and Industries are developed.

The existence of a regulatory system in the United States can be questioned given the recent deregulation at the federal level. The Canadian program defines its system in two parts: an SNA and a regulatory/transport system. With deregulation, the U.S. system may soon be best described in the same way. In the past, the statistical systems of the Interstate Commerce Commission (ICC) and the Civil Aeronautics Board (CAB) were a central and critical element of the nation's statistical knowledge about air, rail, bus, pipeline, and trucking modes. Although these systems are basically gone, the current national system is a residue of this regulatory past. Significant user groups developed around these systems with both regulatory and nonregulatory applications. The CAB system, missing some of the more arcane statistical elements of regulation, has been carried over into DOT's aviation statistical program. ICC's program has diminished significantly in scope and coverage. Other government activities, such as foreign trade and customs reporting, and income tax data sources can be construed as part of the regulatory system. (In Europe, this system has been the centerpiece of the transportation statistical system. In particular, the customs system permitted the extensive organization of freight and passenger flow data. The decline of regulation as part of the Europe '92 program will challenge the systems of many nations.) The regulatory statistical system also can include the data gathered by FAA, FRA, NHTSA, and the Federal Maritime Commission (FMC), as part of their regulatory roles.

The transport system can be briefly, and inadequately, defined as the data developed by DOT and other transportation-related agencies, such as the Corps of Engineers and the Department of Agriculture, to meet their policy, economic analysis, planning, and monitoring needs. The above-referenced regulatory elements of DOT agencies can also be included here.

The hallmark of this system is that DOT is a late arrival on the statistical scene. Therefore, it has sought to make do by adopting and adapting the statistical products of the other systems. DOT's history only extends about 25 years, while the SNA and regulatory systems have almost a century of background. This has proven detrimental in a number of ways. First, the concepts and modes of expression of the SNA, while entirely appropriate to it, are often imperfect or even misleading for transport purposes. Second, the regulatory system was characterized by explicitly, and sometimes arbitrarily, defined reporting criteria that constrained possible analyses. Third, the depth and power of coverage in the regulatory system have been a function of the degree of government regulatory involvement, which can differ sharply from other policy needs. Fourth, changes in the systems, most particularly the demise of regulatory reporting in the 1980s, were often made without consultation with DOT or other transport data users and left nonregulatory users without information support. (This was particularly important because alternative duplicating data collection activities were precluded by law.)

One of the predominant institutions in the area of federal transport statistics has been the Office of Statistical Policy at the Office of Management and Budget (OMB). This organization, which has had various names and has functioned from various locations in government over the years, reviews applications by agencies for statistical undertakings based on statistical and political grounds and concerns for public reporting burdens. Due to lack of staffing and appropriate expertise, its program coordination functions have never been able to fully develop. At one time, OMB sponsored an interagency transportation statistics coordinating group, but it was suspended due to lack of available staff support. A recent Bureau of the Census group oriented to coordination of services-oriented statistics has partially filled that role.

State/Local Institutions

While individual states and local governments will undertake active statistical programs to meet their own needs, the national statistical system contains few data series produced by states that are designed to be comprehensive national data sets. There are many state-generated data sets of value when summed nationally, particularly in the highway area (e.g., highway traffic, spending, and fuel consumption reporting).

For the most part, state and local reporting consists of reporting programs mandated by DOT agencies as part of funding requirements. The Highway Performance Monitoring System (HPMS) of FHWA is the best example of such a program. This program, along with additional summary reports, is an effective summary tool of the status and condition of the federal-aid highway system. The process of reporting is required by Congress on a biennial basis. Similar reporting activities exist in UMTA's programs for program assistance recipients, generally transit properties. FAA has similar reporting requirements for aviation properties. None of these activities truly represents a joint undertaking of state or local agencies with federal authorities. It should also be noted that these systems are victims of their original genesis in program reporting. Thus, the HPMS does not represent non-federal-aid local roads, and UMTA reporting does not provide data on private transit facilities.

Increasingly, these agencies or their public interest group representatives, such as AASHTO, the National Governors Association, the National Association of Regional Councils, and the National Association of Counties, are recognizing the importance of improved data for their organizational policy and planning functions, and those of their members, and have moved to respond to these needs. They represent a powerful potential force for effective data program development. One particularly significant activity may represent a model for future actions. In 1980, DOT and the Bureau of the Census developed a package of special, uniformly defined transport-oriented tabulations of the decennial census. Over 160 metropolitan areas and states purchased this jointly defined tabular package, with federal assistance. This approach saved time and money and increased uniformity. For 1990, the approach is being expanded to include all states and metropolitan areas under DOT program eligible assistance. There are other examples of joint state undertakings to produce national data sets. Most recently this has been stimulated by

the AASHTO 2020 process. This Record includes a paper by an AASHTO committee describing the data difficulties observed in the 2020 process.

Intra-DOT Institutions

It is almost impossible to characterize the diverse number of organizations within DOT that are engaged in data development activities. A review of the DOT organizational structure regarding information programs reveals the lack of a central statistical organization. A number of organizations in the Office of the Secretary play elements of a central statistical role. The Office of Information Resource Management, under the Administrative Secretariat, performs the OMB statistical policy liaison and data collection review functions as well as other oversight functions in its Information Requirements Division. The Transportation Systems Center, no longer in the Office of the Secretary, contains the Center for Transportation Information within its Office of Information Resources. This center performs department-wide statistical reporting functions. Elements of the Policy Secretariat perform statistical overview functions as well.

In the administrations, offices involved with the production of statistics are widely distributed and are given names that may or may not signal their data-related functions. There is no simple way to identify the key statistical office in any administration or to determine any functional equivalence between offices of the different administrations. No administration has a central statistical coordination office or function other than for paperwork management. Fortunately, informal coordination and an exchange of experience occur between professionals in the various programs, but this is not supported by any formal structure. The following list identifies those offices in DOT that have significant information functions as defined in this paper:

- Office of the Secretary
  - —Office of Economics,
  - —Office of International Aviation,
  - —Office of Aviation Analysis,
  - —Office of Information Resource Management, and
  - —Office of Intergovernmental and Consumer Affairs.
- Coast Guard
  - —Office of Law Enforcement and Defense Operations,
  - —Office of Navigation Safety and Waterway Services, and
  - —Office of Command Control and Communications.
- Federal Aviation Administration
  - —Office of Management Systems,
  - —Office of Aviation Policy and Plans,
  - —Office of Planning and Programming,
  - —Office of Air Traffic Evaluation and Analysis, and
  - —Office of Aviation Safety Analysis.
- Federal Highway Administration
  - —Office of Policy Development,
  - —Office of Information Management,
  - —Office of Planning, and
  - —Office of Motor Carrier Information Management and Analysis.
- Federal Railroad Administration
  - —Office of Policy,
  - —Office of Freight Services, and
  - —Office of Passenger Services.
- National Highway Traffic Safety Administration
  - —National Center for Statistics and Analysis,
  - —Office of Market Incentives,
  - —Office of Alcohol and State Programs, and
  - —Office of Defects Investigation.
- Urban Mass Transportation Administration
  - —Office of Capital and Formula Assistance,
  - —Office of Planning, and
  - —Office of Mobility Enhancement.
- Maritime Administration
  - —Office of Information Resource Management,
  - —Office of Trade Analysis and Insurance, and
  - —Office of Policy and Plans.
- Research and Special Programs Administration
  - —Office of Aviation Information Management,
  - —Office of Research and Technology,
  - —Office of Program Management and Information,
  - —Office of Emergency Transportation,
  - —Office of Pipeline Safety,
  - —Office of Hazardous Materials Transportation, and
  - —Office of Information Resources (TSC).

Private Institutions

The increased involvement in data development programs by some private sector organizations has been one of the bright spots in transportation data systems since deregulation. The process of establishing more active programs has varied from organization to organization, and it is unclear what stimuli have resulted in effective programs in some cases but not in others.

Some of the more active programs have been initiated at the Association of American Railroads (AAR) and the American Trucking Association. These programs reflect the greater need for data among their constituents stemming from the market-driven effects of deregulation on competition within and between these industries. On the other hand, organizations such as the American Bus Association and the Air Transport Association have seen declines in their data-oriented activities. One of the casualties of deregulation was the Transportation Association of America (TAA), which was heavily focused on regulatory issues. Its information programs and perspective on the industry were important elements in the transport data picture.

The residual effects of regulation and deregulation are still apparent. Many private sector firms still have fears about government reporting based on years of unpleasant experience with ICC and other regulatory organizations. They resist individually, or through their associations, any attempts at expanded industry reporting, even reporting that would be held confidentially within the industry. At the same time, deregulation has made the marketplace more data intensive, engendering strong interest in marketing data to serve the industry but not in reporting about the industry itself. One of the major changes generated by deregulation was the increasing importance of segments of the transportation industry that had been minor players before and for which data reporting was minimal, such as package express carriers, freight forwarders, brokers, private carriers, and short line railroads.

In some cases, new institutional approaches have evolved. In the public sector, the Bureau of the Census has moved to fill important data gaps regarding transportation industries previously covered by regulatory reporting. The confidentiality rules of the Bureau appear to help calm the fears of some deregulated firms about individual reporting.

In the private sector, AAR has developed a contractual relationship with FRA and ICC to manage and assist in the development of data concerning its industry. This has proven to be an effective new data development instrument.

Another innovation has evolved from the TAA program that produced *Transportation Facts and Trends*, a national summary of transportation activity. When that association declined due to deregulation, the document was continued privately by former TAA staff on an interim basis with the new name *Transportation in America.* It has now been adopted and given new status and support by a private foundation—The Eno Foundation for Transportation, Inc.

The role of private firms in data development pertinent to transportation has been limited for the most part to niche filling. In the passenger sphere, most data are developed by organizations oriented to the intercity travel and tourism industry, focusing on magazine advertising marketing. Primary data of value are produced by these organizations, most notably the US Travel Data Center. The most extensive surveying of intercity travel in the United States that has been performed since the demise of the National Travel Survey in 1977 was conducted by the Canadian government to assist its tourism planning. In the freight data sphere, a mixture of economic consulting firms and ad-hoc data development firms have sought to meet industry needs as a result of increased demand and reduced supply for data resulting from deregulation. The recent TRB/Transportation Research Forum (TRF) conference on freight data needs documented those limited developments. It is important to recognize that transportation data vendors are value-added operators—manipulating, modifying, and supplementing public data sources. They enhance but do not replace these sources.

Two developments may affect private sector data development capabilities. One is the growing interest in Geographic Information Systems (GISs) stemming from new developments in computer processing and geographic base files. This may stimulate greater interest in the data sets appropriate to GIS systems. A related technological development is the growing use of computers for electronic data interchange (EDI) in managing freight shipments. This could expand opportunities for private and public data development but with complex institutional ramifications. The means will soon exist for an industry to assemble its automated working files, purge them of individual identifications, and produce nationally useful vehicle, commodity, or passenger flow statistics on a current and continuing basis.

INSTITUTIONAL FUNCTIONS OF A TRANSPORTATION PROGRAM

There are a distinct set of functions associated with the effective development and operation of a comprehensive information program that generate special institutional requirements. These requirements are discussed below.

Assembling Data Needs

The assessment and determination of information needs is a critical professional function of an effective program. The needs assessment function has many facets.

A Center of Comments

Transportation data users lack a mechanism through which to express their information needs. Users from all sectors—federal, state, and local agencies; private establishments; and private and public operators—have disparate information needs and no useful institutional entity to which they can express their requirements and see those requirements collated with others into a comprehensive statement. In some instances, private operators may be able to collect the information themselves. When this is beyond the capability of an individual or an entire industry, or is more appropriately a public program, the private sector has no public source to which it can express its needs. One example of an approach to this problem is Canada's Federal-Provincial Committee on Transportation Statistics, which was established in 1976 to provide a forum for discussion of transport statistics issues.

One aspect of this function is linked to the ability to locate needed information. Often organizations will assume that data must exist somewhere to meet their needs but that they have just failed to locate the source. They may waste valuable resources in a fruitless search for nonexistent data.

Certain distinctions about the character and scope of this function differentiate it from others. First, the value of the function is its ability to act as a collector and collator of information requirements. This is distinct from the function of the action agency, which might actually collect data to respond to deficiencies. Second, it is also distinct from the function of a data repository, which may serve users as the prime source of information about a topic. These functions may be well served by combining them in a single institution, but they need to be recognized as discrete functions.

Needs Identification

Aside from the value of an assembly point for expressions of public and private information needs, there is a further needs-related function. This is an analytical function that includes evaluation of existing available sources and identification of key gaps and deficiencies. While the first function may be seen as best performed by a secretariat-type institution, it must be the province of transportation analysts and statistical professionals. It may also serve to discover opportunities in the statistical system for beneficial changes as well as identifying deficiencies.

Not the least of the professional functions involved is the construction of appropriate typological nomenclature for the description of information and information requirements. Many elements of the transportation industry suffer from the lack of commonly accepted, detailed definitions of terminology. Transportation is a complex and fascinating mix of engineering, economics, sociology, and other disciplines. This expands the range and scope of data requirements and adds to the semantic and definitional problems involved. The recent pub-

lication of an urban public transportation glossary by the TRB Committee on Public Transportation Planning and Development is one example of the kind of work that is needed.

Secondarily, an institutional entity engaged in assembling and organizing information needs may become a locus of concern for better transportation information.

Comprehensive Program Design

An important function allied to the identification of needs and gaps is the program design function. Fundamentally, this function involves both analysis and synthesis: analysis of future data demands based on long-term policy trends and synthesis of existing needs and resources into a comprehensive needs statement as input for design.

Comprehensive program design is perhaps the most challenging professional task in an information program. It must be a prospective activity, taking into account future transportation trends and the likely directions for policy and analytical focus.

A current issue serves well as an example. Departmental interest and support for intercity passenger travel surveys declined in the 1970s. The demise of the Census Bureau's National Travel Survey after 1977 was permitted, without concern for a substitute. The element of the 1983 National Personal Travel Study (NPTS) focused on long-distance travel and was limited in scope and depth. Even with the presence of this minimal element in the 1990s, the NPTS has been threatened by funding troubles. At the same time, the national policy trend is toward extensive consideration of intercity travel congestion problems and ways to solve them, either by traditional means or by consideration of prospective opportunities for private or public high-speed rail operations and new air technologies. Soon it will become clear that the kinds of data needed for the sophisticated analyses required are lacking. The development of intercity passenger data surveys will require a number of years to create, thus delaying the analytical and decision process. This demonstrates the clear need for the development of a design function that can anticipate future data requirements and link together disparate needs in an overall comprehensive program.

Funding

Lack of adequate funding and erratic variations in funding availability have damaged the effectiveness of some transportation data programs important for policy decision making. A critical function for any data program will be the assessment of resource needs and the building of a funding mechanism to sustain the program on a continuing basis. As noted elsewhere, interest in data programs suffers peaks and valleys. The weakness of past programs has been the inability to establish stable funding mechanisms during periods of peak interest that can sustain project efforts during periods of declining concern. This has resulted in a cyclical funding process—peaking when data subjects are in vogue (during the energy crises of the 1970s, for example), then trying to reconstruct viable programs after periods of disinterest.

A number of funding mechanisms have been employed at various times to sustain programs or individual projects. All of them can be considered options for future funding. The institutional variations involved in these funding alternatives are important to consider.

Centralized Funding

The most evident funding approach for public national data programs is congressional appropriations. There has never been a centralized DOT line item for data. From time to time, individual programs have become line items, especially in the modal administrations and not on a department-wide basis. Other agencies concerned with transportation data, either as using agencies or collectors (such as ICC, the Corps of Engineers, and the Bureau of the Census), have rarely given transportation data the status of a budget line item on a sustained basis. This is important beyond the funding effects it implies because it contributes to the lack of congressional focus on the subject.

A number of variant forms of centralized funding are worth noting. These include

- DOT budgeting of data programs through specific data-related line items;
- DOT funding of data programs as part of program funding, generally when data are highly related to and justified by a specific program; and
- Funding from within the budget of a data collection agency as part of its overall program.

Each of these approaches has been used from time to time in the evolution of a national transportation program. A chief issue in such a decentralized approach is whether an agreed-to program, e.g., a national travel survey, should be funded at DOT and contracted to the Bureau of the Census or funded directly at the Bureau by Congress. There are pros and cons to each approach, not the least of which is determining which path is most likely to produce the needed funding. The Canadian system formalizes this process with a memorandum of understanding between the Ministry of Transport, the National Transportation Agency, and Statistics Canada in which the functional and funding obligations of each agency are spelled out. A base program, funded within Statistics Canada, is acknowledged and a cost recovery program, funded by the other agencies, is identified.

Consortium Funding

One of the effects of a lack of centralized funding, or the lack of a single, large-scale program funding source, has been the tendency to develop consortia of interest around individual projects or programs to provide needed funding. In this approach, a lead agency, usually self-defined, determines a need and establishes a project to respond. It seeks agencies with similar needs and interests that will contribute financially to support the effort. This approach has all the positive and negative aspects inherent in joint activity. It can be negatively characterized as "pass the hat" financing, in which programs engage in a scavenger hunt for would-be financial supporters, wasting time and money on endless meetings and coordination. Its positive side is that it represents something of a system of checks and balances where related interests must be sought out and properly represented to gain needed funding. Many

of DOT's major data programs have been funded in this way. Of particular importance, as a case in point, is the 1990 NPTS.

Pooled Funding

Pooled funding may be considered a special case of consortium funding. It is akin to subscription funding, which is often used in the private sector. In this approach, an idea for a project is advanced by sponsors who permit prospective users to "buy in" for a fee. These users are not sponsors and have no management responsibilities. This is most notably used in data collection programs developed jointly by the federal government and state and local governments. In 1980, this method was used by local government agencies (metropolitan planning organizations) working with states to purchase special tabulations of DOT-developed decennial census data related to transportation. A variant form will be used to develop the 1990 decennial package of census reports.

Cost Recovery Funding

In federal statistical programs, the question of cost recovery has been a major issue. To reduce costs, programs have been required to try to recover components of their costs from users. Problems of pricing policy then become significant. For example, should the full costs of collection be recovered or only those of processing, printing, and dissemination? (This is akin to issues of average versus marginal cost pricing.) Another problem is the time value of data, i.e., whether to price early reporting higher than second- or third-hand distribution. Because the government does not copyright its statistical products, extensive recovery of costs is highly unlikely.

These issues are a product of the differing goals of private and public data collection programs. Private programs developed for profit rarely care about the broad use of their data except in a marketing sense. In fact, they have a strong interest in curtailing uncompensated use, whereas public programs collect data they deem to be in the public interest and are almost always concerned with the broadest public use of their data. Charging fees can conflict with this goal.

There are a few examples of user fees covering a major share of data collection and processing costs in the transportation sphere. One successful approach was that used by the CAB program of aviation statistics to handle data requests. CAB contracted out its statistical reporting process to firms that provided data processing services to requestors for a fee. The approach was apparently successful in the highly data-oriented aviation industry.

Private Funding

The private sector has been active in recent years in developing transportation statistics in certain sectors. Much of this has been a result of losses in public data reporting and the increased demand for information among carriers caused by deregulation. These private programs have enjoyed varying degrees of qualitative and financial success.

In private data collection, an important dichotomy needs to be made between the limited number of primary source data collection efforts and the more typical value-added private efforts that market enhanced versions of publicly produced primary sources. In the latter case, where the firms are highly dependent on the public system for their sources, little is contributed to actual funding of data collection. In fact, the effects may even be deleterious as users become remote from the information sources. Where private industry is the primary source of data collection, a key question is whether public agencies, federal or otherwise, are the major source of the revenue supporting the private venture. In many cases, they are. As a result, the public funding question remains a problem: whether to do a project or to buy it from a vendor. There have been cases in which private funding supported public data collection efforts (usually on a partial basis), but these efforts are rare.

Program Coordination and Monitoring

The funding process often serves as a monitoring and coordination system for information programs. Program sponsors, often working in a consortium, will meet regularly and receive reports on program status as part of their fiscal management responsibilities. Program coordination and monitoring needs go beyond this indirect tool. There are dozens of federal agencies with the responsibility and means to collect data of transportation interest. For instance, the Department of Agriculture tracks arrivals and departures of farm product shipments at major freight terminals, and the customs and passport agencies obtain information pertinent to international travel monitoring. No mechanisms currently exist to ensure coordination of decisions about data collection efforts among interested agencies.

One of the key events in the history of federal transport statistics was the dramatic change in federal reporting as a result of the deregulation of air, rail, truck, and bus travel. In many instances, significant data requirements were met by the regulatory reporting in these modal sectors outside of the needs of the regulatory agencies themselves. Large public and private user constituencies grew up depending on these sources, particularly because the general-purpose statistical agencies, such as the Bureau of the Census, were precluded from duplicating regulatory efforts. When regulatory reporting requirements declined, the agencies took different perspectives with regard to meeting the needs of outside users. CAB recognized an obligation to be responsive to outside users; ICC did not. Varying degrees of coordination resulted in varying degrees of data availability.

No formal or serious informal mechanisms exist in transport data collection to make public or private user/producer agencies aware of changes in reporting systems, publications of data, etc., unless covered by federal register reporting requirements.

Delivery Systems

An important function of a comprehensive transportation information program is maintaining and improving the relationship between the producer and user of statistics. Any institution engaged in this function must recognize user needs and organize the institutional framework to be responsive. Among the key elements in the interface are the needs for timeliness, appropriate design, and product availability.

One of the major weaknesses of publicly provided transportation data programs is the lack of timely reporting, which is often a product of inadequate resources. Data are collected infrequently and, when they are collected, they take too long to process and prepare for release. This latter problem may be due to inadequate staff resources, financial limitations, or lack of priority given to these needs.

Part of the concern regarding responsiveness to users is in the process of developing user products. Some data programs exist only to the internal needs of an agency. Even here, the ability to prepare requested tabulations in a fast, cost-effective manner is important. But in the majority of cases, data programs, especially those producing general-purpose statistics, must think as a wholesaler/retailer and consider the needs of clients in terms of data content, quality, timing, and costs.

The question of user costs for work products generates a number of policy issues. In some cases, a program with limited resources can damage itself by providing products to users at below cost fees or at no cost, reducing funds for other applications. In some programs, even where user products are properly priced, the program agency may not be permitted to receive funds. As a consequence, responsive user products that "sell" well may be a net drain on resources. A further question arises over pricing policies that may retard the distribution of important survey results obtained at substantial public expense. An argument can be made that these cost recovery approaches are not cost effective. If substantial public funds were warranted to obtain information, a small incremental increase in public costs would typically be warranted to ensure the broadest dissemination of the results.

All of these questions are part of building strong support for data programs among prospective constituents. No public transportation information program in the United States has actively engaged in identifying and building rapport with these prospective constituents.

Interrelated with this question of user support are the mechanisms by which data programs are justified. Fundamentally, these mechanisms are reduced to being a function of the persuasiveness of the program officials involved. There are no objective data needs tests, no measure of data adequacy in a program, and no cost-effectiveness tests that prove the value of additional information. Data program officials can assemble lists of users that have requested certain information, appeal to the reason and objectivity of public officials and legislators, or use the arguments of professional judgment. Development of a better means of assessing and proving data needs is required. This is particularly true given the dramatic costs involved in large-scale data programs.

CONCLUSIONS

This paper has attempted to initiate a discussion of the appropriate institutional forms that a comprehensive transportation information program might take. It has delineated the purpose and scope of such a discussion, surveyed some of the institutional forms and types now operating in this sphere, and examined the functions that U.S. institutions will have to perform to be effective.

Observations at this stage are preliminary but can perhaps guide further discussion:

- The current national transportation data program needs new institutions and institutional arrangements to give structure to the scope and scale of its activities.
- It is too easy to suggest that a centralized institutional arrangement is needed for a transportation information program to succeed. This is usually the reflex response to statistical program problems in transportation. It may, in fact, turn out that centralization is desirable, at least for certain functions, but much more discussion and analysis are required before arriving at such a conclusion. The transport sector is so multifaceted that a distributed system of statistical development that reflects that diversity may be more appropriate with some centralized coordinating elements. At a minimum, discussion should focus on what program elements are appropriate to and benefited by centralization.
- A national transportation statistical system (NTSS) needs to be explicitly defined. A context-setting document that explicitly includes and excludes the scope of data and data programs of interest is needed.
- The forms and content of possible memoranda of understanding between producer and user agencies, following the Canadian model, should be explored.
- Mechanisms for providing opportunities for input and assembly of expressions of data needs are required. Institutional mechanisms to accomplish this must be explored.
- Separate intra-DOT and interagency institutions are needed to coordinate data programs and plans.
- An assessment of alternative institutional mechanisms to produce and manage data employed in other sectors of the economy and in transportation statistical systems abroad would be valuable.
- Private/public mechanisms for data development need to be assessed. The ability of the private sector to produce data and the ability of the public sector to purchase it needs to be better defined.
- The opportunities for new forms of data development based on emerging technologies need to be seriously evaluated. The institutional structures necessary for their implementation are a key to their prospective utility. Public actions needed to facilitate these institutional arrangements should be identified.
- Congress must be engaged in this discussion. Congressional requests for information, particularly for recurring reporting such as the HPMS, have caused the initiation of most of the existing effective programs. On the other hand, the disinterest of Congress in transportation data needs, as manifested by congressional response to the *Red Book* 20 years ago, instilled a similar disinterest within DOT, which has been the cause of most of the national transportation data program weaknesses.

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Data Requirements for National Transportation Strategic Planning: AASHTO's 2020 Experience

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An assessment is given of the adequacy of data and analytical processes to enable national transportation policy planning to be readily accomplished. AASHTO initiated a process called "AASHTO 2020" to develop an organizational position on future federal legislation. As part of the 2020 effort, needs were estimated for each mode and analytical judgments were made on the consequences of meeting various need (service) levels. After the technical work was completed, the AASHTO Standing Committee on Planning was asked to review the problems encountered in estimating needs and making tradeoffs among different funding and programmatic alternatives. A questionnaire was developed to determine, for each mode, the adequacy of the data, the information that should be collected on a continuous basis, and the types of questions that should be answered from the strategic planning process. This paper presents an analysis for each modal area, including comments on the current availability of data and analytical techniques as well as recommendations for each mode.

In a recent survey conducted as part of the AASHTO 2020 effort, the chairpersons of each of the AASHTO modal standing committees and the 2020 Highway Technical Advisory Committee (HTAC) were asked to respond to three questions related to transportation data needs:

1. Are the data adequate in the particular modal area?
2. What information should be collected on a continuous basis?
3. What types of questions should be answered from a strategic planning process?

In general, those responding supported the need for adequate data in all program areas to enable national transportation policy planning to be readily accomplished. It was felt that the following types of data should be available and current:

- Facility inventory,
- Usage data/service inventory,
- Financial data,
- Quality of service data, and
- Population and economic data.

There was agreement that policy models should be available to test the consequences of

- Various funding scenarios,
- Major changes in policy direction,
- Major changes in any of the above data categories, and
- Impact of external policies (air quality, energy, etc.).

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HIGHWAYS

The HTAC found the Highway Performance Monitoring System (HPMS) model to be very helpful in inputting to the 2020 process. HPMS appears to be the most advanced policy planning model and has the full support of FHWA and the states. Even with the advanced development of HPMS, the HTAC found some limitations, which were noted in the HTAC subcommittee report. Generally, however, HPMS-type models and processes should be the goal of other modal areas.

The HTAC was hampered by the lack of an equivalent process for scaling bridge needs and testing alternative bridge strategies, but it is understood that FHWA is working on this issue.

Neither adequate data nor a modeling capability were available to determine the multimodal impact of alternative investments on reducing highway needs (such as the impact of TSM strategies or increased transit use strategies).

TRANSIT

The Modal Technical Advisory Committee (MTAC) found that there was no single, consistent source of data for transit operations and that UMTA did not have the capability to collect the data and evaluate strategic alternatives.

Operating Data

UMTA collects data on urbanized area transit operations, including some financial information on operations. The following problems were noted with this data source:

- The data are 2 years old before publication.
- There are built-in obstacles to data manipulation. (The Transit Committee has suggestions for improvements.)
- There is a lack of summary tables and totals.
- The data do not cover rural areas. (A separate Section 18 data process is underway.)

Capital Data

There is no consistent source of data on transit facilities and infrastructure; however, the following sources are available:

- APTA maintains a transit passenger vehicle fleet inventory.
- UMTA conducted a rail modernization study.
- AASHTO maintains a survey of state involvement in public transportation and is conducting a state transit capital funding survey.

Major gaps exist in these data sources:

- Terminal and maintenance facilities are not included with data on condition, needs, etc.
- Consistent definitions are needed.
- Greater compatibility of data is necessary for manipulation.
- There is a lack of quality control.
- Information on financing is not provided by operators or private sources.

The state of Illinois created a policy analysis model to develop a needs estimate and to evaluate several limited options.

The Transit Committee recommended that UMTA assume responsibility for developing and maintaining an adequate, consistent data base as well as the analytic capability to answer the following questions:

- How much money are the sources investing in facilities and infrastructure?
- What amount of funding is from federal, state, and local governments?
- What portion of the funding is based on debt financing?
- What makes up the inventory of transit facilities and infrastructure and what is the condition of the facilities? For bus properties, the data would include size, age, condition, and type of activity for each facility. Rail properties, with more system elements, present a more complicated situation in terms of the type of information and the level of detail to be reported.
- What structures and facilities are to be replaced, eliminated, rehabilitated, expanded, or built?

AVIATION

The Aviation Committee reported on its recent experience in completing the aviation component of an AASHTO study called "New Transportation Concepts for a New Century." The existing aviation data bases were found to be inadequate, and short-range limitations were noted for planning future system needs.

Although FAA has an extensive data base, the committee found the following problems:

- The national data base excludes airports not eligible for FAA funding.
- The data are often old and subjectively derived.
- The data on national airspace planning are not related to the airport physical inventory.
- Future needs are based on use projections and do not consider strategic alternatives, such as the impact of the Airline Deregulation Act of 1978.
- Aviation forecasts are on a top-down basis.
- FAA does not require states to maintain updated inventories.
- Data are not available on airport access needs. (The MTAC did such a survey for 2020.)

The Aviation Committee felt the development of an aviation strategic planning process should identify total system needs, define alternative national and state aviation systems, and apply and evaluate appropriate tax funding alternatives at the national and state levels. It was expressed that alternatives must be interfaced with the air traffic control system and airspace management and that long-term costs associated with limited capacity alternatives should be integral to the strategic planning process.

RAILROADS

Responses from the Standing Committee on Railroads indicated support for national rail transportation strategic planning and for accumulating the data base to allow this planning to proceed. In addition to the five basic data items listed for all modes, the committee felt it was important to collect the following data:

- Car supply, condition, and utilization;
- Motive power inventory, age, capacity, and state of repair;
- Financial condition of railroads including funds spent for maintenance and capital restoration;
- Goods flows by commodity type and origin-destination (O-D) pattern;
- Train accident and safety statistics; and
- Information on grade crossings and grade separations.

Many of these data are already being collected in different places, but no single group is assembling the data in a common data base. Examples cited include R-1 annual reports done by the Association of American Railroads (AAR) on inventory, utilization, efficiency, and financial trends; summary data from waybill samples; and unit cost data developed by the Interstate Commerce Commission (ICC). Clearly, no governmental agency is collecting the data and conducting strategic planning. The Rail Committee felt DOT should fill this void.

The states felt the overall health and utilization of the rail network should be reviewed periodically and the effect of alternative policies and programs should be tested for impact on the rail system's viability. The example most cited was the impact of various trucking regulations on rail systems. It was recommended that overall mission/goals for the rail industry be established as part of the national transportation policy after evaluating alternative missions using accurate data.

A standing committee on railroads stated "Securing existing data with the inclusion and appropriate protection for proprietary information in a comprehensive and timely fashion, in addition to the new data, would allow states to determine the reliability and longevity of various rail lines serving different sectors of their respective state. This would be useful in long-range transportation planning relating to modal balance and split, economic development opportunities, resource access, import/export impacts, and the opportunity to assess

and implement the use of public funds where warranted as beneficial to the states."

The area of rail passenger service is also a vital concern for the states. In this area, Amtrak was the only major entity included. It was reported that Amtrak not only does not have a strategic plan but has been prohibited from preparing a 5-year plan. All the above comments on railroad data needs and analyses suggest that Amtrak and DOT must create the long-term capability to plan for various levels of rail passenger service.

WATER TRANSPORTATION

The comments of the Standing Committee on Water Transportation regarding data and strategic planning were similar to those of the Rail Committee. Large amounts of data are collected by various agencies and trade organizations, but there is no common data base and no strategic planning. The committee reported the following:

> Addressing the transportation funding and service needs within budget constraints requires the recognition that all elements of our transportation infrastructure (rail, highways, water and air) are part of an integrated and interdependent system. Budgetary constraints will force federal, state and local governments to reassess their needs and begin to strategically plan for future investments.
>
> To ensure a workable water transportation network for the nation is maintained, there must be a comprehensive surface transportation program which defines a water transportation network of national significance. A National Strategic Planning process should provide the data needed to assess the importance of a port facility or length of waterway to the nation's economy or for the nation's defense. A subjective assessment of the value of the commodities handled by a port or carried on a waterway segment can be used as a basis to determine investment needs and required improvements that should receive financial assistance from the Federal Government.
>
> A large gap in data for National Strategic Planning for water transportation appears to be the lack of consistent data on use. With the trend towards intermodal movements, it is becoming difficult to obtain consistent data on flows, origins, and destinations. Intermodalism and the creation of large integrated domestic and international carriers will present potentially greater obstacles to consistent comprehensive data on transportation system utilization. This is the area that should receive significant attention for National Strategic Planning purposes. Other information, like facility inventories, are generally available from federal modal agencies and other sources. Rate information is available from carriers and federal regulatory agencies. However, since deregulation, rate information is not very meaningful because of the many discounts and service contracts available.
>
> The Nation's water transportation system carries not only freight but also passengers. Ferry systems carry a good deal of both freight and passengers and offer an option to land based transportation methods (bridges or tunnels for rail and highways or commuter rail or bus in urban areas). Very little nationwide data has been collected on ferry systems. The basic information concerning ferry services, i.e. number of vessels, total passengers ferried, total vehicles ferried, total number of routes, total cost of operation (expenses), current toll (fare structure), ratio of tolls to expense and percentage government support is not available on a national basis. This makes it difficult to assess the potential of a ferry system over another more "conventional" transportation mode.

OTHER NEEDS

SCOP members also commented that data and analytical processes are needed for three additional areas:

- Truck data,
- Multimodal planning, and
- Economic development.

Truck Data

In performing the highway analyses, HTAC found that data on heavy truck usage were not reliable or useful. Because of the importance of trucking to our national economy, the intermodal tradeoffs with rail, and the incidence of roadway wear and tear caused by heavy trucks, these data are critical to policy and program decisions. Truck data needs are analogous to rail data needs except for the facilities inventory.

Multimodal Planning

Several members cited the need to evaluate the impact of national policy strategies on goods movement shares between truck and rail. The same problem exists for passenger needs, both urban and intercity. The AASHTO Intermodal Committee is concerned with this issue, and an inventory of modal interlinks needs was done as part of AASHTO 2020. These inventories should be periodically updated as part of the national strategic planning process.

Economic Development

AASHTO recognizes the lack of data regarding the impact of transportation investment on economic development and has appointed a special committee on economic development.