Scan of Recent Data Research

September 1996

TMIP

Travel Model Improvement Program

Department of Transportation
Federal Highway Administration
Federal Transit Administration
Office of the Secretary

Environmental Protection Agency

Department of Energy

U.S.Department of Transportation

U.S.Environmental Protection Agency

Travel Model Improvement Program

The Department of Transportation, in cooperation with the Environmental Protection Agency and the Department of Energy, has embarked on a research program to respond to the requirements of the Clean Air Act Amendments of 1990 and the Intermodal Surface Transportation Efficiency Act of 1991. This program addresses the linkage of transportation to air quality, energy, economic growth, land use and the overall quality of life. The program addresses both analytic tools and the integration of these tools into the planning process to better support decision makers. The program has the following objectives:

1. To increase the ability of existing travel forecasting procedures to respond to emerging issues including; environmental concerns, growth management, and lifestyle along with traditional transportation issues,

2. To redesign the travel forecasting process to reflect changes in behavior, to respond to greater information needs placed on the forecasting process and to take advantage of changes in data collection technology, and

3. To integrate the forecasting techniques into the decision making process, providing better understanding of the effects of transportation improvements and allowing decisionmakers in state governments, local governments, transit operators, metropolitan planning organizations and environmental agencies the capability of making improved transportation decisions.

This program was funded through the Travel Model Improvement Program.

Further information about the Travel Model Improvement Program may be obtained by writing to:

Planning Support Branch (HEP-22)
Federal Highway Administration
U.S. Department of Transportation
400 Seventh Street, SW
Washington, D.C. 20590

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Prepared by
Cambridge Systematics, Inc.
with Barton-Aschman Associates

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1.0 Introduction

The purpose of Track D of the Travel Model Improvement Program (TMIP) is to identify, design, and develop improved data collection procedures that will meet decision maker's current and future needs. To support the development of the overall Track D Data Research Program, a review of ongoing data-related research has been undertaken. This review has focused on two major areas of data research:

- Data needs, collection methods, and analyses for transportation program applications conducted by state departments of transportation and regional planning agencies; and

- Data needed to support the kinds of short- and long-range travel demand model improvements being developed in Tracks B and C of the TMIP.

This technical memorandum presents the results of this review. Relevant federal, state, and university research is identified, including an assessment of its relevance and relationship to Track D. The review was performed during the spring and summer of 1995, with the results initially documented in a July 1995 Technical Memorandum. This August 1996 update incorporates a number of revisions, most notably an expanded description of FHWA's own research projects relating to Track D of TMIP. This update, though, does not represent a comprehensive revision of the original scan of recent data research.

In summary, a wide range of research and technology activities currently are taking place which address the topic of data collection methods and sources. This research touches on nearly all aspects of transportation planning, and is particularly important for the development of improved travel demand models. One area of particular relevance is the set of new and advancing technologies which can be used for data collection.

The organizations conducting research in this area include federal agencies such as the U.S. Department of Transportation, the Federal Highway Administration, the Federal Transit Administration, the Environmental Protection Agency, and the Department of Energy; state planning and research programs; pooled-fund research programs such as the National Cooperative Highway Research Program (NCHRP) and the Transit Cooperative Research Program (TCRP); universities and associated research centers; and the private sector.

While Track D of the Travel Model Improvement Program is concerned with improved data collection procedures, it is important that an assessment of the relevance of ongoing research programs occur within the larger context of the changes that are occurring to travel demand models themselves. Requirements for the kinds of short- and long-term model improvements that are being developed under Tracks B and C of the TMIP determine both the kinds of data that may be needed and the relevance of potential data collection approaches. Section 2.0 of this Technical Memorandum, therefore, briefly covers

the data requirements of travel models, as they likely will exist in the future. The third section deals with research relating to the use of various types of travel surveys for acquiring data. The fourth section looks at new data collection methods and tools and the changes that technology will bring. Appendix A includes a listing of research programs and Appendix B contains a literature search of publications which are related to Track D.

2.0 Data Requirements of Emerging Travel Models

A great deal of attention has been placed in recent years on the use of travel demand models for transportation planning. In response, a number of programs have been established to examine how these models can be improved. The final form that these models will take will have a dramatic impact on future data needs and collection methods of transportation agencies.

Research efforts include both the short-term and long-term data needs of travel models. In addition to the Travel Model Improvement Program a number of other research programs are conducting comprehensive reviews of the modeling process and the resulting data requirements. For example, NCHRP Project 8-32, "Multimodal Transportation Planning Data," being conducted by Cambridge Systematics will provide a comprehensive review of data requirements, availability, uses, and collection methods for transportation planning. This project will fill a gap in the current body of research by taking a top-down look at data needs. This project, though, represents a comprehensive examination of multimodal transportation planning rather than the Track D focus on travel demand forecasting. University-sponsored research in recent years has addressed the data requirements of travel models as they relate to a particular focus area, rather than a comprehensive set of guidelines.

2.1 Short-Term Travel Model Improvements

The data collection programs of most agencies currently consist of a variety of travel surveys, and collection of system operating characteristics and performance measures. Travel surveys are used for a number of purposes and include household surveys, transit on-board surveys, truck surveys, roadside origin-destination and external cordon surveys. These travel surveys are primarily focused on individual travel behavior and choices. System characteristics collected can include traffic counts and transit ridership, speed data, travel costs, energy use, vehicle emissions, and auto occupancy. While enhanced travel demand forecasting improvements will be implemented in coming years as a result of the TMIP Track B and C research programs, it is likely that these existing data sources will continue to provide the basis for travel model development for many urban areas.

A starting point for determining the data needs of short-term model improvements is the documentation of "Best Practices" used in the profession. For example, Harvey and Deakin (1993) prepared *A Manual of Transportation-Air Quality Modeling for Metropolitan Planning Organizations* for the National Association of Regional Councils. The manual

calls for more regular updating of travel surveys and a strong focus on data used for monitoring improvements. Similar best practice manuals have been developed for other organizations, with one example being the *Review of Best Practices* prepared for the Metropolitan Washington Council of Governments (Parsons Brinckerhoff Quade & Douglas, 1992).

Two efforts recently have been completed that are designed to comprehensively document current travel survey practices. Work performed by Peter Stopher for the Transportation Research Board summarized the state of the practice for household surveys. Under NCHRP Project 20-5; Synthesis Topic 26-03 "Synthesis of Household Travel Surveys" information was collected from metropolitan planning organizations on existing and proposed survey criteria, guidelines, and methods. Cambridge Systematics, with Barton-Aschman Associates has prepared a July 1996 Travel Survey Manual for FHWA documenting recommended practices for the conduct of eight types of travel surveys.

Track B of the Travel Model Improvement Program is documenting the state of the art of available near-term improvements. Some of the data needs identified with these immediate enhancements include land use and demographics, temporal and life-cycle influences on travel patterns, non-motorized modal characteristics, speed variations, emissions, commodity flows, and more disaggregation of travel patterns.

2.2 New Approaches to Travel Models

Fundamentally new approaches to travel demand models are being developed under Track C of the TMIP. This effort began in earnest in July 1992 when the Federal Highway Administration issued a solicitation for proposals to redesign the travel forecasting process. Awards were made to four different teams: 1) Resource Decision Consultants, Inc., 2) Caliper Corporation, 3) Massachusetts Institute of Technology (MIT), and 4) the Louisiana Transportation Research Center. A synthesis of the research proposals released in January of 1994 (DOT-T-94-15) listed a number of common themes regarding data requirements. Three of the proposals recommended the implementation of household activity diaries which collect data on activities, whether or not they result in trips. Other changes in travel surveys include the use of stated preference surveys, longitudinal surveys, and multi-day collection of data. New requirements for data also include more detailed network data and more extensive use of Census data.

Since completion of this series of four 1992 initiated projects, many university research projects have focused on common characteristics which new approaches to travel forecasting models might encompass. This new framework includes microsimulation of travel demand and network flows, dynamic representation of trip making over a 24-hour period, and travel deriving from activities (Lawton and Pas, 1995). A number of research programs have looked at dynamic, activity-based models, choice-set models, and travel behavior; especially at Duke University, the University of California at Davis, the University of California at Irvine, and MIT. An implication of each of these research

efforts is that future travel models may include a much greater level of detail about travel demand and system characteristics than exist in current model systems.

The largest research program designed to develop a dynamic microsimulation model is the TRansportation ANalysis SIMulation System (TRANSIMS). The project is being conducted at Los Alamos National Laboratory under Track C of the Travel Model Improvement Program. The project is aimed at linking previously separate travel forecasting, microsimulation, and air quality models to predict trips for individual households, vehicles, and residents rather than for traditional zonal aggregations of households. The level of detail being modeled requires and generates a tremendous amount of data, some, but not all of which will be the same as that used by the traditional four-step models.

2.3 Modeling Commercial Vehicle Travel and Goods Movement

In the development of both short- and long-term improvements to travel demand models, considerable attention is being devoted to the forecasting of commercial vehicle, freight, and intermodal goods movement. The development of travel models for commercial travel consequently is the focus of a number of current research programs. Both the Federal Highway Administration and NCHRP Project 8-32 are conducting comprehensive studies of freight modeling. These projects will establish guidelines for data collection on goods movement, an area that most agencies currently do not cover.

Some university programs also have looked at data requirements for freight models. Examples include regional analysis and database (RPI and Cornell), truck inventory (Michigan), models for commodity flows (Kansas State), and freight network models for mode choice and route choice (Berkeley).

2.4 Interface with Air Quality Models

Passage of the 1990 Amendments to the Clean Air Act and the associated air quality provisions contained in the 1991 ISTEA legislation have triggered a number of projects examining the interrelationship of transportation air quality modeling, including the consistency of the respective data requirements for each of these families of models. An early response was the Land Use Transportation Air Quality (LUTRAQ) project for the Portland metropolitan area conducted by the 1000 Friends of Oregon and sponsored, in part, by the Federal Highway Administration and Environmental Protection Agency.

NCHRP Project 25-7 "Improving Transportation Data for Mobile Source Emissions Estimates," has resulted in improved guidelines for the integration of transportation data with air quality planning. Conducted by The University of Tennessee, a final report was completed in October 1995. NCHRP Project 8-33, "Quantifying Air Quality and Other

Benefits and Costs of Transportation Control Measures," is directed at developing a new analytical framework for examining transportation air quality measures. This effort includes a consideration of underlying uncertainties in current data and modeling approaches, and is emphasizing the data required to improve the linkages among transportation, emissions, and air quality models.

University-sponsored research also has looked at transportation air quality modeling, including the prediction of mobile sources and fuel consumption (University of Texas at Austin); forecasting vehicle size, energy, and emissions (Texas A&M); and forecasting carbon monoxide concentrations using cameras and neural networks.

3.0 Research on Travel Survey Data Sources

The data sources used to support travel model development vary greatly and have evolved over the past decades. The primary data sources used by most agencies are travel surveys, a broad category encompassing a range of survey types (household, on-board transit, roadside origin-destination and external cordon surveys) and methods (in-person, telephone, mail-out). Travel surveys are used to collect information about travel behavior, and more recently attention has focused on traveler choices and activities. Other primary data sources can include transportation system data such as speeds, volumes, vehicle class, travel costs, energy use, vehicle emissions, and auto occupancy. Secondary data sources (collected by others) that are increasingly being used by many agencies include the Nationwide Personal Transportation Survey (NPTS), the Census Transportation Planning Package (CTPP), and the decennial census Public Use Microdata Sample (PUMS).

Research addressing travel surveys and secondary data sources is quite broad and extensive, as documented in Appendices A and B. Academic researchers, especially Pas and Kitamura, have focused a great deal on time use and activity analysis, and their implications for surveys and models. Other comprehensive treatments of travel surveys include FHWA's recently completed "Travel Survey Manual" and the NCHRP project, "Synthesis of Household Travel Surveys."

3.1 Household Surveys

Data collection efforts during the 1950s to develop travel models were based on the use of large-sample (10 to 20 percent in some cases) surveys in which respondents were interviewed at home and asked to recall trips that had been made on the previous day. Today the household survey continues to play a central role in data collection for model development. However, the methods used to collect household information have changed a great deal. Common characteristics include:

- Small samples (often less than one percent of the population);
- Cross-sectional data for a single day;
- Revealed preferences (travelers describe travel behavior as it happened); and
- A focus on trips made by walking and bicycling as well as by auto or transit.

The state-of-the-art in household surveys also is moving toward the collection of greater detail concerning activities not related to trip making.[1] Research pertaining to the use of activity-based surveys, stated preference surveys, and longitudinal or panel surveys is summarized below.

Time-Use/Activity Analysis

The shift from trip-based surveys to activity-based surveys is based on the theory that travel should be modeled as a derived demand, a result of the need to participate in activities. Most household surveys in the past collected information on trip purposes, such as shopping and work, but did not ask for information for activities not related to a specific trip. Recording activities instead of trips facilitates recall of short, infrequent trips since respondents must account for every period of the day. In-home activity substitution, such as exercising at home instead of traveling to a gym, also can be captured. By analyzing the use of time, a traveler's choice about when to travel can be viewed in terms of the activities which are foregone and the utility of different activities.

Activity-based research goes back to the 1960s but there has been renewed interest only since the late 1980s. Most of the research has been conducted at universities, although in 1993 the Federal Highway Administration began work looking at travel time budgets through an FTA-sponsored study. There have been only a few attempts to implement an activity-based survey in this country. Most recently, these include work by the North Central Texas Council of Governments (Dallas-Fort Worth). AMOS, an activity-based travel demand model, is being developed for the Metropolitan Washington Council of Governments and was based on a special stated-preference survey. A second implementation of AMOS is now beginning for the Los Angeles metropolitan area in cooperation with the Southern California Association of Governments. An activity-based travel survey, supplemented by stated preference surveys, also has been collected by Portland (Oregon) Metro and will be used to estimate the next generation of travel demand models for that region, including the development of tour-based models.

Stated Preference Surveys

Stated-preference surveys are a useful source for information regarding non-observable variables and new or hypothetical situations.[2] An example is the analysis of market responses to new technologies. Another area where revealed-preference surveys may not

[1] The state of the art of household travel surveys is described in detail in the July 1996 *Travel Survey Manual* prepared by Cambridge Systematics, Inc. and Barton-Aschman Associates, Inc. for the Travel Model Improvement Program. In addition, the May 1996 TMIP report, *Scan of Recent Travel Surveys,* summarizes travel surveys that have been conducted in recent years by more than 50 metropolitan planning organizations and state DOTs. An in-depth description of one particular travel/activity survey is contained in the April 1996 TMIP report, *Data Collection in the Portland, Oregon Metropolitan Area.*

[2] An expanded discussion of stated-preference surveys is contained in Chapter 13, Section 1 of the TMIP *Travel Survey Manual.*

be adequate is with non-motorized travel due to the difficulties in collecting a large enough sample. Stated-preference surveys are based on conjoint analysis which has been employed by market researchers since the early 1970s. Applications in travel demand forecasting are increasing but greater training of professionals is needed. A short course on stated-preference and choice models is now being taught at Portland State University, with Jordan Louviere and David Hensher serving as instructors. Both stated-preference and revealed-preference surveys are likely to be used in the future for model development, with the former based on the use of a smaller sample and for specialized analyses. Ongoing travel demand model work for the state of New Hampshire and the Portland, Oregon metrpolitan area both represent examples of the conbined use of stated- and revealed-preference surveys.

Longitudinal or Panel Surveys

A number of research programs have looked at the use of longitudinal data instead of the typical single-day cross-sectional surveys.[3] In addition to before and after data collection studies, longitudinal surveys include:

- Panel surveys; and
- Repeated cross-sectional surveys.

Panel surveys have received the most attention for transportation applications. These surveys involve a repeated survey of the same sample of respondents. One advantage of this type of survey is that it can show how travel behavior changes over time along with the change in the stage of the family lifecycle (i.e., married without children, married with children, retired couple). Panel surveys also recognize that for travel forecasting, present decisions affect future behavior and are affected by past decisions.

The Puget Sound panel survey was the first application of this survey type for transportation purposes in the United States and has been the focus of a number of studies, including those sponsored by the Puget Sound Regional Council and Pennsylvania State University. Further descriptions of this survey can be found in Murakami and Watterson (1990 & 1992). The First U.S. Conference on Panels in Transportation Planning was held in 1992 in Lake Arrowhead, CA. Other panel surveys have been conducted in Europe including the first major panel for transportation - the Dutch National Mobility Panel - which began in 1984 and ran through 1989.

Cross-sectional surveys also are being extended so as to collect longitudinal data. One approach is simply to repeat the cross-sectional survey every few years. Another approach is to extend the reporting period from one to two days, similar to what was done for the recent Portland home-interview survey. Multi-day samples reduce the variation in trip generation rates, particularly as they relate to travel demand management measures, part-time carpooling, and weekend travel.

[3]The use of longitudinal or panel surveys is described in Chapter 13, Section 2, of the TMIP *Travel Survey Manual.*

3.2 Census Data for Transportation

The U.S. Census often is used as a secondary data source, especially the Census Transportation Planning Package (CTPP) and the Public Use Microdata Sample (PUMS). A number of changes now occurring in the design and collection of the Census, however, could affect transportation applications.

Data on commuting behavior is collected on the long form along with information on vehicle ownership, household size, and income level. Funding for the long form of the Census, though, is uncertain and the absence of this information in the future could have important implications for many metropolitan areas. An alternative to the long-form collection of travel data by the Bureau of the Census is the use of continuous measurement surveying, with more regular census sampling conducted over a five-year period.

The CTPP currently includes only work trips, and not information on the fast-growing number of non-work trips. Such information may be difficult to collect with a standard mail-out Census since non-work travel is less regular and harder to recall. Technological changes to the CTPP also may include the ability to access data over the Internet or by using a modem, and improvements to TIGER files.

A number of research projects have studied applications of Census data for transportation. A 1994 TRB conference held in Irvine, "Decennial Census for Transportation Planning," included a discussion of future uses. However, many factors, especially those that could result from budget reductions, are uncertain and discussion continues.

3.3 System Performance Data

Nearly all transportation data collection programs include the collection of system performance data ranging from traffic counts to travel times. In some cases, these data are derived from the Highway Performance Monitoring System (HPMS). Most recently, the use of ISTEA management systems to develop system performance data has been the focus of attention.

The Federal Highway Administration has a number of ongoing programs which address system performance data, as documented in Appendices A and B. These include studies of continuous traffic monitoring, cost-effective collection of travel time data, and vehicle classification and occupancy. The Federal Transit Administration has conducted a study of transit conditions, including variables relevant to travel models. TCRP is conducting a study of automatic passenger counters.

4.0 Research on Data Collection Technologies

Changes are occurring in both the types and amount of data that need to be collected by transportation surveys. This review of data collection research also indicates that significant changes are taking place in the methods by which travel survey data can be collected. In the past decade, transportation data collection has been greatly influenced by the wide-spread adoption of the microcomputer. In the coming decade, microcomputer technologies will continue to have widespread influence on data collection. Existing computer aided survey methods will be augmented by advanced video and graphics technology. Many of the technologies developed to support Intelligent Transportation Systems (ITS) also have applications in data collection. The following sections summarize current research efforts in advancing the technologies used for data collection.

4.1 Computer-Assisted Surveying

Current state-of-the-practice for household travel surveys is based on the use of telephone interviews for recruitment and collection of mail-out travel diaries. Survey coding, error-checking, and analysis rely heavily upon computer techniques. Computer-assisted interviewing now includes telephone interviewing (CATI); personal interviewing (CAPI), often administered through the use of Personal Digital Assistants (PDAs); and self-interviewing (CASI). Future trends are toward integration of multiple data collection methods with different sub-populations surveyed with different methods. CATI will continue to have widespread applications for collection of household surveys, but the use of cellular telephones and personal telephone numbers (not tied to a specific location) will have a large impact on sample designs.

One major research program which has looked at computer-based surveying is the CASES project at the University of California at Berkeley sponsored by the Association for Computer-Assisted Surveys (with support from the Bureau of Labor Statistics, U.S. Bureau of the Census, and National Agriculture Statistics Services) which was founded in the early 1980s. Major changes anticipated in the future include:

1. Direct electronic procedures: touch tone entry, voice reproduction and recognition, bar code scanning, document scanning, and telephone-based without interviewer assistance;

2. Integration of data collection and database management;

3. Network-based information services (Internet); and

4. Major redesign of survey forms based on evolving graphical user interface technology.

4.2 Geographic Information Systems/Databases

The use of geographic information systems (GIS) is expected to make a dramatic change in the way that transportation data are stored, analyzed, and retrieved. The range of transportation GIS applications is almost certain to continue to grow in coming years. Sarasua and Meyer (1995) list four main uses of a GIS for travel surveys:

1. **Input** – Transportation data can be input using GIS, particularly for graphical information that is difficult to describe. An example of this application is the tracing of route information using path calculations.

2. **Geocoding** – Travel surveys can be geocoded automatically to traffic analysis zones or other geographic units based on the coded address. Address matching requires careful specification of the address on the survey and a complete address file. On-screen editing of the geocoding can reduce errors.

3. **Processing and Analysis** – Data from a number of different surveys and sources can be combined for analysis based on a common geographic coordinate system. Analysis can be aided through aggregation of data for summaries, statistical analyses based on locations, and analyses of spatially defined data such as routes and traffic flows.

4. **Output** – Survey results can be output using mapping and reporting capabilities, as well as formatted for input to travel models.

The major drawbacks to the increased use of GIS for travel surveys are cost (but cost will continue to decrease as the technology matures), the extensive data requirements such as address files, and the expertise and training needed.

A substantial amount of research has focused on GIS and its applications in transportation. The New Technologies Workshop held as part of the Conference on Household Travel Surveys (Murakami 1995) concluded that a synthesis project is needed that documents the uses of GIS with travel surveys, and the associated costs and benefits. Another conclusion was that research is also needed in the development of an integrated CATI/GIS that would provide many of the address matching capabilities on-line while the survey was being conducted. Limited applications of this kind have been completed in Baltimore and Toronto. The Federal Transit Administration is developing a transit GIS which will be used as a tool for measuring performance.

University-sponsored research on GIS for transportation applications has been conducted at the University of Wisconsin, University of Tennessee, Utah State University, University of Florida, Georgia Tech, UNC-Charlotte, Portland State University, and the University of

California at Santa Barbara. The University of Wisconsin conducted NCHRP Project 20-27, "Adaptation of Geographic Information Systems for Transportation." Texas A&M has conducted research on the preparation of multimodal databases. A related subject area is the application of databases and information systems to answer transportation planning questions through artificial intelligence (Virginia Tech) and decision support systems (University of Virginia).

4.3 Video Surveillance

The use of video camcorders has had promising results in the collection of origin-destination data. The 1991 Boston Region O-D cordon survey recorded license plate numbers using video and matched with Registry of Motor Vehicle records to obtain addresses for a mail-out survey. One main advantage is that video surveillance of vehicles avoids interference with traffic. Video camcorders also may be the best way to obtain adequate license plate data in high speed/volume traffic.

An emerging technology which could automate video collection of license plate data is machine visioning where images are converted into computer-readable characters automatically. Paul Shuldiner at the University of Massachusetts has found that machine vision processing is not yet a proven alternative due to high error rates, but that a hybrid manual/machine approach could improve results. The University of Washington has conducted research in the area of video imaging for incident detection.

4.4 Intelligent Transportation Systems

The term Intelligent Transportation Systems (ITS) refers to a number of technologies which will shape the nation's infrastructure in the years to come: traffic monitoring and signal control (ATMS), advanced traveler information systems (ATIS), advanced vehicle control systems (AVCS), and commercial vehicle operations (CVO). In 1993, nearly half of the Federal Highway Administration's research funds went to traffic operations and ITS.

The impact of ITS on data requirements for travel models is two-fold. First, the future role of transportation planners will be defined by the nature of the transportation system and the availability of dramatically expanded information to both the consumer and the provider/operator. This role is only now beginning to be explored by researchers. Second, the technologies developed for ITS can be used to improve the efficiency of data collection performed for traditional planning functions.

One technology which is available today is the use of global positioning systems (GPS) to measure travel time and distance. Machine-recorded travel is likely to be much more accurate than self-reported information on surveys. Vehicle data loggers, which record

engine performance, can be used in association with GPS to provide geographically accurate travel information.

The Federal Highway Administration has looked at global positioning systems and data transfer standards. TCRP has also conducted studies of information technology applications and the use of bar coding. Travel time can be estimated using automatic vehicle identification and simulations based on loop detector data.

ITS-related topics studied by universities include motorist information systems (MIT, University of Massachusetts, University of Texas-Austin); automated data collection at intersections (Portland State); and estimation of travel time using real time sensors and automatic vehicle identification (University of Washington). University research recently has been focused at the ITS Research Centers of Excellence.

4.5 Satellite Imaging/Aerial Photography

Images of transportation facilities recorded by satellite or photographed from an airplane may offer new ways to collect traffic volume data, particularly in areas where it is impractical to use automatic counting equipment. In 1994, the Federal Highway Administration conducted a feasibility study using NASA's Center for Commercial Development of Space at Ohio University to see how well satellite images showed vehicular traffic. The study found that tops of vehicles were indistinguishable from pavement at the present resolution of 5-m. Resolution of 1-m or better, though, should be readily available in the coming years.

Aerial photography is much more accessible than satellite images. The Metropolitan Washington Council of Governments conducted a study of congestion on the Capital Beltway that used vehicle densities derived from aerial photographs.

4.6 Multimedia/Virtual Reality

Both traditional and "leading edge" market research data collection techniques have been successfully applied within transportation for the past decade. The use of focus groups represents one such example. Stated preference surveying and modeling is a second example, with both Tom Adler and Mark Bradley having developed innovative computer systems to facilitate the use of these surveys.

Computer-based surveying allows much more complicated branching than traditional survey approaches. This approach to survey administration has now become common place within market research, and is being regularly used for transportation surveys in Europe. The application of advanced computer-based survey techniques, though, is still in the early stages of implementation within the United States.

The prominence of television and video for entertainment has suggested that respondents may be receptive to travel surveys conducted using a multimedia platform. This represents the next evolution of computer-based surveys and could increase both response rates and the reliability of data.

Video and multimedia applications may be especially important for stated preference surveys. In their proposal for a new approach to travel forecasting, MIT recommended that additional research should be devoted to the use of computer simulation and concepts of virtual reality to give survey respondents a more realistic representation of real-life choices. A research program at MIT's Sloan School of Management has introduced "information acceleration" as a technique for presenting information about a new product through simulation to potential customers. This method is based on the premise that if you can realistically give the customer the same information they will have in the future when they evaluate the new product, then preferences, purchase intentions, and information usage data can be collected to forecast and design new products.

Computer-based surveying and the use of multimedia techniques also will facilitate the use of new market segmentation approaches for the collection and analysis of transportation data. The application of market segmentation techniques already is widely applied within consumer market research but is still in the early stages of being applied within the transportation sector. TCRP Project B-9, "Market Segmentation Strategies to Increase Transit Ridership," has been initiated with the Northwest Research Group this past year to examine market segments based on characteristics such as demographics, attitudes, behaviors, values, and lifestyles in addition to geography.

5.0 Assessment of Current Research

This scan of recent and current data collection research has revealed a wide range of activities concentrating on both the types of data being collected and on the emerging technologies applicable to transportation data collection. Many of the research projects focus on specific travel demand modeling approaches (particularly at the university-level) and the associated data requirements. Others have focused on the application of a new technology, such as video imaging, for data collection. Much of the research is directed at supporting or testing a particular hypothesis.

While considerable new and important research has been undertaken in the last few years and currently is underway, the majority of these initiatives are oriented to the development of new approaches to travel demand modeling rather than to data collection per se. This characterization can be applied to the TMIP itself, the TRANSIMS component of TMIP, and to the extensive university-based research that currently is underway. The rationale for this orientation is that existing model systems are not fully satisfactory for today's needs and, therefore, an entirely new generation of travel demand modeling procedures is required. Once these new approaches to travel demand modeling are developed and validated, specification of the associated new data requirements will directly follow.

There are, however, important cost implications for metropolitan planning organizations and state departments of transportation that will bear the responsibility of collecting the data necessary to support these enhanced and new travel forecasting systems. New modeling approaches will be of little practical value if the data needed for their development and application can not be cost-effectively collected. Increased attention, therefore, needs to be given to the development of new approaches to collecting data, the costs of various types of data collection efforts, and the potential for data transferability among urban areas.

Although there is evidence of some interest in simpler, quick responsive modeling approaches, the vast majority of existing travel demand research points in the direction of new travel models that are much more data intensive than today's traditional four-step model systems. The introduction of various forms of activity-based modeling and the integration of traffic microsimulation with network assignment capabilities are both examples of this trend. If these new approaches to travel demand modeling are to be effectively implemented, both better and more data will be needed. This expanded information includes the requirement for additional traffic flow information; the treatment of the full range of modal alternatives, especially those available for short trips; a broader geographic coverage; a broader time period coverage so that off-peak and non-work travel can be fully modeled; the ability to model travel during different seasons of the year or days of the week; the inclusion of lower level transportation facilities; the explicit treatment of travel demand management options such as telecommunications;

and data on daily and weekly activity patterns for all members of a household so that trip generation and destination choice can be modeled more responsively than at present.

This demand for additional and better data, however, comes at a time when state and local transportation agencies are facing significant reductions in budget and personnel. The examination of existing data-related research indicates that an important motivation of metropolitan planning organizations and state departments of transportation is for more cost-effective means of data collection. The objective is an increase in data collection productivity, either permitting the same amount of information to be collected by fewer people or the same number of personnel to collect information from a larger sample. While important new data collection initiatives have been undertaken throughout the country during the 1990s, many of these have encountered budget difficulties and there is no evidence that these are yet viewed as routine or even periodic practice. The motivation in most cases has been that since relatively little data collection occurred during the 1980s, existing data had become sufficiently old that they no longer were an accurate reflection of current demographic and transportation patterns.

Less attention has been given within the transportation community to developing improvements to either traditional or innovative approaches to collecting the information required to support travel demand forecasting efforts. The review of research that has been undertaken nonetheless indicates that important changes still are occurring in data collection practices. While many of these changes result from the introduction of new modeling approaches such as stated preference and activity-based modeling, they also are occurring with respect to traditional four-step modeling approaches. New approaches to sample design are being developed that utilize both smaller samples and increased stratification. New data collection techniques are being utilized, based in large part on the use of microcomputer and advanced electronic technologies. These new procedures are now common within research studies, are beginning to be seen in selected urban area and state data collection practices, and likely will become routine over the longer term. FHWA training programs can begin to immediately reflect these new approaches so that their use by state and local transportation agencies is both facilitated and expedited.

The most important finding to emerge from this review of data-related transportation research is the rapidly emerging availability of electronic technologies for data collection and processing. Dramatic improvements are taking place in the use of computer-assisted surveying techniques, geographic information systems, aerial photography, video surveillance, satellite imaging, multimedia capabilities, and systems of "virtual reality." Techniques such as these increasingly are being used for data collection and market research purposes in other disciplinary fields and to a lesser degree within transportation. The emphasis by the federal government and the states on the introduction of Intelligent Transportation System technologies will only help in the implementation of these other electronic data collection technologies.

An important benefit associated with these new data collection technologies is that their use permits a much higher integration of sampling, data collection, processing, and analysis than has traditionally been the case. Highly manual and sequentially rigid data collection processes are being replaced by dynamic, analytically driven, computer-based approaches. In undertaking a TMIP Track D data research program, there is a need to facilitate the introduction of these emerging technologies into the data collection and processing practices of transportation agencies. It also is important, though, to look more

fundamentally at how these information technologies can be used to influence the types of data that are collected and how information is processed and displayed within the overall travel demand forecasting process. While it is valuable to take the current model-driven approach to determining data collection needs, the inverse approach of designing procedures based on emerging data collection and processing technologies also may provide important insights.

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Appendix A

Research Projects Relating to Track D of TMIP

Research Projects Relating to Track D of TMIP

Travel Model Improvement Program

Travel Survey Manual

This manual provides information on the following kinds of surveys: household, transit onboard, vehicle intercept, commercial vehicle/freight, workplace/establishment/visitor, panel, stated preference, special generator, and parking. For each of these survey types, the information includes: conduct of the survey, administration, design, sampling, data collection procedures, pre-testing and data entry, verification, and analysis. In addition, example survey forms are included. A National Highway Institute training course also is being developed based on this manual. Two separate CD-ROMs are being prepared, one in support of the NHI training course and one as a supporting reference to the Travel Survey Manual.

Contractor: Cambridge Systematics, Inc.
Status: Published July 1996.

Quick Start Projects

A white paper is being written comparing the state of the practice with the state of the art in travel data collection. This paper summarizes the results of several investigative activities including 1) a scan of recent travel surveys, 2) a scan of recent and current data-related research, and 3) a synthesis of previous conference recommendations and other "off-the-shelf" research statements. The information is being used in the development of a recommended long-range research program for Track D.

Contractor: Cambridge Systematics, Inc.
Status: Draft paper completed in November 1995.

Portland, Oregon Data Collection Case Study

A case study of Portland, Oregon was prepared to illustrate the application of leading-edge state-of-the-practice data collection techniques. This case study describes a number of transportation data collection activities in the Portland metropolitan area, covering the full spectrum of the travel demand modeling process from socioeconomic and land-use data through traffic volumes, speed, and vehicle classification.

Contractor: Cambridge Systematics, Inc.
Status: Completed April 1996.

Travel Time Data Collection Source Book

The objective of this project is to develop guidance for travel time data collection. The document will be user-friendly and written in clear and concise language with graphics, charts, and tables for easy data presentation. The potential users include decision makers, planners, and traffic engineers. The source book will help the users to:

- Identify travel time data needs in key areas of transportation planning applications;
- Compare the strengths, weaknesses, costs, and effectiveness of several data collections methodologies;
- Obtain guidance on sample design and sample size requirements for various transportation planning applications (facility type, level of congestion, level of precision); and
- Develop a step-by-step process for conducting travel time surveys based on specific methodologies and requirements.

Contractor: Volpe National Transportation Systems Center
Status: Pending

Case Study of CMS Data Collection: Develop a "Travel Time Data Collection Source Book"

This is a separate but related phase to the research on best methods of travel time data collection. Travel time is examined as a performance measure for evaluating mobility-increasing strategies and transportation system operation, and for calibrating travel forecasting models.

Contractor: Volpe National Transportation Systems Center
Status: Draft Report on "Travel Time Data Collection Lessons Learned"

Using Global Positioning Satellites (GPS) for Personal Travel Surveys

The FHWA Office of Highway Information Management and Office of Environment and Planning are cooperating in research projects investigating the use of small, portable, "user-friendly" units for recording personal travel by private vehicles and measuring

travel speeds. For the personal travel component, a small palmtop computer with a GPS PCMCIA card or other similar equipment will record time, position, trip purpose, and vehicle occupants. Distance, speed, roadway classification will be calculated in post-processing.

By using GPS, travel routes will be recorded with less respondent burden, but with potentially greater concerns by respondents about privacy. The precision of the travel time distribution should be increased when compared to self-reporting, and a fairly precise distribution of travel by functional classification of the roads also should be generated.

Contractor: Battelle is the lead agency; ETAK, and Cambridge Systematics are providing additional support.
Status: Ongoing, a field test will be conducted starting early in FY97 in cooperation with an MPO with an up-to-date, positionally accurate street network.

Dallas-Ft. Worth Household Travel Survey Pretest Report

The North Central Texas Council of Governments (NCTCOG) conducted a formal pretest to their 1995 household travel/activity survey. This pretest included three variations: 24-hour vs. 48-hour reporting, 7 questions vs. 11 questions per activity, and different incentives ($2, gift pen, or both). Additional research funds were provided to NCTCOG to expand the pretest with two additional variations: booklet vs. log format or diaries and telephone vs. mailback retrieval.

Contractor: North Central Texas Council of Governments (NCTCOG)
Status: Final report is available from the U.S. DOT's Bureau of Transportation Statistics

Analysis of Longitudinal Data from the Puget Sound Transportation Panel

The Puget Sound Transportation Panel was started in 1989 by the Puget Sound Regional Council. This research effort was established to develop a well integrated and well documented longitudinal data set covering 1989 through 1993 that could be sued for analyzing travel behavior changes and offered potential for use in new travel demand forecasting models. A standard set of weights has been developed which will, hopefully, result in more consistent analysis of the data set. Analytic work using the longitudinal component includes analysis of mode transitions and analysis of activity/travel patterns.

Contractor: Pennsylvania Transportation Institute at Pennsylvania State University as a subcontractor to Battelle.
Status: Completed

Synthesis Projects on Non-Response and Panel Surveys

There will be two separate products from this project. The first will be a document on reporting non-response, and methods to reduce non-response in household travel surveys. The second document will be a primer on panel (longitudinal) surveys and how they can be used in transportation research.

Contractor: Battelle, with NORC
Status: Underway.

Improved Vehicle Occupancy Data Collection

Develop case studies assessing a wide range of methods for monitoring corridor-wide, multimodal vehicle occupancy. Study sites are Chicago, Baltimore, Louisville, and Albany.

Contractor: Battelle
Status: Underway.

Congestion Management System Application Testing

Assessment of TRANSIMS microsimulation data as a source for performance measures to support a metropolitan area's CMS

Contractor: Federal-Aid through TXDOT to NCTCOG
Status: Underway.

Congestion Management System Application Testing

Development of methods, hardware, and software to coordinate data collected by the Automated Traffic Control System (ATMS) with the performance measures needed for the region's CMS.

Contractor: Federal-Aid through Washington State DOT to Puget Sound Regional Council
Status: Underway.

Urban Traffic Monitoring Scan

Investigate how traffic monitoring programs are operating in urban areas, report on findings, develop case studies.

Contractor: Volpe National Transportation Systems Center
Status: Underway.

Characteristics of Urban Freight Systems (CUFS)

Will provide a database that summarizes the characteristics of urban freight transportation systems as reported in literature or collected by local/regional planning agencies, State DOTs, and transportation operators. Second phase may involve collecting additional data.

Contractor: University of Tennessee
Status: Completed

Data Analysis and Policy Implementation for TDM Strategies (support testing of AMOS Model)

Develop a better understanding of relation between household activity and travel behavior and to study the influence of TCMs on policy measures.

Contractor: Federal-Aid through D.C. Department of Public Works and WASHCOG.
Status: Final report completed.

Development of Notebook Computer Software to Collect Trip Generation at Intermodal Passenger and Freight Facilities

Development of software to run on notebook or hand-held computers to collect trip generation and other transportation data at intermodal facilities such as airports, seaports, and rail terminals.

Contractor: Small Business Innovation Research Program
Status: Underway.

Improved Decision Support - Computer-Aided Technologies and Tools Used in Decision Making, Training, and Presentation

With the National Association of Regional Councils (NARC) and a task force of representatives from AMPO, TRB, AASHTO, etc. - define existing practice, and identify opportunities for enhancing and improving practice with recent advances in high technology (e.g., hypermedia, distance learning, etc.); assess the potential and implications for incorporating technology in the planning process in the near term.

Contractor: Cooperative Agreement with NARC.
Status: Underway.

Handbook for Data Collection/Acquisition in Small- and Medium-Size Areas

The majority of travel surveys in the 1990s (80%) have been in metropolitan areas with a population of 750,000 or more. Experience in smaller metro areas is limited, as are resources to perform basic data collection. Approaches other than traditional travel surveys often are necessary to provide the information needed to support the analytical planning process. The objective of this project is to develop and field test a Handbook for Data Collection/Acquisition for Small/Medium-Sized Areas. This handbook will contain guidelines for borrowing/sharing data, using data from different sources/pooling data from several sources; incorporating secondary data into locally collected data; transferring data; and collection of metropolitan level data on a statewide basis.

Contractor: Cambridge Systematics, Inc.
Status: Starting.

Transportation Planning Uses of Commercial Data

Travel data for use in transportation analyses traditionally are collected through surveys for a small sample of a region's households. However, it is both difficult and expensive to obtain this data. A set of innovative tools based on the use of commercial sources of data are being developed that will allow planning agencies to decrease their reliance on specially-collected survey data and make use of information such as credit reports, vehicle registrations, sales records, marketing studies and other similar information. These tools will be in the form of new or altered computer models and databases that will allow planning agencies to either supplement or replace existing data sources.

Contractor: Small Business Innovation Research Program
Status: Underway.

Comprehensive Intermodal Visual Database

Collection and aggregation of current intermodal freight transportation data from throughout the U.S. into one broad-based visual database. Database will include visual images and other computer graphics and images, narrative project descriptions, data related to intermodal facilities, county-to-county movements by mode and commodity type using CD-ROM, hypermedia, and multimedia technologies.

Contractor: Small Business Innovation Research Program
Status: Phase I feasibility study completed
Phase II scheduled for FY97.

■ Federal Transit Administration

Technology Deployment Program Support
(DC-26-7016)

Director of Technology Deployment of the Office of the Secretary is seeking to develop new alliances with other government agencies and the private industry to harness new technologies to solve transportation problems.

Transit Geographic Information System
(MA-26-0002-05 - EG&G Dynatrend; MA-26-0001-02 - Technology and Management Systems, Inc.)

Development of an electronic transit geographic information system (GIS) to be a key tool for measuring and understanding the extent, use, and performance of public transit system assets. Information developed for this system will also be a key component of the National Transportation System database.

Data on Transit Conditions
(VA-26-6003-02 – Booz-Allen & Hamilton)

The purpose of this project is 1) to develop information on transit conditions in order to improve the quality of data available for the Report to Congress on Transit and Highways Conditions, Performance, and Investment Requirements, and 2) to develop ongoing methods to collect this information.

Travel Behavioral Research
(VA-26-9014 – FHWA)

The objective of this study is to discover the travel behavioral correlations which will result in improved travel demand model structures. The determinants of travel behavior are being studied using data which has been collected from comprehensive travel behavioral surveys conducted recently. The comprehensive nature of this survey allows for examination of many travel demand issues which have been unresolved due to limited data.

Travel Time Budgets
(VA-26-9015 – FHWA)

This project is examining available data to determine whether evidence exists to either support or refute the theory that individuals have a travel time budget and travel cost budget which serve as limits to how much travel individuals are willing to do. Information being examined includes panel surveys, recent home interview surveys, the National Personal Transportation Survey, and other sources. Establishing the travel time budget theory would directly improve the ability to forecast individual response to additional highway capacity, supporting the alternatives analysis process with implications for analysis of air quality.

■ Transportation Research Board

Travel Estimation Techniques for Urban Planning
(NCHRP Project 8-29 – Barton-Aschman Associates)

This report is an update to the publication NCHRP Report 187, "Quick-Response Urban Travel Estimation Techniques and Transferable Parameters," which was based primarily on data-collection efforts conducted in the 1960s and early 1970s. The objectives of this research are to 1) identify and evaluate current and anticipated trends and issues in travel behavior, urban structure, and the transportation planning tools that will be needed to address them and 2) develop a replacement for NCHRP Report 187, with emphasis on small- and medium-sized urban areas.

Characteristics and Changes in Freight Transportation Demand
(NCHRP Project 8-30 - Cambridge Systematics)

The objectives of this research are to examine the changing character and composition of U.S. freight transportation across all modes and to develop a process for forecasting future freight transportation demand. This involves a macro-level analysis over time of the characteristics of freight transportation demand and its changes; the key economic, technological, political, and social factors that contribute to those changes; and the interaction effects between freight transportation demand and supply system.

Multimodal Transportation Planning Data
(NCHRP Project 8-32(5) - Cambridge Systematics)

The overall objective of this research is to develop guidelines on the availability and use of data to support statewide and metropolitan multimodal transportation planning pursuant to the Clean Air Act, ISTEA, and subsequent regulations. The research is 1) developing guidance for the strategic assessment of data requirements for all levels of planning; 2) evaluating current data from primary and secondary data sources by examining traditional definitions of data needs for passengers and freight planning and assessing current and future data gaps; 3) examining new analytic techniques and the data required and providing a compendium of prototypical data collection and assembly methods and technologies including traditional, innovative, and emerging techniques; 4) performing an economic assessment of transportation data programs; and 5) identifying means of integrating data for multimodal planning.

Improving Transportation Data for Mobile Source Emissions Estimates
(NCHRP Project 25-7 - The University of Tennessee Research Corporation)

The objective of this research was to improve the integration of transportation data with emissions-estimation procedures and air quality planning. Key elements of this integration process include: 1) transportation variables that are available or necessary for developing emissions estimates and other air quality projections, 2) techniques for developing values for these variables, and 3) inter-relationships between transportation data and emissions rates. The research critically evaluated these elements, and then identified and prioritized improvements to existing procedures for calculating or estimating transportation data, given existing transportation, emissions, and air quality models.

Synthesis of Household Travel Surveys
(NCHRP Project 20-5, Synthesis Topic 26-03 - Dr. Peter R. Stopher)

The objective of this synthesis was to summarize the state of the practice as found in existing criteria, guidelines, and methods. It also included information on quality control practices and methods used to plan, design, conduct, and evaluate household survey data. A questionnaire was sent to MPOs and other agencies that have conducted household surveys in the past five to seven years to gain information on how and when the survey was conducted, sampling and data collection method, pre-test pilot study, survey management, publicity, incentives, reminders, editing and coding, geocoding, costs, response rates, trip rates, and products.

Integrating Market Research into Transit Management
(TCRP Project B-2 – Northwest Research Group)

The objectives of this research were to: 1) define the status of market research as practiced in transit agencies, 2) identify major market issues confronting transit operations and services, 3) evaluate and refine, as needed, market research strategies appropriate for transit, and 4) provide guidance to integrate and institutionalize market research into the decision-making processes of transit agencies.

Demand Forecasting for Rural Passenger Transportation
(TCRP Project B-3 – SG Associates)

The objective of this research was to provide methods for forecasting rural passenger-transportation demand. Tasks include evaluation of current methods and development of improved methods, comparison of actual ridership levels with forecasts, and development of a conceptual framework and procedures for forecasting. The recommended procedures will include determination of data needs, data-collection techniques, demand-forecasting methods, and any other components needed for an effective estimation process of rural passenger-transportation demand.

Market Segmentation Strategies to Improve Transit Ridership
(TCRP Project B-9 – Northwest Research Group)

The objective of this project is to develop guidelines for transit managers to effectively use market segmentation in developing strategies to increase ridership. The guidelines at a minimum will provide the following:

1. A definition of market segmentation and its significance to transit systems' efforts to increase ridership;

2. Methods to identify and evaluate market segments in a variety of transit settings;

3. Implementation strategies from transit organizations for several market segments that show the greatest potential to use transit; and

4. A methodology to evaluate the effectiveness of the strategies.

Customer-Defined Transit Service Quality
(TCRP Project B-11 – Market Opinion Research and Cambridge Systematics)

The objective of this project is to develop a methodology that will assist transit agencies in identifying, implementing, and evaluating customer-defined quality service and in defining performance indicators that include customer-defined quality service measures for fixed-route transit. This research includes rural, suburban, and urban markets.

Information Technologies - State-of-the-Art Applications for Transit Properties
(TCRP Project G-1 - Castle Rock Consultants)

The objectives of this research are to: 1) review and critique state-of-the-art technologies and evolving real-time transit information systems, which can benefit transit properties or patrons; 2) establish criteria and develop evaluation procedures for use by transit agencies to indicate the value of each information system under consideration; and 3) demonstrate the usefulness of these procedures by evaluating several examples of applications drawn from categories such as data acquisition/handling, communications, display mechanisms, storage/retrieval, analysis/action generating, and systems integration.

Bar Coding in Transit Operations and Maintenance
(TCRP Project G-2 - Telephonics Corporation)

Bar coding has been used extensively in many industries as the standard for identification technology and some transit systems have implemented systems for inventory control, asset control, and timekeeping. The objective of this study is to develop a guidebook addressing technological advances applicable to transit and describing the costs and advantages.

Improved Passenger Counter and Classification System for Transit Applications
(TCRP IDEA 5)

This investigation develops and tests a foot-pressure generated, mat-type, passenger sensor and interface system for real-time passenger counting, classification, and transit ridership data.

■ University Transportation Centers Program, 1988-1993

New England

Analysis of Traffic Congestion and Motorist Information Systems, M. Ben-Akiva, Massachusetts Institute of Technology, (617) 253-5324. Status: Completed. Sponsor: U.S. DOT. 9/88-12/89.

Application of Video Technology and Pattern Recognition in Data Acquisition for Improved Transportation Systems Management and Planning, P.W. Shuldiner, University of Massachusetts, (413) 545-0724. Status: In progress[1]. Sponsor: U.S. DOT. 9/92-8/93.

[1]Status of "In-progress" or "Present" refers to the end of 1993.

Identification of Research Projects to Address the High Priority Needs of Transportation Operating Agencies, R. Long, University of Connecticut, (203) 486-4018. Status: In progress. Sponsor: U.S. DOT. 9/89-12/90.

Topological Databases for "Smart Driver" Information System, R. DeNeufville, University of Massachusetts, (617) 253-7694. Status: In progress. Sponsor: U.S. DOT. 9/89-Present.

Use of Information Technology for Improving Traffic Flows, M. Koutsopoulos, Massachusetts Institute of Technology, (617) 253-7132. Status: Completed. Sponsor: U.S. DOT. 9/88-12/89.

New York/New Jersey

Goods Movement: Regional Analysis and Database, G. List, Rensselaer Polytechnic Institute, (518) 276-6362, and M. Turnquist, Cornell University, (607) 255-4796. Status: Completed. Sponsor: U.S. DOT. 7/1/91-9/30/92.

Improving the Knowledge Base and Tools for Transportation Systems Capacity, W. McShane, Polytechnic University of New York, (718) 260-3848, and G. List, Rensselaer Polytechnic University, (518) 276-6362. Status: Completed. Sponsor: Pennsylvania DOT. 1/89-3/91.

Mid-Atlantic

Advanced Technology in Intermodal Surface Transportation, W. Allen and E. Morlok, University of Pennsylvania, (215) 898-8346. Status: In progress. Sponsor: UPS Foundation. 9/92-8/94.

Analysis of the First Two Waves of the Puget Sound Transportation Panel, K. Goulias, The Pennsylvania State University, (814) 863-7926. Status: In progress. Sponsors: The Puget Sound Regional Council and MAUTC. 10/92-12/93.

Applications of Artificial Intelligence to Transportation Problems, J.W. Dickey, Virginia Polytechnic Institute & State University, (701) 231-7307. Status: Completed. Sponsor: Virginia Department of Transportation. 1/89-7/90.

Decision Support for Geographic Information Systems in Transportation, Michael J. Demetsky, University of Virginia, (804) 924-6362. Status: Completed. Sponsor: Virginia Department of Transportation. 9/91-12/92.

Modeling Transportation and Economics Development at the Regional Level, D.R. Drew, Virginia Polytechnic Institute & State University, (703) 231-6070. Status: Completed. Sponsor: Virginia Department of Transportation. 1/89-7/90

Planning Multimodal Advanced Technology Transportation Applications in the Greater Philadelphia Area, E. Morlok and E. Bruun, University of Pennsylvania, (215) 898-8346 or (215) 898-3683. Status: In progress. Sponsor: UPS Foundation. 9/92-8/94.

Southeast

Geographical Information System (GIS) Database, G. Long, University of Florida, (904) 392-0378. Status: In progress. Sponsor: Florida Department of Transportation. 8/89-Present.

Geographic Information Systems in Transportation Planning and Management, W. Nichols, North Carolina Central University and W. A. Walcott, University of North Carolina, Charlotte, (919) 560-5171. Status: Completed. Sponsor: North Carolina Department of Transportation. 10/88-8/89.

Integration of Social Scientific Knowledge into Mobility Management with Special Reference to Travel Demand in High Growth Regions, E. Pas, Duke University, (919) 684-2434. Status: In progress. Sponsor: North Carolina Department of Transportation. 8/90-10/91.

Intercity Travel Analysis, E. Pas, Duke University, (919) 684-2434. Status: Completed. Sponsor: North Carolina Department of Transportation. 10/88-10/89.

Great Lakes Center for Truck and Transit Research

Analysis of the 1987 Truck Inventory and Use Survey, K. Cambell, University of Michigan, (313) 763-6076. Status: Completed. Sponsor: Motor Vehicle Manufacturers Association. 6/90-12/90.

Southwest

Aging Driver Needs for Mobility in an Automobile-Oriented Region, R. Koppa, Texas A&M University, (409) 845-3540. Status: In progress. Sponsor: U.S. Department of Transportation. 1/89-Present.

Baseline Projections on the Effects of Socio-Demographic, Economic, and Technological Trends, N. Ledé, Texas Southern University, (713) 527-7097. Status: Completed. Sponsor: U.S. DOT. 1/89-8/91.

Behavioral Considerations in IVHS: ATIS and APTS, H. Mahmassani, University of Texas at Austin, (512) 471-4379. Status: In progress. Sponsor: U.S. DOT. 9/1/92-Present.

Computational Realizations of the Entropy Condition in Modeling Congested Traffic Flow, P. Nelson, Texas A&M University, (409) 845-4132. Status: In progress. Sponsor: U.S. DOT. 8/91-Present.

Developing Mobility Measures for Public Transportation, G. Shunk and T. Lomax, Texas A&M University, (409) 845-1535. Status: In progress. Sponsor: Governor's Energy Office – Oil Overcharge Funds. 5/92-Present.

Economic and Technological Forecasting for Transportation Planning and Policy, J. Memmott, Texas A&M University, (409) 845-9939. Status: In progress. Sponsor: U.S. DOT. 1/89-Present.

Improved Forecasts of Vehicle Size and Age Distribution and the Impact on Energy Consumption and Vehicle Emissions, D. Pearson, Texas A&M University, (409) 845- 3326. Status: In progress. Sponsor: Governor's Energy Office – Oil Overcharge Funds. 5/92-Present.

Incorporation of Improved Energy Estimates and Vehicle Technology into the HPMS Needs and Impact, J. Memmott, Texas A&M University, (409) 845-3405. Status: In progress. Sponsor: Texas DOT.

Information Needs of Elderly Users of Mass Transit, R. Koppa, Texas A&M University, (409) 845-3540. Status: In progress. Sponsor: U.S. DOT. 9/1/92-Present.

Information and Telecommunication Approaches to Improve Transportation System Performance, H. Mahmassani and R. Herman, University of Texas at Austin, (512) 471- 4379. Status: In progress. Sponsor: U.S. DOT. 1/89-Present.

Modal Energy Database for Transportation, D. Burke, Texas A&M University, (409) 862-2946. Status: In progress. Sponsor: Governor's Energy Office – Oil Overcharge Funds. 9/89-Present.

Prediction of Mobile Source Emissions and Fuel Consumption, R. Machemehl and R. Harrison, University of Texas at Austin, (512) 471-4379. Status: In progress. Sponsor: Governor's Energy Office – Oil Overcharge Funds. 5/1/93-Present.

Preparation of Multimodal Databases and Methods to Analyze Data for Use in Multimodal Planning and Project Selection, D. Burke, Texas A&M University, (409) 845- 5815. Status: In progress. Sponsor: Texas DOT. 8/17/92-Present.

Urban Public Transit Systems Modeling Capabilities, R. Krammes, Texas A&M University, (409) 845-9898. Status: In progress. Sponsor: Governor's Energy Office – Oil Overcharge Funds. 12/7/92-Present.

Midwest

Development of Spatial Data Infrastructure for Transportation Planning and Public Policy Analysis, Gerad Rushton, University of Iowa, (319) 335-0150. Status: In progress. Co-sponsors: U.S. DOT and Iowa DOT. 7/92-Present.

An Improved Methodology for Considering Safety in Road Investment Decisions, David Forkenbrock and James W. Stoner, University of Iowa, (319) 335-6800. Status: In progress. Co-sponsors: U.S. DOT and Iowa DOT.

Heuristic Microcomputer Transportation Model Formulation and Solutions, L.S. Franz, University of Missouri-Columbia, (314) 882-8372. Status: Completed. Sponsor: U.S. DOT. 10/90-5/93.

Maintaining the Independence, Mobility, and Safety of Older Drivers, C.R. Mercier, Iowa State University, (515) 294-1466, and J.M. Mercier, Iowa State University, (515) 294-8889. Status: In progress. Sponsors: U.S. DOT, Iowa DOT, General Motors Corporation, Farm Bureau Insurance, 3M Company, and City of Ames. 10/91-Present.

A Study of Using Microcomputer Transportation Planning Models to Develop Key Highway Commodity Flows and Estimate Truck ESAL Values, E.R. Russell, Kansas State University, (913) 532-5862. Status: In progress. Co-sponsors: U.S. DOT and Kansas DOT. 10/90-5/93.

Mountain-Plains

Assessing the Transportation Needs of Native Americans on Reservations, T.L. Anding and W.J. Craig, University of Minnesota, (612) 625-1551. Status: Completed. Sponsor: U.S. DOT. 2/89-6/93.

An Assessment of Rural Transit Research Needs, J. Bitzan, K. Vachal, North Dakota State University, (701) 237-8949. Status: Completed. Sponsor: Internal. 6/91-6/92.

Data Reporting Needs and Potential for Standardized Database in the Shortline Railroad Industry, D. Tolliver, D. Zink, North Dakota State University, (701) 237-7190. Status: In progress. Sponsor: Internal. 6/91-6/93.

Rural Transportation Geographical Decision Support System, K. Nygard, North Dakota State University, (701) 237-8203. Status: In progress. Sponsor: Internal. 6/91-6/93.

Statistical Techniques for Traffic Volume Estimation, P.G. Benson, University of Minnesota, (612) 624-0568. Status: Completed. Sponsor: U.S. DOT. 2/89-4/91.

California

An Activity-Based Approach to Accessibility, Chienho Chen, University of California, Irvine, (714) 856-6571. Status: In progress. Co-sponsors: U.S. DOT and State of California DOT. 7/1/92-Present.

Activity-Based Models of Accessibility: Planning Implications for Urban Subcenters, W.W. Recker, University of California, Irvine, (714) 856-5642, and M. McNally, (714) 856-8238. Status: In progress. Co-sponsors: U.S. DOT and State of California DOT. 8/90-Present.

Choice-Set Modeling for Telecommuting, P. Mokhtarian, University of California, Davis, (916) 752-7062. Status: In progress. Co-sponsors: U.S. DOT and State of California DOT. 7/1/92-Present.

A Comparison of Alternative Estimation Models of Travel Behavior, R. Pendyala, University of California, Davis, (318) 231-6511. Status: In progress. Co-sponsors: U.S. DOT and State of California DOT. 7/1/92-Present.

Competitive Network Equilibrium, W.D. Walls, University of California, Irvine, (714) 725-2782. Status: In progress. Co-sponsors: U.S. DOT and State of California DOT. 7/1/92-Present.

Dynamic Discrete-Choice Modeling of Commuting Behavior, M. Khanal, University of California, Irvine, (714) 856-6571. Status: In progress. Co-sponsors: U.S. DOT and State of California DOT. 7/1/92-Present.

Dynamic Model of Household Adaptation to Changing Travel Patterns, W.W. Recker, University of California, Irvine, (714) 856-5642. Status: Completed. Co-sponsors: U.S. DOT and State of California DOT. 10/88-7/90.

Freight Network Models for Mode and Route Choice, E.C. Sullivan, University of California, Berkeley, (805) 756-1166. Status: Completed. Co-sponsors: U.S. DOT and State of California DOT. 10/88-9/89.

A GIS-Based Computational Process Model of Travel Destination, R.G. Golledge, University of California, Santa Barbara, (805) 893-2731. Status: In progress. Co-sponsors: U.S. DOT and State of California DOT. 7/1/92-Present.

A GIS Data Model for Transportation Modeling and Planning, Mei-Po Kwan, University of California, Santa Barbara, (805) 893-2731. Status: In progress. Co-sponsors: U.S. DOT and State of California DOT. 7/1/92-Present.

Improved Methods for Assessing Auto-Transit Choices, D. Bunch, University of California, Davis, (916) 752-2248. Status: In progress. Co-sponsors: U.S. DOT and State of California DOT. 7/1/92-Present.

Long-Term Forecasting with Dynamic Microsimulation, K. Goulias, University of California, Davis, (814) 863-7053. Status: Completed. Co-sponsors: U.S. DOT and State of California DOT. 8/90-7/92.

Modeling Dynamic Driver Behavioral Choice in Response to Real-Time Driver Information, J. Adler, University of California, Irvine, (714) 856-6571. Status: Completed. Co-sponsors: U.S. DOT and State of California DOT. 7/1/92-Present.

Understanding and Forecasting the Growth Rate of Auto Travel, C. Lave, University of California, Irvine, (714) 856-6502. Status: Completed. Co-sponsors: U.S. DOT and State of California DOT. 7/1/92-Present.

Northwest

The Application of Geographic Information Systems Technology to Transit Organizations, K.D. Dueker, Portland State University, (503) 464-4020. Status: Completed. Co-sponsors: U.S. DOT and Oregon DOT. 9/89-8/90.

Development of an Automated Data Collection System for Two-Way and All-Way Stop-Controlled Intersections, B.K. Lall, Portland State University, (502) 725-4245, and M. Kyte, University of Idaho, (208) 885-6002. Status: Completed. Co-sponsors: U.S. DOT and Oregon DOT.

Development of a Methodology for Subdividing Large Suburban Traffic Analysis Zones to Support Micro-Scale Traffic Impact Studies, J.B. Schneider, University of Washington, (206) 543-8678. Status: Completed. Co-sponsors: U.S. DOT and Washington State DOT.

An Evaluation of Automatic Passenger Counters: Validation, Sampling and Statistical Inference, J. Strathman, University of Idaho, (503) 725-4049. Status: Completed. Co- sponsors: U.S. DOT and Oregon DOT. 1/89-9/89.

Forecasting of CO Concentrations Near Intersections using Camera Traffic Surveillance and Neural Networks, T. Larson, University of Washington, (206) 543-6815. Status: In progress. Sponsor: Washington State DOT.

Forecasting Internal Transit Trips, N. Nihan, University of Washington, (206) 543-9639. Status: In progress. Sponsor: Washington State DOT.

Freeway Database Storage and Loop Detector Data Validity, N. Nihan, University of Washington, (206) 543-8268. Status: Completed. Co-sponsors: U.S. DOT and Washington State DOT. 1/89-9/89.

Geographic Information Systems Applications in Transit Organizations: Phase 2, K. Dueker, Portland State University, (503) 725-4042. Status: Completed. Co-sponsors: U.S. DOT and TriMet. 9/90-8/91.

Improved Error Detection and Incident Detection Using Prediction Techniques and Video Imaging, N. Nihan, University of Washington, (206) 543-8268. Status: In progress. Sponsor: Washington State DOT.

Improved Estimates of Travel Time from Real-Time Inductance Loop Sensors, D.J. Dailey, University of Washington, (206) 543-2493. Status: Completed. Co-sponsors: U.S. DOT and Washington State DOT.

Use of Automatic Vehicle Identification Techniques for Measuring Traffic Performance and Performing Incident Detection, G.S. Rutherford, University of Washington, (206) 685-2481. Status: Completed. Co-sponsors: U.S. DOT and Exxon.

Vehicle Occupancy Forecasting, C. Ulberg, University of Washington, (206) 543-0365. Status: Completed. Sponsor: U.S. DOT. 9/89-8/90.

Appendix B

Literature Search of Recent Publications and Working Papers Relating to Track D of TMIP

Literature Search of Recent Publications and Working Papers Relating to Track D of TMIP

■ Travel Behavior, Models, and Surveys

Adamowicz, W., Louviere, J.J., and Williams, M., *Combining Revealed and Stated Preference Methods for Evaluating Environmental Amenities,* Working Paper, Department of Rural Economy, University of Alberta, unpublished, 1992.

Axhausen, K.W., *Travel Diaries: An Annotated Catalogue,* Working paper, Center for Transport Studies, University of London, 1994.

Barnard, P., *Evidence of Trip Under-reporting on Australian Transportation Home Interview Surveys and its Implications for Data Utilization,* in New Survey Methods in Transport (Eds., Ampt, E.S., Richardson, A.J., and Brog, W.), VNU Science Press, Utrecht, The Netherlands, 311-331, 1985.

Beckman, R., *Disaggregate Synthesis of Traveler Populations for Transportation Systems Analysis,* paper presented at the 74th Annual Meeting of the Transportation Research Board, Washington, D.C., January 1995.

Ben-Akiva, M., Morikawa, T., *Estimation of Switching Models from Revealed Preference and Stated Intentions,* Transportation Research, A 24, A 96, 485-495, 1990a.

Ben-Akiva, M., Morikawa, T., *Estimation of Travel Demand Models from Multiple Data Sources,* in M Koshi (ed.), Transportation and Traffic Theory (Proceedings of the 11th ISTTT) Elsevier (pages 461-476), 1990b.

Bradley, M.A., Kroes, E.P., *Simultaneous Analysis of Stated Preference and Revealed Preference Information,* Proceedings of the 18th PTRC Annual Summer Meeting, Seminar H, University of Sussex, 1990.

Bradley, M.A., and Daly, A.J., *Estimation of Logit Choice Models Using Mixed Stated Preference and Revealed Preference Information,* Preprints of the 6th ICTB, Quebec, Volume 1, 117-133, 1991.

Cambridge Systematics, Inc. and Barton-Aschman Associates, Inc., *Travel Survey Manual,* prepared for the U.S. Federal Highway Administration and U.S. Environmental Protection Agency, Washington, D.C., 1996.

Golob, T.F., and Meurs, H., *Biases in Response over Time in a Seven-Day Travel Diary,* Transportation, 13, 163-181, 1986.

Goodwin, P., *Panel Analysis of Travel Behavior: Some Empirical Findings,* paper presented at the First U.S. Conference on Panels in Transportation Planning, Lake Arrowhead, CA., 1992.

Goodwin, P., Kitamura, R., and Meurs, H., *Some Principles of Dynamic Analysis of Travel Behavior,* in Developments in Dynamic and Activity-Based Approaches to Travel (Ed., Jones, P), Averbury, Aldershot, 56-72, 1990.

Hartgen, D.T., *Coming in the 1990s: The Agency-Friendly Travel Survey,* Transportation, 19(2), 79-95, 1992.

Hassounah, M.I., Cheah, L-S, and Steuart, G.N., *Under-reporting of Trips in Telephone Interview Travel Surveys,* Transportation Research Record 1412, 90-94, 1993.

Hautzinger, H., *Design and Analysis of Travel Surveys,* paper presented at the 6th International Conference on Travel Behavior, Quebec City, Quebec, Canada, May 1991.

Hensher, D., *Longitudinal Surveys in Transport: An Assessment,* in New Survey Methods in Transport (Eds., Ampt, E, Richardson, A.J., Brog, W.), NVU Science Press, Utrecht, 1985.

Hensher, D.A., and Raimond, T., *The Timing of Change: Discrete and Continuous Time in Panels in Transportation,* presented at the First U.S. Conference on Panels in Transportation Planning, Lake Arrowhead, CA, October 1992.

Kitamura, R., *Panel Analysis in Transportation Planning: An Overview,* Transportation Research, A 24, 401-415, 1990.

Kitamura, R., Lula, C.V., and Pas, E.I., *AMOS: An Activity-based, Flexible and Behavioral Tool for Evaluation of TDM Measures,* Proceedings of the 21st PTRC Summer Annual Meeting, 1993.

Kitamura, R., and Bovy, P.H.L., *Analysis of Attrition Biases and Trip Reporting Errors for Panel Data,* Transportation Research, A 21, 287-302, 1987.

Kitamura, R., and Van der Hoorn, T., *Regularity and Irreversibility of Weekly Travel Behavior,* Transportation, 14, 227-251, 1987.

Kitamura, R., and Pas, E.I., *Time Use Data and Analysis: New Approach to Transportation Planning,* presented at the 74th Annual Transportation Research Board Annual Meeting, Washington, D.C., 1995.

Kitamura, R., Robinson, J., Golob, T.F., Bradley, M., Leonard. J., and Hoorn, T. v.d., *A Comparative Analysis of Time Use Data in the Netherlands and California,* Proceedings of Seminar E, 20th PTRC Summer Annual Meeting, PTRC Education and Research Services Ltd., London, pages 127-138, 1992.

Lawton, T.K., and Pas, E.I., *Resource Paper, Survey Methodologies Workshop*, prepared for Conference on Household Travel Surveys: New Concepts and Research Needs, Irvine, CA, March 1995.

Ma, J., and Goulias, K.G., *A Dynamic Analysis of Activity and Travel Patterns Using Data from the Puget Sound Transportation Panel*, presented at the 74th Annual Transportation Research Board Meeting, Washington, D.C., 1995.

Mahmassani, H., and Stephen, D., *Experimental Investigation of Route and Departure Time Dynamics of Urban Commuters*, Transportation Research Record 1203, 69-84, 1988.

Mannering, F., Murakami, E., and Kim, S-G, *Temporal Stability of Travelers' Activity Choice and Home-stay Duration: Some Empirical Evidence*, Transportation, 21(4), 371- 392, 1994.

Meurs, H., and Ridder, G., *Empirical Analyses of Attrition and Reporting Errors in a Transportation Panel*, presented at the First U.S. Conference on Panels in Transportation Planning, Lake Arrowhead, CA, October, 1992.

Morikawa, T., Ben-Akiva, M., and Yamada, K., *Forecasting Intercity Rail Ridership Using Revealed Preference and Stated Preference Data*, Transportation Research Record 1328, 30-35, 1991.

Morikawa, T., Ben-Akiva, M., and Yamada, K., *Estimation of Mode Choice Models with Serially Correlated RP and SP Data*, prepared for the 6th WCTR, Lyon, 1992.

Morikawa, T., *Correcting State Dependence and Serial Correlation in the RP/SP Combined Estimation Method*, Transportation, 21, 153-165, 1994.

Murakami, E., and Watterson, W., *Developing a Household Travel Panel Survey for the Puget Sound Region*, Transportation Research Record 1285, 40-46, 1990.

Murakami, E., and Watterson, W.T., *The Puget Sound Transportation Panel After Two Waves*, Transportation, 19, 141-158, 1992.

Parsons Brinkerhoff Quade & Douglas, *Review of Best Practices*, prepared for Metropolitan Washington Council of Governments, Washington, D.C., December 1992.

Pas, E.I., *Multi-day Samples, Parameter Estimation Precision, and Data Collection Costs for Least Squares Regression Trip-generation Models*, Environment & Planning, A 18, 73-87, 1986.

Pas, E.I., and Koppelman, F.S., *An Analysis of the Determinants of Day-to-day Variability in Individual's Travel Behavior*, Transportation, 14, 3-20, 1987.

Pas, E.I., and Harvey, A.S., *Time Use Research: Implications for Travel Demand Analysis and Modeling*, in Understanding Travel Behavior in an Era of Change (Eds., Stopher, P.R., and Lee-Gosselin, M.), Pergamon Press, 1995.

Pas, E.I., and Kitamura, R., *Time Use Analysis for Travel Behavior Research: An Overview*, presented at the 74th Annual Transportation Research Board Annual Meeting, Washington, D.C., 1995.

Pas, E.I., and Sundar, S., *Day-to-day Variability in Urban Travel Behavior: Some Additional Evidence,* Transportation, 1995.

Pendyala, R.M., Goulias, K.G., Kitamura, R., and Murakami, E., *Development of Weights for a Choice-based Panel Survey with Attrition,* Transportation Research, A 27, 477-492, 1993.

Purvis, C.L., *The Decennial Census and Transportation Planning: Planning for Large Metropolitan Areas,* paper presented at the National Conference on Decennial Census Data for Transportation Planning, Irvine, CA, March 1994.

Purvis, C.L., *The San Francisco Bay Area Household Panel Survey: A Response to Clean Air and Mobility Initiatives,* paper presented at the First U.S. Conference on Panels for Transportation Planning, Lake Arrowhead, CA, October 1992.

Purvis, C.L., *Survey of Travel Surveys II,* Transportation Research Record 1271, 23-32, 1990.

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■ Data Collection, New Technologies, and Databases

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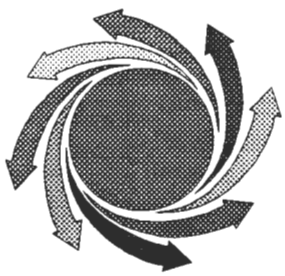
NOTICE

DOT-T-97-07

DOT-T-97-07



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