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CONFERENCE PROCEEDINGS 42

Innovations in Travel Demand Modeling

Summary of a Conference

VOLUME 1: SESSION SUMMARIES

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Rapporteur

May 21–23, 2006
Austin, Texas

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

This project was sponsored by the Transportation Research Board, the Federal Highway Administration, the Federal Transit Administration, the Capital Metropolitan Transportation Authority, the Central Texas Regional Mobility Authority, HNTB Corporation, PBS&J–Austin, and URS Corporation.

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Preface

On May 21–23, 2006, the Transportation Research Board (TRB) convened the Innovations in Travel Demand Modeling Conference in Austin, Texas. The conference was sponsored by the following agencies, organizations, and companies to provide an opportunity for a frank exchange of ideas and experiences among academics, model developers, and practitioners: TRB, the Federal Highway Administration (FHWA), the Federal Transit Administration (FTA), the Central Texas Regional Mobility Authority, the Capital Metropolitan Transportation Authority, PBS&J–Austin, URS Corporation, and HNTB Corporation. Approximately 220 individuals participated, including individuals from across the transportation research community—at national, state, regional, and local levels and from the public and private sectors and academia.

Background

The last major specialty travel demand modeling conference was held as part of the U.S. Department of Transportation's Travel Model Improvement Program (TMIP) in the fall of 1996. At that time, there was little research and no practical application of land use models and activity-based travel demand models, or integration of these models with demographic, economic, and network modes. Since then, there has been a literal revolution in travel demand forecasting. In particular, significant advances have been realized over the past decade in survey methods and analysis tools available to the travel demand modeling profession.

Conference Planning

To plan this conference, TRB assembled the Committee on Innovations in Travel Demand Modeling: A Conference, appointed by the National Research Council. Under the chairmanship of Chandra R. Bhat, University of Texas at Austin, and Kenneth J. Cervenka, North Central Texas Council of Governments, the planning committee identified three objectives for the conference. The first objective was to examine advances in travel demand modeling. The second objective was to facilitate the sharing of ideas and information among academics and practitioners on the opportunities and the challenges associated with the implementation of advanced travel models. The third objective was to identify additional areas for research, education, and training to ensure that the travel demand modelers of today and tomorrow are adequately prepared to apply the new model techniques.

After identifying the three main objectives listed above, the committee issued a call for papers. The committee sought high-quality three- to five-page white papers addressing the themes of the interactive sessions. The themes included the following:

- Data needs to support activity-based and land use microsimulation models;
- Innovations in survey data collection to support travel demand forecasting;
- Population and household synthesis;
- Validation and assessment of activity-based travel models;
- Implementation of activity-based models;

- Emerging traffic microsimulation applications;
- Innovations in traffic assignment and improvements of forecast speeds;
- Institutional, monetary, staff, data, hardware, and training resources needed to move innovative approaches to practice; and
- The role of models in decision making in the contemporary decision-making context.

The final versions of these papers are reproduced in Volume 2.

Conference Format

The conference opened with two workshops: Innovations in Practice and FTA Findings for Meaningful Forecasts. Two plenary sessions held at the beginning of the conference framed the underlying policy issues that drive model development and the issues associated with moving innovative modeling techniques into practice. Following these plenary sessions, 11 breakout sessions were held. These breakout sessions were largely based on the papers, although several non-paper-based presentations were included in areas where the committee felt that additional information was required to cover the topic. The breakout sessions were designed to provoke lively discussion. A final plenary session focused on the institutional issues to be addressed in moving research into practice.

Conference Proceedings Format

Volume 1: Session Summaries

This volume contains summaries of the plenary and breakout sessions. The workshops are not summarized because they were very informal training sessions. However, a background paper used in Workshop 1, Innovations in Practice, has been included in Volume 2. The conference summary was prepared by Katherine Turnbull, Texas Transportation Institute. A list of all conference participants can be found at the end of this volume.

Volume 2: Papers

Volume 2 contains 31 individual authored papers from the breakout sessions.

Acknowledgments

This volume has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's Report Review Committee. The purposes of this independent review are to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the committee's charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process.

TRB thanks the following individuals for their review of this report: Kenneth J. Cervenka, North Central Texas Council of Governments, Arlington, Texas; Maren L. Outwater, Cambridge Systematics, Inc., Sammamish, Washington; and Erik E. Sabina, Denver Regional Council of Governments, Denver, Colorado.

Although the reviewers listed above provided many constructive comments and suggestions, they did not see the final draft of the report before its release. The review of the final draft of this report was overseen by C. Michael Walton, University of Texas at Austin. Appointed by the National Research Council, he was responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered.

The conference planning committee thanks the TRB Transportation Demand Forecasting Committee, the Traveler Behavior and Values Committee, the Travel Survey Committee, and the Moving Activity-Based Modeling into Practice Task Force. The leadership and members of these committees and task force were important contributors to the conference.

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Overview of the Policy Issues

Chandra Bhat, *University of Texas at Austin, Conference Planning Committee Cochair*
Ken Cervenka, *North Central Texas Council of Governments, Conference Planning Committee Cochair*
Frank Koppelman, *Northwestern University*
Michael Morris, *North Central Texas Council of Governments*
Edward Weiner, *U.S. Department of Transportation*

WELCOME

Chandra Bhat

My name is Chandra Bhat and I am the cochair of the planning committee for this innovative modeling conference. Ken Cervenka is the other cochair. On behalf of Ken and the entire Conference Planning Committee, I would first like to extend a very warm welcome to all of you to our glorious longhorn world and city of Austin. We are pleased you are able to join us in what we hope will be an important landmark conference in travel modeling.

I would like to take this opportunity to recognize the sponsors of the conference. These sponsors include the Transportation Research Board (TRB), the Federal Highway Administration (FHWA), the Federal Transit Administration (FTA), the Capital Metropolitan Transportation Authority, the Central Texas Regional Mobility Authority, HNTB Corporation, PBS&J–Austin, and URS Corporation.

I will spend a few minutes on the history that led up to this conference and the objectives of the conference. As you are all probably aware, the last major specialty travel demand modeling conference was held as part of the U.S. Department of Transportation's Travel Model Improvement Program (TMIP) in the fall of 1996. At that time, there was little research and no practical application of land use models and activity-based travel demand models and their integration with demographic, economic, and network modes. Since then, there has been a literal revolution in the development, testing, and use of activity-based travel models. In particular, we have seen significant advances over the past decade in survey methods and analysis tools available to the travel demand modeling profession. The past decade has certainly been a very fertile period for the development of new approaches and techniques in travel modeling. It is indeed a very exciting time for travel demand modeling professionals.

Planning for this conference began 2 years ago under the auspices of the TRB Transportation Demand Forecasting Committee. The Traveler Behavior and Values Committee, the Travel Survey Committee, and the Moving Activity-Based Modeling into Practice Task Force also participated in the development of the conference. The Conference Planning Committee did an excellent job of organizing an interesting, informative, and challenging conference.

The conference is intended to promote an open and frank exchange of ideas and experiences among academics, model developers, and practitioners. The planning committee identified three objectives for the conference. The first objective is to examine advances in travel demand modeling. The second objective is to facilitate the sharing of ideas and information among academics and practitioners on the opportunities and the challenges associated with the implementation of advanced travel models. The third objective is to identify additional needs for research, education, and training to ensure that the travel demand modelers of today and tomorrow are adequately prepared to apply the new model techniques.

I hope you will find the conference to be informative. I encourage you to actively participate in discussions during the breakout sessions.

Conference Participants and Agenda

Ken Cervenka

I would like to welcome you to this conference and to Austin. As of yesterday afternoon, 200 people were registered for the conference. Participants come from metropolitan planning organizations (MPOs), state departments of transportation, transit agencies, federal agencies, universities, consultants, software developers, and other groups.

The conference began yesterday with two well-attended workshops. After the opening session this morning, the afternoon includes breakout sessions addressing key issues. Many of you completed an online survey to help identify topics of interest for discussion during the breakout sessions. The session moderators have a copy of the survey results and will be using them to help guide discussion after the presentations. The closing session tomorrow afternoon will summarize some of the key themes emerging from the sessions, as well as identify future research, technology transfer, and training needs to advance the state of the practice.

I hope you find the conference to be educational and stimulating. I encourage you to actively participate in the breakout sessions and to share your ideas and experiences with others.

Travel Demand Modeling and Public Policy

Frank Koppelman

As Chandra Bhat noted, the past 10 years have seen major advancements in activity-based demand modeling and land use modeling. The 1970s and 1980s were also an important time for fundamental research in these areas. We have seen progress during this period in both advancing the state of the art and in narrowing the gap between the state of the practice and the state of the art in travel demand modeling.

My comments focus on the link between the modeling community and practitioners and decision makers. There are two issues that tend to separate modelers and practitioners and slow the process of advancing transportation practice: limited communication and differences in values between the two groups.

To improve communication, decision makers must provide a clear statement of forecast needs to modelers. Modelers then need to present their work in a way that focuses on issues relevant to decision makers and in a way that helps a nontechnical audience understand very technical results.

Modelers and policy makers have two unique sets of values. Modelers tend to place high priority on the technical properties of models and their ability to represent accurately the behavior of individuals with respect to activity participation and travel. Modelers recognize that transportation is, of course, only one aspect of broad public policy; nonetheless, their emphasis is on the precision of the transportation and, sometimes, related models. Conversely, public decision makers face a range of issues, including schools, law enforcement, emergency services, water and sewer services, economic development, and other community needs as well as transportation services. Their focus is inherently broader in scope and less concerned with the causal and econometric elements of predictive models. They do not necessarily see an advantage in the evolutionary change from historical models, which were driven by statistical descriptions and simple relationships, to current models, which focus primarily on understanding and representing causality. Causality is very complex and is not one-dimensional. Understanding causality is not only a difficult aspect of modeling; it is difficult to explain to policy makers.

Different perspectives on the view of models in the decision process are illustrated in Figures 1 and 2, attributable to my colleague, Joseph Schofer. Figure 1 illustrates the modeling process from the perspective of a decision maker. As shown in the figure, policy makers tend to view the model as a relatively modest part of the decision-making process. Policy makers typically view other factors as more important than the model results and focus on information that addresses these factors.

As illustrated in Figure 2, modelers focus almost exclusively on the model and its properties. Other factors are considered to be minor. There is obviously a need to bring these groups closer together in developing a common understanding of the decision-making process and how model results can assist policy makers.

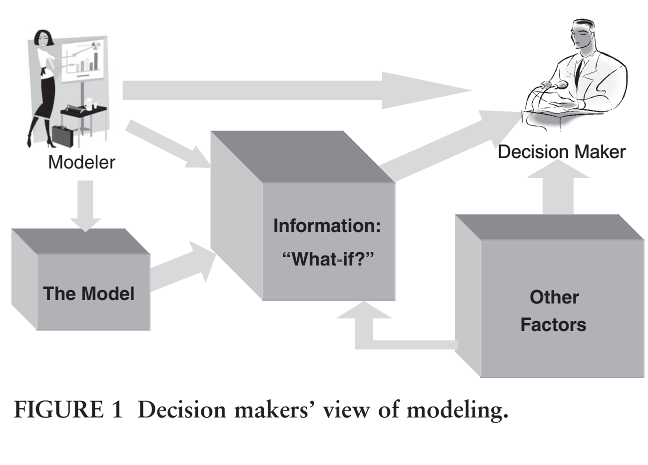

FIGURE 1 Decision makers' view of modeling.

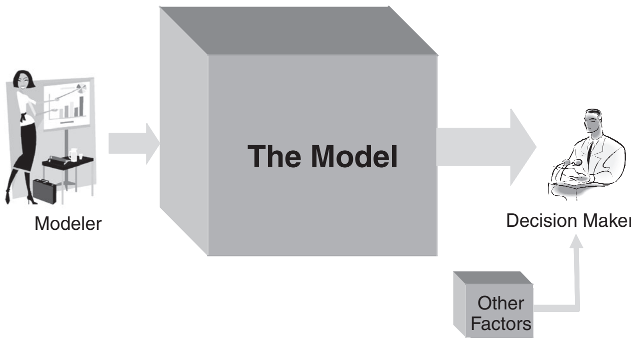

FIGURE 2 Modelers' view of decision making.

A key phenomenon of the past 30 years is a change in the scope of decision making. When I first became involved in travel modeling, the primary decisions concerned investment analysis. This analysis focused on identifying what should be built, where it should built, and how it should be designed. We have seen a very dramatic expansion in the number and the scope of issues included in the transportation decision-making process over the years. While capital investment is still a central issue, a wide range of other decisions have achieved a much higher level of importance. Such decisions include system operations and policy decisions for both transit and highway systems, pricing and the impacts on the environment, energy consumption, and urban and regional development. We need to recognize and take account of the linkages among all these components of the context as we develop and implement models.

We have seen many important developments in travel modeling over the past 30 years. These developments can be divided into the broad categories of conceptual, econometric, spatial, computational, transportation service, and land use. I will briefly discuss recent developments in each of these areas.

A key conceptual development over the past 10 to 20 years is the organization of travel behavior as part of a daily pattern of activity-based travel pattern analysis. This analysis considers all travel by household members during a portion of the day, the entire day, or longer time periods. It takes account explicitly of intraperson and interperson consistency as well as joint choice. This imposes a variety of constraints on travel analysis, including not starting an activity until the preceding activity and necessary travel are completed, and coordination of joint travel and joint activity participation between individuals and with other travel and activity participation. Further, it ensures that travel resources, primarily cars, are assigned to no more than one tour at a time.

Model design issues that need to be addressed in activity-based travel pattern analysis include generation of activities, scheduling activities, location of activities in time and space, assignment of activities to individuals within a household, and development of the travel-activity tour structure. All of these elements fit together into the daily travel-activity pattern and must be designed in a consistent and integrative way for each person and each household.

Other issues associated with activity-travel modeling are the conflict between realism and feasibility. A model cannot be a perfect representation of the real world; part of the art of modeling is deciding which components can be ignored without seriously undermining the usefulness of the model to represent behavior and inform decision makers. An effective structure balances the need to represent activity and travel components; balances activity location, scheduling, and tour structure to satisfy time–space constraints; and relates travel pattern and mode choice.

Figure 3 highlights the tour modeling dimensions. An important observation about this diagram is that the component models are generally estimated distinctly. Each component is estimated separately in both application and most research and is linked analytically. An important step in the advancement of activity-based travel models is to integrate the information and estimation process; this is a very difficult, but critical, task to ensure the consistency of relationships between the model elements.

Integrating the activity generation and scheduling process is important for entire-day schedule consistency. This process needs to recognize the dynamics of individual behavior. We tend to reflect behavior based on what individuals have done in a specific period of time. But we do not know how much of those activities were planned and how much are the result of changes in activities or conditions during early portions of the day.

The major economic developments in this field are adoption of disaggregate analysis and discrete choice modeling. The historical argument over disaggregate versus

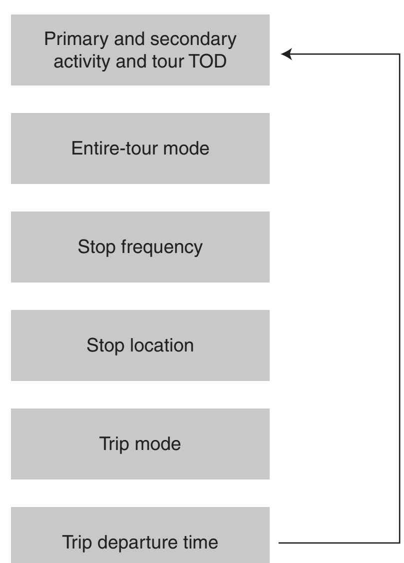

FIGURE 3 Tour modeling dimensions. (TOD = time of day.)

aggregate analysis has been resolved, with general agreement on the use of disaggregate analysis. Advances in discrete choice modeling include the use of multinomial and nested logit models, generalized extreme value models, and mixed logit models. These models better represent complex choices and substitutions among those choices.

Addressing computation-related issues has been helped by the development of enhanced algorithms for many aspects of transportation analysis. The adoption of microsimulation in travel prediction and in transport systems operations has also been a major improvement. Enhanced data collection and processing has enhanced analysis techniques for control purposes.

There have been significant advancements in land use modeling. We have also seen improvements in our ability to represent spatial detail and realistic land market representation. There has been increased application of geographic information systems (GIS) in transport system components, trans-shipment terminals, and land use components.

Dynamic assignment is one of the most central issues related to transportation service representation. However, to be effective, such analysis must be informed by a good time-of-day representation of demand. Other issues include spatial detail, consistency across levels of detail, refinement of travel supply functions, and enhanced operational control.

Despite the tremendous progress that has been made, we continue to need an increased understanding of behavioral responses. Both modelers and policy makers need to understand why we sometimes get unintended consequences from decisions that seem wise based on travel forecasts. We also need a better ability to focus on small areas or population groups, as well as the ability to represent more complex behaviors in models. As we learn more about what we know and what we do not know, the limitations of existing models become more obvious.

Other issues that need to be addressed include improved presentation of all the aspects of transportation and activity-based analysis, including supply, demand, and land use. One of the core issues is the need for better communication between modelers and decision makers. Modelers need a fuller understanding of policy issues and to improve the presentation of modeled impacts to policy makers. Modelers and decision makers also need to expand the range of decision options to be examined.

State and Local Agency Perspectives on Policy Issues: One Size Does Not Fit All

Michael Morris

This is a very critical conference at a very critical time. My remarks focus on what state and local officials expect from the modeling community. I would like you to write down four items to remember: (*a*) what you do is very important; (*b*) things are changing very rapidly; (*c*) things are changing faster than our ability to respond; and (*d*) under certain circumstances, we need to change the foundation of the way we do our jobs.

Figure 4 highlights the role of MPOs in the transportation decision-making process. I think Keith Lawton and others in the Portland area deserve a great deal of credit and thanks for the work they have done on testing activity-based models and other applications. I think all MPOs have an obligation to the modeling community—not just as users of models, but also as developers and testers of models.

MPOs receive guidance from the U.S. Department of Transportation, citizens, local jurisdictions, and policy makers. Many MPOs are involved in sharing experiences with different models and applications. Within Texas, we have partnerships to help integrate models across the state. I think MPOs should be more involved in collaborative research and we should be encouraging more partnerships with the private sector and with universities. We all have an obligation to increase communication, and by increasing communication we can help advance the state of the practice, the state of the art, and the decision-making process.

Models are not an end to themselves. Travel models are a tool to help in the decision-making process. I think we are on the verge of a new foundation in travel models. Too often in the past, the information system and the model system have been the same. We often have a problem with the public and policy makers confusing the steps in the transportation planning process and the steps in the modeling process.

Figure 5 illustrates the role that travel models play in the implementation process. I think there has to be a broader information system that creates a foundation for the whole transportation planning process. Travel models then become part of this broader foundation. Travel models, land use models, goods movement models, and input–output models are all needed.

As Frank Koppelman noted, I think one shortcoming is that we do not spend enough time interpreting the model results. The goal of travel models is not to forecast the exact number of vehicles that will use a collector street in 2010. The goal is to interpret what that number means.

One important issue is the different scales for forecasting tools and the need for consistency. We need a strong national transportation system that includes national transportation data sets. The national data need to be integrated into statewide data sets. Within Texas, new intercity corridors, called the Trans-Texas Corridors, are being developed. Tools are needed to assess travel in these corridors that are consistent with those

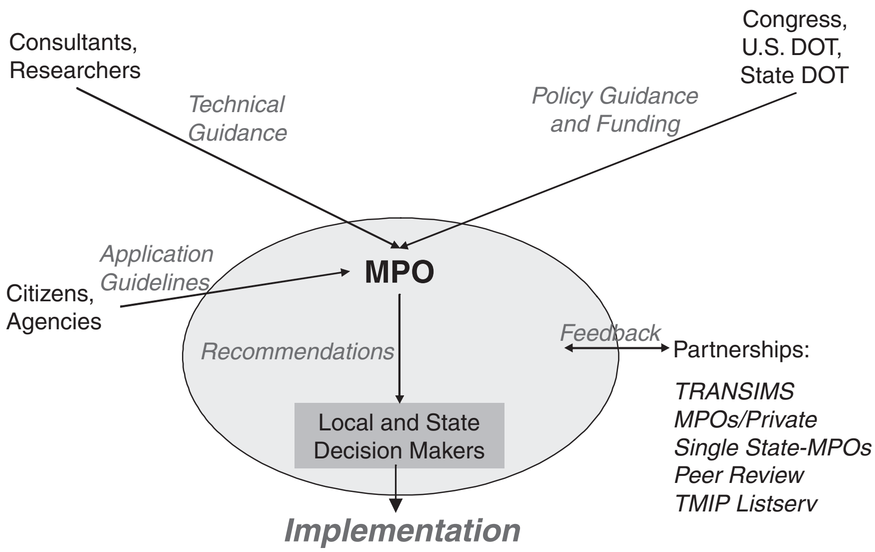

FIGURE 4 Role of MPOs in the transportation decision-making process.

used by the 26 MPOs in the state. There continues to be growing interest in rail freight operation simulation and input–output and commodity flow models. National and statewide data sets need to be consistent with regional data sets. Regional data sets often suffer from the lack of consistency within the model itself or within the activity decision-making tree.

As modelers, we face two important issues. The first issue is that we do not tend to talk about context. We need to establish the context within which the models are being applied. For example, regions are growing at different rates. The size of regions varies. Congestion levels are different and the air quality status may be different. Model applications may be used for new start projects, megaprojects, toll roads, and value-pricing projects.

It is not fair to us as modelers to recommend model elements to a community if we do not first establish a context for the community. We also need to remember who the client is in the development and use of technical tools. If we as professionals do not do a good job of answering the questions, the political process will answer them for us.

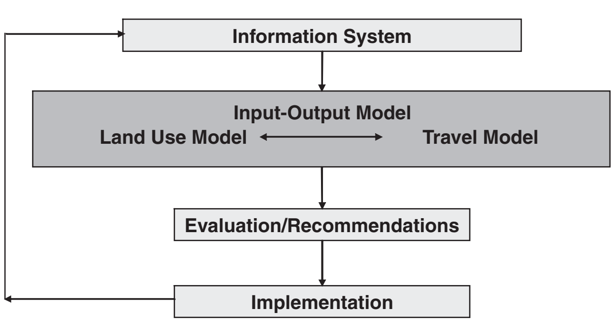

FIGURE 5 Role of modeling in the implementation process.

When most of us went to school, we were trained to help predict and analyze future assumptions. We were trained to inform the public of the consequences of specific futures based on one set of demographics. We were trained to test alternative road and transit networks. We also learned to examine one road and transit network and test alternative demographics. Finally, we learned to examine alternative networks and alternative demographics.

However, we live in a different world today. Elected officials are not modelers. Some policy makers in our region have suggested that we run our travel models backwards. This approach involves the transportation profession identifying the transportation networks, the transportation modes that should be built in various corridors, and what projects should and should not be added to corridors so the region can sustain the demographic forecasts.

The Dallas–Fort Worth Metroplex is growing by about 1 million people every 7 years. Current transportation funding cannot keep pace with the needs of this increased population. Policy makers are looking at a variety of transportation options, including tolling, variable pricing, managed lanes, and commuter rail to accommodate the mobility needs of a region with a current population of 6.5 million that is continuing to grow at a rapid rate.

The land use model starts with the residential location of the housing trip, rather than the trip distribution model, which picks the work place location of a specific trip. The model efforts under way in Denver, Colorado, focus on simultaneously calibrating the land use and the transportation elements. The model that is run backwards is the land use model. Using a land use model starts with a need to know what the public really wants.

Free market forces respond to the future vision. We need to better integrate networks and demographics.

From a strategic viewpoint, we need to do a better job of establishing priorities. We cannot model everything. In some cases, a broader information system may be enough to answer a question without detailed modeling. We also need to conduct reasonability checks related to estimation, calibration, validation, prediction, and sensitivity.

I will highlight a few policy issues and model application needs. Land use patterns are changing to include mixed use and infill development, transit-oriented development, and bicycle- and pedestrian-friendly environments. Public–private partnerships are also more important today. These partnerships relate to both subsidies to encourage private development and privatization of toll roads. We also need to be aware of the influence of changing technology, including intelligent transportation systems (ITS) to maximize flow and provide information to drivers, telecommuting, and changing work environments and dynamic pricing. We are also seeing more interest in financial constraint issues, emergency preparedness initiatives, and congestion or time-of-day pricing.

There is interest in time-of-day pricing for a number of reasons. For example, the North Central Texas Council of Governments has been asked to assess the impact of increasing peak-period tolls on carpooling, vanpooling, and transit use. We also need to know what the impact is on moving discretionary trips to off-peak periods, moving short trips to the frontage roads, and encouraging trip chaining. Other possible impacts relate to increasing flextime hours, work schedule changes, and telecommuting. Finally, we need to be able to assess whether increasing peak-period tolls will reduce trip length over time and increase reliability on the system. We need to provide policy makers with a list of the potential impacts and the possible magnitude of these impacts.

As modelers we do not always do a good job of interpreting the model results. We do not spend enough time developing and using performance measures that focus on trip performance rather than link performance. We also need other measures that better address issues of interest to policy makers and the public. Performance measures that focus on multimodal user benefits, environmental justice, accessibility by mode, and trip-time reliability are needed. Other measures that address crashes, injuries, and fatalities by mode, as well as fuel consumption would also be of benefit.

In conclusion, it is important that we continue to maintain an objective technical process. We need to transition from existing models to better models. We need to do a better job of training and documenting these new models. It is also important to keep the new models user friendly. Universities need to educate more modelers and MPOs need to ensure competitive salaries for modelers. Finally, it is important to maintain a focus on who is the client of the modeling process. Modeling is not an end in and of itself. Our job as modelers is to present the model results to policy makers and the public.

Federal Demands on Travel Demand Models

Edward Weiner

My presentation focuses on the various federal requirements that influence the use of travel demand models, including provisions of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). SAFETEA-LU continues the same basic transportation planning requirements for MPOs and states. The three basic planning documents that must be developed include a long-range transportation plan, the transportation improvement program (TIP), and the financial plan. The long-range plan and the TIP have to be updated every 4 years.

Numerous options may be considered in these plans to address transportation issues in an area. Examples of these options include transportation and land use coordination and new and expanded transportation facilities. Transportation system management components, transportation demand management strategies, ITS, and nonmotorized travel may also be considered.

There are no specific travel demand modeling requirements associated with the development of these plans. However, there are a number of transportation planning factors that should be considered. These factors include supporting economic vitality and increasing safety and security. Other factors address increasing accessibility, enhancing mobility options, protecting the environment, and promoting energy conservation. The consistency between transportation and development patterns should also be examined. Additional factors to consider include enhancing integration and connectivity of the system, promoting efficient system management and operation, and preserving the existing transportation system.

There are two basic environmental requirements related to the transportation planning process and the project development process. The first requirement relates to the National Environmental Policy Act (NEPA) and the second addresses transportation air quality conformity analysis. NEPA requires an estimate of environmental impacts and an evaluation of land development effects of new highways. Mitigation strategies must be developed and implemented if there are any negative impacts. An air quality conformity analysis that meets the National Ambient Air Quality Standards must be completed on projects. There are sanctions for failure to meet the requirements.

A variety of transportation control measures (TCMs) may be considered to help areas meet the conformity requirements. These measures include public transit improvements, traffic flow improvements, high-occupancy vehicle (HOV) lanes, and shared-ride services. Other TCMs include bicycle and pedestrian facilities and flexible work schedules. Restrictions on roads for use by buses or HOVs, restrictions on construction of roads for single-occupant vehicles, and trip-reduction ordinances may also be considered.

There are specific U.S. Environmental Protection Agency modeling requirements for MPOs in areas over 200,000 in population and for transportation management agencies (TMAs). These areas must use network-based travel models, validated against peak and off-peak counts. The model must be analyzed for reasonableness and must use the best available land use, population, and network assumptions. Future land uses must be consistent with the transportation system. In addition, emissions estimates must be based on peak and off-peak volumes and speeds. Zone-to-zone travel impedances must be used for distribution based on final assignment. The network models must be sensitive to time, cost, and other relevant factors. Finally, all assumptions and results must be documented.

These programs cover the basic requirements. There are other requirements depending on the type of transportation or transit improvement being considered and the federal funding category. The Transit New Starts program provides one example of additional requirements associated with a specific funding source. The Transit New Starts program is a discretionary grant program. FTA must make choices among competing projects from various urban areas. Consequently, FTA has emphasized the need for consistency across urban areas and the need for consistency in analytical approaches. The evaluation criteria for the New Starts program includes mobility improvements, environmental benefits, operating efficiencies, cost-effectiveness, land use impacts, and a financial commitment on the part of the area.

Environmental justice represents another area that requires special consideration. Environmental justice requires an analysis of the impacts of a project or plan on minority and low-income communities and populations. This analysis is needed to ensure that minority and low-income groups do not receive a disproportionate percentage of the negative impacts from a project. These analyses require the ability to assess the impacts of transportation improvements on specific minority and low-income populations.

MPOs in areas with populations over 200,000 and MPOs classified as TMAs must have a congestion management system (CMS). Additionally, in air quality nonattainment areas and TMAs, federal funds cannot be used for projects that increase single-occupant vehicle capacities unless the project is part of a CMS. Strategies to address congestion must be incorporated into plans and TIPs.

A wide variety of congestion management strategies may be considered and incorporated into a CMS. These strategies include travel demand management measures, traffic operational improvements, the use of HOV lanes, and public transportation improvements. Other techniques include the use of nonmotorized modes, congestion pricing, growth management strategies, and access management techniques. Still other strategies include incident management techniques, ITS applications, and the possible addition of general-purpose lanes.

There are also a number of new and emerging emphasis areas that may require special treatment in the modeling process. Examples of these emerging emphasis areas include environmental streamlining, nonmotorized transportation, ITS, private financing, pricing, and security. It is important to integrate the transportation and environmental planning processes to provide more accurate and more detailed forecasts.

Consideration of nonmotorized transportation is intended to better integrate bicycling and walking into the transportation planning and project development mainstream. The Safe Routes to Schools program provides one example of this approach. ITS are becoming more widely deployed in metropolitan areas of all sizes. It is important to be able to model the travel demand effects of freeway management systems, arterial management systems, and traveler information systems.

Private financing of different elements of the transportation infrastructure and transportation operations is being considered in many areas. Private investment firms and banks have requirements for accurate travel demand forecasts and accurate revenue forecasts. Value pricing, high-occupancy toll (HOT) lanes, and managed lanes are also being considered and implemented in some areas. The ability to model the effects of highway tolls, transit fares, HOT lanes, and variable or dynamic tolls on travel demand is needed in these areas.

Transportation security is also a critical issue facing metropolitan areas today. Elements of transportation security include prevention, protection, response, and recovery. Examples of major federally directed studies include evacuation planning for natural and man-made disasters and flu pandemic planning. The ability to model evacuation routes, as well as sheltering in place, is needed.

Obtaining and maintaining the data needed for accurate travel demand forecasting continues to be an issue in all urban areas. Much of the data used in travel demand forecasting is old and outdated. Further, much of the available data does not have the geographic and socio-demographic detail needed today. Most areas have limited funding for new data collection. In addition, non-response rates to all types of surveys are increasing.

There are numerous concerns with the travel data traditionally collected at the national level. There is currently no funding for the American Travel Survey. We are still trying to find funding for the National Personal Transportation Survey, but the situation does not look good. The American Community Survey, which is the replacement for the Decennial Census long form, may provide opportunities to obtain some travel-related data. The Census Bureau has become very concerned over data confidentiality, however, and it does not currently appear that we will be able to create urban area trip tables out of this data set. Funding was found for the Commodity Flow Survey, so we should have access to updated data on goods movement. There are similar problems with surveys and data collection at the state and local levels. Available data are frequently outdated and resources for new surveys are limited.

Additional data will also be needed to analyze other new emphasis areas. These emphasis areas include safety-conscious planning and goods movement. There is renewed interest in energy conservation and telecommuting with the recent increase in the price of gasoline. Further, SAFETEA-LU also contains requirements for the use of visualization techniques in the transportation planning process, especially public participation activities.

Even with all these concerns, MPOs still need demand models that are internally consistent and that are able to function at various geographic scales. The results must be usable at various levels of aggregation. Finally, models must be sensitive to different policy scenarios.

In closing, I offer a few ideas on criteria for success as we look at new models and analysis techniques. First, it is important to ask if the new procedures address current issues and options. Second, do they produce credible results? Third, do they have a sound theoretical foundation? Fourth, are they superior to current procedures? Fifth, do they make sufficient changes to affect outcomes? Sixth, are they in a user-friendly format? Finally, can they be incorporated into travel forecasting practice in an evolutionary fashion?

Chandra Bhat moderated this session.

PLENARY SESSION

Moving Innovative Models into Practice

Martin Wachs, *RAND Corporation*
Keith Lawton, *Keith Lawton Consulting*
Edward Granzow, *CH2M Hill*
Brian Gardner, *Federal Highway Administration*

Travel Demand Forecasting Models: Raising Some Issues

Martin Wachs

A lot has been accomplished since the previous Travel Model Improvement Program (TMIP) conference on travel demand modeling. There is still a great deal to be done, however, to advance the state of the practice in travel demand forecasting.

The TRB study, Determination of the State of the Practice in Travel Forecasting, mentioned by previous speakers is under way and the report should be available in 2007.* I have the privilege of chairing the study committee. The study identified areas in which progress has been made in the application of more advanced travel forecasting models, as well as areas in which little headway has been made. It is important to acknowledge that there is a consensus that there is a need for improvement in travel demand modeling. There is also a feeling that progress is being made at many metropolitan planning organizations (MPOs). The study results also give rise to some concerns. The findings are still preliminary at this point.

The TRB Committee on State of the Practice conducted a web-based survey of MPOs and states. A total of 228 responses were received from MPOs. The survey results are available on line at www.trb.org/ITPC/Page01.asp. In addition, in-depth follow-up interviews were conducted with personnel at 13 more innovative MPOs. A total of six interviews were conducted in person and the others were completed by telephone. The survey was conducted in detail by Frank Spielberg and members of the committee. Frank deserves a lot of credit for his work. The committee discussion of the survey has been completed and the draft of the final report is in progress. The comments in this presentation are my own, but they are influenced by the survey results and the work of the committee.

In 1993, Greg Harvey and Betty Deakin wrote that the state of the practice was not up to the tasks that were being asked of forecasters. At that time, we were beginning to discuss issues related to the growing importance of goods movement and pricing. There have been changes since 1993, including greater use of geographic information systems, improved algorithms, more feedback loops, and increases in the number of zones used in most study areas. The basic model strategies have not improved, however, and these models are being asked to address even more complex tasks.

Data inputs remain a problem in most areas. Many jurisdictions reported in the survey that population and economic activity forecasts are negotiated in political processes. Many areas use simple allocation processes to divide forecasts from larger jurisdictions, which is a highly inadequate method of forecasting. Small survey sample sizes and outdated data are common problems in many areas. Given this situation, it might be wiser to allocate limited resources to improve data than to implement advanced models.

* Special Report 288, *Metropolitan Travel Forecasting: Current Practice and Future Direction*, was published by the Transportation Research Board of the National Academies, Washington, D.C., in October 2007 and is available at http://onlinepubs.trb.org/onlinepubs/sr/sr288.pdf.

While progress is being made in many areas, it is slow. There is also wide diversity among MPOs in the use of models, available resources, and staff capabilities. A total of 11 out of 228 responding agencies reported using destination choice models. Fewer than 50% of large MPOs distribute person trips rather than vehicle trips. Approximately 75% of smaller MPOs and one-third of large MPOs do not use impedances in trip distribution that vary by time of day. These results indicate there is still a long way to go to implement what most of us regard as the state of the practice.

Only about half of the responding MPOs reported using K-factors or any zone-specific adjustments to trip distribution models. The lack of independent data was frequently noted as the reason for not using K-factors or other zone-specific adjustments. A total of 22 MPOs reported being engaged in New Start transit planning, but do not have mode choice modeling capabilities. Approximately 80% of large MPOs, 40% of midsized MPOs, and a few small MPOs reported feeding back travel times from assignment into distribution. Only 40% of large MPOs reported feeding back travel times to land use or automobile ownership models.

Goods movement is emerging as a very important public policy issue. The survey results indicate that approximately half of the small and medium-sized MPOs and 80% of large MPOs model truck trips. Further, 20% of the respondents reported using synthetic trip tables and 30% reported using factoring procedures. Some 50% reported using other methods, including borrowing coefficients from other regions. Approximately 25% of the MPOs reported using truck models that are more than 10 years old.

Despite decades of discussions in the literature, only one MPO reported using an activity-based model set and two reported trying tour-based modeling but abandoned that approach. The vast majority of MPOs stated they have no interest in trying those approaches. Most of the MPOs specifically reported seeing no reason to consider changing their current practice. This result suggested there is still a wide gap between the state of the art and the state of the practice.

The survey results indicated that validation is not conducted at all by most agencies. Where something called validation was performed, it usually consisted of comparing model outputs across a screenline with ground counts, but often using the same data that were used to calibrate the model. Statisticians would tell us that this approach is flawed as method of validation. Fewer than 10 agencies nationally demonstrated statistically appropriate validation procedures.

The committee identified a number of pressing issues. These included error propagation through chains of models, poor representation of the price or the cost of travel, and poor representation of goods movement. Further, the committee found that point estimates provide very poor support of policy making. Existing models are difficult to apply to new policy issues, such as evacuation scenarios addressing terrorism or hurricanes. The committee also found poor representation of nonresident travel, such as conventions and tourism, which are a growing percentage of the trips made in some cities. These individuals have different travel patterns, use different modes, and stay in different areas than residents. We do a poor job of modeling the travel of these groups, which are very important to the economy of those areas.

Despite these findings, most of the agencies responding to the survey rated their performance as acceptable and their models as adequate to their tasks. The committee even thought that the modeling community has performed reasonably well with the resources at hand. Most MPOs reported that they have too few staff and not enough staff time to consider the development of model improvements. If MPOs do not advocate for model improvements as a priority, who will?

Given this situation, the committee considered approaches by which to enhance travel models and the modeling process. There was agreement that better data, better use of existing models, and new model development are all needed. As a modeling community, we may be guilty of resting on our laurels. There is a need for federal leadership beyond TMIP. The possibility of MPO pooled-funding efforts is another approach. More MPOs and university partnerships represent another approach for advancing the state of the art and state of the practice.

Modeling Needs

Keith Lawton

My comments focus on some of the limitations with current models and possible approaches to address these issues. There are both structural problems and problems of practice with current travel demand models. Examples of structural issues include the use of aggregate trip-based models with a matrix-based approach and the application of static assignment using volume and delay functions. An example of a problem of practice is the limited use of integrated or linked transport and land use models.

Trip-based aggregate travel modes do not address the concept of trip sequencing in a tour. This concept is important because it affects location choice and mode choice. The needs of certain activities in a sequence affect earlier or later mode choices. Trip-based models cannot address questions related to the impact of variable pricing or dynamic pricing. Aggregate matrix processing limits the ability to examine multiple market segmentation, such as effects of household composition, income, and age. Activity-based models allow for a richer household composition and market segmentation.

Static equilibrium assignments are important. After level of service E is reached, volume demand functions are questionable. This issue affects mode choice, air quality analysis, activity location choice, and time-of-day choice. Volume-to-capacity ratios do not necessarily pinpoint problems in a way that can be prioritized. The lack of vehicle dynamics, such as acceleration and stopping, makes analysis of air quality issues a problem.

The general assumption of a static land use component negates the effect of infrastructure investments on housing and job location. It does not consider the effects of not building sufficient transportation infrastructure on land use. Static land use assumptions can either underestimate or overestimate needs.

I would like to offer a few suggestions on the direction in which modeling should be moving. First, we need to move toward the use of tour-based or better activity-based models. Second, we need to continue to develop large-scale microsimulation or large-scale dynamic traffic assignment (DTA) models. Third, there is a need to deploy integrated land use models for major planning exercises.

There are some limitations with the current tour-based models. The model structure is typically similar to the trip-based model structure, which begins with activity location and mode. It is possible to improve on the trip-based approach, however, because the activity pattern is known at mode choice. With network microsimulation, it becomes evident that location choice for transit users and walk trips might be fundamentally different than for automobile trips.

There is a lot of activity focused on current microsimulation and DTA limitations. TRANSIMS provides an approach to addressing many concerns, including the need for more scale and more granularity.

There are limitations with currently available land use models. Some of these limitations focus on competing technologies and tools that add complexity, as well as additional staff and financial resource needs. Land use modeling should be attempted, however, even if it is only a simple approach. A simple technique can begin the institutionalization of using land use models with technical staff and policy makers.

We need to continue to focus on bridging the gap between the use of trip-based models and the use of more advanced tour-based models. Tour-based models are in practice in a few places, but additional implementation is needed. There are still some improvement needs with tour-based models, but they produce better results than trip-based models. Minor improvements from common postprocessing are not enough with assignment. There is a need to explore other available methods. We have much to learn from the experiences with the use of different models in different areas.

Developing Detailed Projections of Impacts of Spatial Separation, Mitigation, Supply and Demand, Infrastructure, and Strategies in a Volatile Economic, Social, and Physical Environment

Edward Granzow

My comments focus on software systems and their application in travel modeling. As we consider travel demand models, it is important to focus on the uses of these models. This approach helps us to better understand what the various models can and cannot do, where we stand in terms of current and expected innovative practice, and challenges we still face. My comments focus on both operational and theoretical aspects of travel modeling. Any approach we take will have potential costs and benefits in terms of the operational environment and in terms of the theory.

It is important to remember that we are moving from a modeling environment that is fairly flexible and easy to use, and that has benefits to MPOs in solving real-world problems, into an environment where there is a lot more fidelity. There are a number of items that are important to consider in moving toward more widespread application of advanced models.

The innovations in travel models that we are discussing are phenomenal, but more work is still needed before we will see widespread application. It is important to remember that advanced travel demand models are not a magic solution.

There is still uncertainty related to the future demands that we may face as modelers and I do not think that we have a coherent strategy for addressing these demands. We need a broader perspective as we examine the future of travel demand modeling. The title of my presentation, Developing Detailed Projections of Impacts of Spatial Separation, Mitigation, Supply and Demand, Infrastructure, and Strategies in a Volatile, Economic, Social, and Physical Environment, highlights some of these points.

The first few words are the key part of the title. Most of the words after that are modifiers. As modelers, we are being asked to provide more information about the future. We are being asked to deal with a larger number of varied assumptions as model inputs. I use the concept of "feasible regions" to potentially identify an area of a graph that represents the possible outcome of a situation given a number of model runs. Models are more complex today. This complexity may limit the viability of models to conduct "what if" analyses. Also, the cause and effect and impact chains become less clear. Model complexity can obscure practical applications.

The three words—spatial, separation, and mitigation—relate to the way in which telecommunications is interacting with transportation. Telecommunications is changing extremely quickly. Options to "transporting" are becoming more viable. Spatial, separation, and mitigation activities must be the base for forecasting. Pricing and economic models are becoming more varied and complex.

Available technologies are shortening the response times and the dispersion times. These items need to be examined in travel demand modeling and may impact the fundamental assumptions and parameters that are being utilized. The baseline may be changing in the modeling process. There is a need to evaluate radically different scenarios. There is also a need to be able to quickly accommodate changing baselines.

There are a number of transportation planning issues and questions that cannot be addressed by current travel forecasting models. There are a range of questions stemming from opportunities related to technology, institutional change, and broader social and environmental change that challenge the capabilities and the range of predictive powers of models currently being used or envisioned in the future. I think this is an issue that needs to be addressed in the long term.

To help address this issue and other concerns, the travel modeling community needs a comprehensive and coherent view of the range of demands being placed on travel models. This approach means establishing a top-down process that begins by inventorying capabilities, identifying needs and potential needs, and moving toward a balanced research and application perspective.

To help bridge the gap between current model practice and innovative model research, the travel modeling community should establish a program to further identify development and deployment goals. Research, demonstration projects, and funding should be tied to a consensus-driven program that represents the best assessment of methods to address future forecasting needs.

There is a need to increase resolution and focus on specific time-of-day models. Other areas of need include the ability to forecast turning movements, evacuation planning, transportation demand management analysis, and congestion management. Enhanced capabilities in transportation system management and intelligent transportation system deployment and evaluation are also needed. Safety planning, submode analysis, and interim improvement planning and analysis highlight other needs.

It is important that travel modeling focuses on more than just transportation. The framework of analysis is becoming increasingly comprehensive and travel models are being asked to predict travel impacts on the entire social fabric. Examples of these expanded social issues include environmental justice; land use economics and location; urban planning; system operations policy; and air, noise, and water quality.

We also face increasing complexity in understanding need–option relationships. Markets are more complex with diverse supply–demand relationships. There is greater interplay today between public and private ownership and management of different modes of the transportation system.

Innovations in Modeling

Brian Gardner

Other speakers have highlighted many of the issues that need to be addressed as we work toward improving both travel demand models and the use of new modeling techniques. Examples of model enhancements include addressing future land use changes, activity and travel budgets, and departure time and peak spreading. Being able to assess traffic operations impacts, including traffic control and queuing, is also important.

A number of factors appear to be influencing the slow movement toward widespread application of new travel demand models. There is a perceived lack of need in many areas due to institutional issues and market inertia. There is sometimes a lack of interest in using models beyond meeting federal and state requirements. There are limited data on the benefits of using new models. There is limited quality assurance and quality control on some travel demand models. Finally, many MPOs and areas face staffing and financial limitations.

There are also factors pushing for change, however. First, there is more stress on the policy and investment decision process in many areas. The growth in demand for travel in all sectors is outpacing the growth in supply. Active, well-informed stakeholders with competing agendas are pushing for better data and better models. Policy makers and all groups are faced with more complex decisions.

Let me suggest a few areas on which we should focus our energy and resources. First, there is a need for accurate data programs to support the "3C" planning process. We must understand key regional travel markets and support best-practice model validation. Second, it is important to improve model quality assurance and quality control methodologies. Third, we need to make the results from the travel demand modeling process more useful and understandable to policy makers and stakeholders. Finally, we must do a better job of incubating new travel demand modeling technologies and methods.

To help advance the state of the practice, we need to improve access to new tools through licensing, distribution, teaching, and research. Practical documentation of the new travel demand forecasting tools and techniques is also needed. Case studies using real issues and real data, as well as published peer review findings, are required.

Bruce Spear, Federal Highway Administration, moderated this session.

BREAKOUT SESSION

Tour-Based Models

Mark Bradley, *Mark Bradley Research and Consulting*
John Bowman, *John Bowman Research and Consulting*
Peter Vovsha, *PB Consult, Inc.*
Kuo-Ann Chiao, *New York Metropolitan Transportation Council*
Maren Outwater, *Cambridge Systematics, Inc.*
Billy Charlton, *San Francisco Transportation Authority*
David Schmitt, *AECOM Consulting*
Rebekah Anderson, *Ohio Department of Transportation*

Design Features of Activity-Based Microsimulation Models for U.S. Metropolitan Planning Organizations

Mark Bradley and John Bowman

Mark Bradley discussed the design features of activity-based models recently developed or implemented at selected metropolitan planning organizations (MPOs) throughout the country. The metropolitan areas examined included Portland, Oregon; San Francisco; Sacramento; New York; Columbus, Ohio; Atlanta; and Denver. Volume 2 includes a paper on this topic.[1] The following points were covered in the presentation.

- The activity-based models in the seven areas are in different stages of development, implementation, and use. The Portland model was developed in the late 1990s and has been used in a number of studies, including examining road pricing options. The San Francisco model and the New York model were implemented after Portland. The Sacramento model is being implemented. The Atlanta model is in the estimation stages. The design stages of the Denver and the San Francisco Bay Area models are just being completed and the estimation stages are beginning.

[1] See Bradley, M., and J. Bowman. Design Features of Activity-Based Microsimulation Models for U.S. Metropolitan Planning Organizations: A Summary. In *Conference Proceedings 42: Innovations in Travel Demand Modeling, Volume 2: Papers*, Transportation Research Board of the National Academies, Washington, D.C., 2008, pp. 11–20.

- The activity-based models examined share a similar overall structure, with a hierarchy of levels. They are all microsimulation based, simulating people and households one at a time. The models also produce trips that go into an aggregate equilibrium assignment. The assignment procedure is the same as in the four-step modeling process. The process for trips going into the model assignment is different, however. At the bottom level are trips and stops, which are similar to trip-based models. The second level, which includes tour-level decisions, and the third level, which includes person-day decisions and household-day decisions, are different. The top level of longer-term household and person-level decisions is also different. This level includes decisions related to work, school, and automobile ownership. There are important design features that distinguish the different models.
- All of the model systems simulate persons one-by-one and require a representative sample of households and persons for the base year and a given forecast year. Most of the models use a synthetic sample, which represents every person in the population in a given forecast year. Most areas use three variables to design and construct the sample for every zone. These variables are household size, number of workers in the household, and household income. Other variables used in some models include the age of the head of the household, the presence of children under 18 years of age, the presence of adults over 65 years of age, and family and nonfamily households. Race and ethnicity are being added to the San Francisco model.

• A key design issue at the person-day level is the number of activity and tour purposes to be considered. The early versions of the Portland model and the San Francisco model include three activity purposes. The other models have at least seven activity purposes. These activity purposes typically include work, school, escort, shopping, meals, personal business, and social and recreational. Most models do not distinguish between different types of in-home activities, including work and nonwork activities.

• A key feature of most of the models is the ability to model a person's daily activity pattern. This feature includes how many trips individuals make for different trip purposes. In addition, some models include the presence of extra stops by purpose, the allocation of stops to particular tours, and the presence of work-based subtours. Only a few models include in-home activities.

• The least consistent aspect of the different models is how tour complexity and trip chaining are measured. Some models consider these elements at the upper level of the model and all of the tour and trip decisions cascade off of this level, which results in a lot of substitution at the top level. Other models predict tours at the upper level of the model. These models predict if the individual makes stops and the purpose of the stop.

• Four types of household linkages are included in some of the models. First, the main pattern type for each person in the household is explicitly linked. A second linkage is joint tours with household members traveling together, which are generated separately for individual tours. A third linkage allocates some activity purposes—such as escorting or chauffeuring, shopping, and other maintenance—between household members. A fourth linkage uses escorting as a tour or stop to pick up or drop someone off with a different activity purpose. These linkages add complexity to a model. The Columbus model is the only model that includes all four linkages.

• Time-of-day models include simultaneously predicting the time that an individual arrives at work and the time that he or she leaves work. A question is how narrow the time period should be for these models. One to 2 hours seems appropriate. At the trip level, where an individual may make intermediate stops along the tour, there is a need to predict what time the individual leaves each stop. In this case, a smaller interval, typically 15 or 30 minutes, is needed. The benefit of these types of models is that they provide consistent tours across the day. Most of the models have fully consistent time windows. Every time an individual is predicted making a tour or a trip, that time window is blocked out so that the individual cannot do anything else. Time-pressure variables may also be used. These variables may result in individuals squeezing activities into shorter time periods or reducing the length of a trip. Time and space constraints can also be introduced into models.

• A major advantage of microsimulation models is that the analysis is completed at the zone level. The zone level can be used for origin and destination matrices, skims such as zone-to-zone travel times, and travel level of service. A more detailed level of spatial aggregation can be used for transit access times, walk times, and pedestrian environment factors.

• The Sacramento model can predict travel demand at the parcel level. There are 700,000 parcels in the model. A building level or parcel level is also being considered in the Denver model. A hybrid approach of being able to use both a zone level and a parcel level may be a logical approach. The model design is similar for these applications.

• The models also allow accessibility from the land use and travel system to affect every single decision in the model system, not just mode choice and destination choice, but trip chaining, making more tours, automobile ownership, and work location. A traditional log-sum approach, where the whole model system is one large nested decision structure, would not be able to accommodate these elements, because it would take a very long time to run the model. Determining good log-sum or accessibility measures that can be used at the upper-level tour generation day pattern models and car ownership models may be needed in some models. Fairly detailed log-sums can be used for work and school destinations. Precalculated zonal mode and destination choice log-sums by segment can be used for transit accessibility, automobile availability, and household income.

New York Metropolitan Transportation Council Tour-Based Model Development

Peter Vovsha and Kuo-Ann Chiao

Kuo-Ann Chiao and Peter Vovsha described the development and use of the New York Metropolitan Transportation Council (NYMTC) model. They discussed the need for a new travel model, the key elements of the model, and applications of the model. Volume 2 includes a paper on this topic.[2] The following points were covered in their presentation.

• Work began on developing a new travel model in the New York region in the late 1980s. One of the limitations of the old model was that it stopped at the Hudson River. Household travel surveys were conducted in 28 counties in three states as part of the model development process. The region is approximately 9,700 square

[2] See Vovsha, P., and K.-A. Chiao. Development of New York Metropolitan Transportation Council Tour-Based Model. Volume 2, pp. 21–23.

miles, with a population of approximately 20 million. There are approximately 4,000 traffic assignment zones, six trip purposes, and 10 motorized modes in the model, as well as four types of urban development. The four urban development types range from the very dense central business district (CBD) to rural areas.

- The NYMTC model has four major consecutive modules. The first module is tour generation that includes household synthesis, automobile ownership, and journey frequency choice models. The second module is tour mode and destination choice that includes premode choice, primary destination choice, entire tour mode combination choice, stop-frequency choice, and stop-location choice. The third module is the time-of-day choice and preassignment processor that includes tour time-of-day choice for outbound and inbound directions, trip mode choice, and construction of mode-specific and time-of-day period-specific trip tables. The fourth module is traffic and transit simulation that is implemented by time-of-day periods. The first three modules are implemented as fully disaggregate microsimulation procedures working with individual records for the synthesized population, which includes households, persons, and tours. The fourth module is based on standard aggregate zone-to-zone assignments implemented in TransCAD.
- A tour-based model was used because it was the best approach to addressing complex mode and time-of-day choice in a consistent manner. The model also provides the best method to understand and forecast the highly diverse demographic and travel patterns in the region.
- There are numerous stakeholders in the New York region. NYMTC staff undertook an outreach and education program to explain the need for the new model and to build support among different groups. These efforts included technical outreach to staff at other agencies, as well as meetings with policy makers.
- The model has been used in a number of applications, including air quality conformity analysis, major investment studies, and local planning activities. Examples include the Tappan Zee Bridge study, the Goethals Bridge study, and the Manhattan area pricing study. The experience to date with the use of the model has been positive.
- Work is under way to make the model accessible on the Internet. A new wave of data collection will also be starting. This data collection will include a major household travel survey, a work place survey, and obtaining information on visitor trips. The results of the data collection efforts, which are anticipated to take approximately 3 years, will be used to update the model.
- It is important that models are calibrated to ensure that they replicate reality. A nontrivial and often not explored question relates to validating and calibrating a model chain rather than a single model. A key aspect in the calibration process is to properly identify the source of any discrepancy. It is important to identify the problem first before rushing to make adjustments in the model. Another suggestion is not to overadjust. A good approach is to begin with the largest discrepancies.
- Reporting and analysis are also important elements. Most staff who operate the models are not involved in all aspects of the planning process. Reporting the results represents the link between the modelers, planners, and policy makers. Take care to distinguish between reporting options per se and reliability of the forecasts at a fine level of typological, spatial, or temporal detail. Activity-based models are more exposed than aggregate models because more detailed reports may be generated from these models.

The San Francisco Model in Practice: Validation, Testing, and Application

Maren Outwater and Billy Charlton

Maren Outwater and Billy Charlton described the validation, testing, and application of the San Francisco County Chained Activity Modeling Process (SF-CHAMP), which was developed for the San Francisco County Transportation Authority (SFCTA). They discussed the development of the model, the model validation process, applications of the model, and comparisons of the model to the four-step model. Volume 2 includes a paper on this topic.[3] The following points were covered in their presentation.

- SF-CHAMP was developed in 2000 and 2001. The model was developed to provide detailed forecasts of travel demand for various planning applications in the county. These applications include countywide plans, corridor and project-level evaluations, transit plans, and neighborhood plans. The objective was to accurately represent the complexity of the destination, temporal, and modal options, as well as to provide detailed information on travelers making discrete choices. A tour-based model using synthesized population as the basis of decision making rather than zonal-level aggregate data sources best met this objective.
- The development of the model was influenced by limited resources and time availability. These limitations were considered in the development process. First, no transit onboard survey data were available to validate the mode choice elements of the model. This limitation would have been an issue for a trip- or a tour-based model. New onboard survey data have recently been collected and are being used to update the model. The peak-

[3] See Outwater, M. L., and B. Charlton. The San Francisco Model in Practice: Validation, Testing, and Application. Volume 2, pp. 24–29.

spreading model component that was used was transferred from the Metropolitan Transportation Commission (MTC) model. Some issues had to be addressed in transferring the model and expanding it for different trip purposes. The peak-spreading model has been updated based on the results of FHWA-sponsored research on integrating time-of-day models with activity-based models. Due to limited resources, a traditional aggregate assignment was used for trip assignment rather than a microsimulation assignment.

- The model was developed for SFCTA. To maintain consistency with the regional model, the MTC's regional trip-based model was used and integrated with the tour-based model for San Francisco County. This approach presents some limitations on the cross-county movement. Stated preferences surveys were used to collect data on crowding and reliability and the impacts of these two features on mode choice. Equilibrium measures of time were estimated for commuters and noncommuters to higher and lower levels of crowding and reliability. Although there were significant effects from these measures, the results were not intuitive to the transit boarding data available at the time. As a result, they were taken out of the model.
- The model validation process required significant resources. A variety of traditional data sets were used for validation purposes. Validation was conducted for each model component separately. Additional validation was conducted by comparing the model to the trip-based regional model for each model component. The comparison to the four-step model was conducted for both the base year and the forecast year. The comparison, which was conducted for San Francisco County residents, included all the input data, the assumptions, and the model output for the base year and the forecast year. Because of the limitations in the trip-based model, which produced only trips and not tours, the comparisons were made at the trip level.
- The trip generation comparison included examining the trip rates per household for different trip purposes. The other, non-home-based trip categories were overestimated in the San Francisco tour-based model, while the work and school trips were underestimated. These differences appear to be the result of using estimations based on two different surveys, rather than the models. A comparison of the district-to-district trip table summary showed very little difference in the two models. One of the noticeable, although not significant, differences was in the higher percentage of trips in the San Francisco CBD zone for the San Francisco tour model. It appears that this difference also results from the underlying survey data set and not the models.
- The mode share components in both models were estimated based on the same data sets. The differences in mode share appear to be a by-product of calibrating the San Francisco tour model with transit boardings in San Francisco, which may overestimate from the original model. These differences resulted in a reduction in transit trips in the tour model compared with the regional model and a corresponding increase in driving alone and walking. This difference was a calibration issue more than a difference in the models. Tour-based models and trip-based models are both validated to observed data. The differences that were identified in the validation process related to differences in the underlying data sets, not the models.
- There are differences in the outputs from the two models for the forecast year. A comparison of the trip tables for 2030 highlights one of these differences. Most of the differences by districts are small. The San Francisco tour model shows a larger increase in trips in the suburban district and a drop in trips in the intradowntown district. The MTC trip-based model shows more growth in trips to the downtown district and more growth in intradowntown trips.
- In terms of mode share, both models show an increase in drive-alone trips for 2030. The growth in suburban portions of the county, which do not have good transit access, may account for this increase in drive-alone trips. The MTC trip-based model shows a more significant drop in walk trips, while the San Francisco tour model has a more significant decline in walk-to-transit trips. In the San Francisco model, walking is integrated as part of many different types of tours that people make during a day. As a trip-based model, the MTC model does not have this feature. Increases in trip distances impact the number of walk trips.
- The San Francisco tour model has been used for a number of different applications. The model has been well received by technical personnel, policy makers, and other groups. The model has been used for both traditional planning studies, as well as projects utilizing the tour-based features. A disaggregate equity analysis was conducted to examine possible unintended consequences of countywide improvements being considered in the 30-year plan. The analysis focused primarily on two factors: mobility, as measured by total travel time for a group or total transit travel time for a group, and accessibility, as measured by the total amount of employment that could be reached within 30 minutes of a zone or the total amount of retail that could be reached within 30 minutes of a zone. The different groups examined in the analysis were households with no automobile available, low-income households, female-headed households with children, and single-parent households. The no-automobile households and the low-income households received most of the benefits from the countywide plan because the improvements focused primarily on the transit system. Female-headed households with children received few benefits from the plan. It may be that these households are not making trips by transit.

• An application of the tour model was also used on the proposed New Central Subway project in downtown San Francisco. This analysis represented one of the first applications of a tour-based travel model on an FTA New Starts program submission. Software was developed to collapse the microsimulation output of the tour and trip mode choice models into a format compatible with the FTA SUMMIT program. The SUMMIT program was used to analyze user benefits accruing to the project.

Mid-Ohio Regional Planning Commission Tour-Based Model Development

Rebekah Anderson

Rebekah Anderson discussed the development and application of a tour-based travel forecasting model at the Mid-Ohio Regional Planning Commission (MORPC) in Columbus, Ohio. She described the model development process, including the use of a multiagency advisory committee, and highlighted elements of the model. More detailed information on the model components and the validation process are described in other sessions. Volume 2 includes a paper on the topic.[4] The following points were covered in her presentation.

• In the summer of 2001, MORPC issued a request for proposal for improving the existing four-step model, which was a destination-choice model, oriented to journey-to-work trip purposes. In the fall of 2001, PB Consult, Inc. was selected to conduct the model improvement and proposed a disaggregate microsimulation tour-based model.

• An advisory committee provided guidance during the development of the new tour-based model. The advisory committee included representatives from MORPC, the Licking County Area Transportation Study (LCATS), the Ohio Department of Transportation, Ohio State University, the Northeast Ohio Areawide Coordinating Agency, the Ohio-Kentucky Indiana Regional Council of Governments, FTA, and the Central Ohio Transit Authority. The committee examined elements related to the advantages of tour-based models, as well as data requirements and cost implications. LCATS was also interested in being able to freeze the non–Licking County portion of the model. Overall, the advisory committee favored the structure of the model. The committee also thought the ability to present a range of forecasts was valuable. FHWA and FTA staff supported the use of the microsimulation model and provided feedback during the development process.

• It is important not to underestimate the model development time. The development of the MORPC model took longer than anticipated. In December 2001, MORPC accepted the disaggregate model approach. In June 2004, the highway model validation and the long-range transportation plan were adopted. In December 2004, the advisory committee accepted the full model validation. The MORPC experience also indicates the importance of validating the existing model first.

• Since 2004 the model has been used on the draft of the Environmental Impact Study on the North Corridor Transit Project and other studies. AECOM Consulting was also hired to conduct a quality assurance and quality control analysis of the model. PB Consult, Inc. also conducted a transit refinement.

Application of a Microsimulation Model for User Benefit Calculation in Transit Projects

Peter Vovsha

Peter Vovsha discussed the use of microsimulation travel models for estimating user benefits of New Starts transit projects. He described the FTA requirements for estimating user benefits, the use of microsimulation models in this process, and the application of the MORPC activity-based model in the North Corridor study. Volume 2 contains a paper on the topic.[5] The following points were covered in his presentation.

• The FTA requirements for estimating user benefits are based on the general methodology of assessing the difference between the total composite utilities before the project is implemented and after the project is operational. FTA limits the composite utility choices to mode and route choices. The total trip table is assumed fixed and the mode and route choice attributes that are used for calculation of the composite choice utility are reported.

• The FTA approach and the SUMMIT software developed to meet the requirements are designed primarily for traditional four-step models that are characterized by the ability to separate the trip distribution and the mode choice steps. This permits a fixed trip table to be run through the mode choice step for each alternative being evaluated. The more complicated structure of activity-based, tour-based microsimulation models requires reconsideration of calculating user benefits. Trip generation, trip distribution, and time of day are fixed across all scenarios in the four-step model. Mode choice, estimation of user benefits, and assignment are rerun for

[4] See Anderson, R. Development of Mid-Ohio Regional Planning Commission Tour-Based Model. Volume 2, pp. 30–32.

[5] See Vovsha, P. Application of Microsimulation Model for User Benefit Calculation in Transit Projects. Volume 2, pp. 33–36.

each scenario. The trip distribution and mode choice stages are more closely intertwined with the new microsimulation models. In theory, the new models offer additional possibilities for quantifying user benefits of transit projects compared with the traditional models. There are still numerous methodological and technical questions to be addressed, however.

- The MORPC model was used in the North Corridor study. Key subsets of the model include the primary tour destination model, the time-of-day model, the entire tour mode and best transit submode, the stop frequency model, the stop location model, the trip mode model, and the traffic and transit assignment.
- In the North Corridor study, the MORPC model was first run for the base scenario. All tours were fixed with their primary destinations and the build scenario was run for several iterations, including only mode, stop frequency, and stop location choices, as well as assignments. The tour-level mode choice statistics are used for the user benefit calculation. The SFCTA model has also been used on an FTA New Starts program analysis. This assessment was part of the New Central Subway Project in downtown San Francisco. With the SFCTA model, user benefits are estimated from both the entire tour mode choice and the trip mode choice.

Application of the Mid-Ohio Regional Planning Commission Microsimulation Model: Review of the New Starts Program

David Schmitt

Dave Schmitt described the use of the MORPC microsimulation model to generate forecasts for the North Corridor Transit Project (NCTP). He summarized the model elements, the requirements of the FTA New Starts program, the NCTP, and the application of the model with the NCTP. Volume 2 includes a paper on this topic.[6] The following points were covered in his presentation.

- An independent review of the MORPC microsimulation model was conducted at a New Starts level of scrutiny. The key review elements included trip distribution, transit network (including access coding, automobile and transit speeds, path building, and mode choice), transit assignment, and user benefit results.
- The MORCP model is a disaggregate tour-based model applied with the microsimulation of each individual household, person, or tour. Travel is accounted for at the tour level, as opposed to the trip level, for each individual household and person, rather than zonal and market segment aggregates. The network and assignment procedures use disaggregate tours converted to trips and aggregated to the zonal level. The model uses a typical zonal network, which includes 1,877 zones and 26,000 links, with transit and path building and assignment routines in TP+.
- The New Starts program is the primary federal funding source for new fixed-guideway capital investments. Approximately $1.5 billion is available for fixed-guideway transit investments on an annual basis. All projects undergo an evaluation and are rated by FTA. A key criterion in the evaluation is the cost per unit of benefit. The cost measure is the annualized incremental capital cost plus the annual operating cost. The benefit measure is the hours of transportation system user benefits. Since 2002, the characteristics of the travel forecasting model used in the analysis have become a concern to FTA. The travel demand model used in a New Starts analysis must undergo rigorous scrutiny in terms of model structure, parameter values, and forecasting results.
- The North Corridor included in the New Starts project is 13 miles in length. The NCTP is currently in the Draft Environmental Impact Statement stage, with potential submission as a New Starts project in the next few years. The corridor includes three major employment centers interspersed with large residential areas. The three employment centers are the Crosswoods/Polaris area, Ohio State University, and the Columbus CBD. A total of 13 districts were used in the analysis.
- The simulated year 2000 work trip distribution was compared with the 2000 Census Transportation Planning Package (CTPP) to assess the work-tour component of the distribution model. Overall, the modeled work trip distribution appeared to be reasonable and almost all the markets were within 20% of the CTPP total. The modeled trip distribution for all journeys and tours compared with the CTPP was not as good as the work-tour distribution, but was still reasonable. A few production districts overestimated trips, while the attraction districts appeared closer to the CTPP.
- User benefit results are considered reasonable if they reflect the benefits of the proposed build project. For example, the corridor area should accrue the majority of user benefits, while areas outside of the corridor should receive minimal benefits. Major employment areas that benefit the most from the project should receive larger user benefits. The district-to-district summary tables and corresponding maps illustrating the travel analysis zones that receive the most benefits and disbenefits from the project were reviewed. This approach is useful in evaluating whether the user benefit results are directly related to the proposed project.

[6] See Schmitt, D. Application of the Mid-Ohio Regional Planning Commission Microsimulation Model: Review of the New Starts Program. Volume 2, pp. 37–45.

• The district tables show that the MORPC model produces reasonable user benefit results. The majority of user benefits occur in the corridor, with minimal level of benefits in intradistrict markets. The CBD district has the highest level of benefits in terms of attractions.

• Mapping the results provides a good tool to highlight the benefits and disbenefits of the project. The production map illustrates that a majority of the benefits accrue to people living in the corridor, especially by those living near the rail stations. The areas not receiving significant benefits reflect the longer travel times from the proposed project as compared with the existing bus service. Benefits are realized around stations near major employment areas, especially Ohio State University and the northern suburbs.

• The review highlighted that complex models using simplified networks still require well-coded networks and sound modeling procedures. The turnaround time to correct relatively small issues can be lengthy. For example, recalibration took 3 to 7 days, running the baseline alternative took 3 days, and processing a build alternative took 1 day.

• Overall, the MORPC model produced good distribution results and user benefit results. Complex models are still susceptible to network coding issues and problems, however. These problems may include network speeds, the need to revise transit access and path building, and recalibration needs. It is also important not to underestimate the time needed to perform the analysis of various options.

Karen Faussett, Michigan Department of Transportation, moderated this session.

BREAKOUT SESSION

Data and Synthetic Populations

Erik Sabina, *Denver Regional Council of Governments*
Gregory Erhardt, *PB Consult, Inc.*
Thomas Rossi, *Cambridge Systematics, Inc.*
John Coil, *Denver Regional Council of Governments*
John Bowman, *John Bowman Research and Consulting*
Guy Rousseau, *Atlanta Regional Commission*
Bin Zhou, *University of Texas at Austin*
Kara Kockelman, *University of Texas at Austin*

Processing the Denver Travel Survey to Support Tour-Based Modeling: Methods, Data, and Lessons Learned

Erik Sabina, Gregory Erhardt, Thomas Rossi, and John Coil

Greg Erhardt described the travel surveys conducted by the Denver Regional Council of Governments (DRCOG) as part of the development of a new activity-based travel model. He discussed the background to the surveys, the survey methods, and the results. Volume 2 includes a paper on the topic.[1] The following points were highlighted in his presentation.

- The development of the DRCOG integrated regional model includes three phases. The refresh phase included a partial reestimation and a full recalibration of the existing trip-based model. This phase has been completed. The vision phase, which included the evaluation of advanced modeling techniques and projects throughout the United States and Europe, is also complete. The update phase entails the development of an integrated modeling system, including a tour-based travel model and disaggregate land use model components. This phase is currently under way. The tour-based model builds on the previous work in San Francisco; Portland, Oregon; New York; Columbus, Ohio; and Atlanta.
- The Travel Behavior Inventory (TBI) was conducted before the start of the refresh phase. The TBI involved a suite of regional surveys, including a household travel survey. Data collection in 1997 included a home interview survey, an onboard transit survey, a commercial vehicle survey, and an external station survey.
- The initial home interview survey design used an activity-based format with one record of data collected for each activity engaged in by household members. The results from the pilot survey indicated that individuals found this format confusing. As a result, a place format survey was used, following the approach used in New York. Respondents were asked to describe the sequences of places they visited throughout the day and what they did there. Respondents were asked to select primary and secondary activities from a list of 12 possibilities. A sample of 4,196 households completed the survey. An additional 677 households, recruited through an onboard transit survey, also completed the place format survey. The onboard transit survey collected basic information on trip purpose and demographic characteristics of the rider. Passengers on 51 routes were included in the survey, which was also used to recruit the transit riders for the place format survey.
- Three traditional trip purposes were included in the survey. These trip purposes were home-based work (HBW), home-based nonwork (HBNW), and non-home-

[1] See Sabina, E. E., G. D. Erhardt, T. F. Rossi, and J. Coil. Processing the Denver Travel Survey to Support Tour-Based Modeling: Methods, Data, and Lessons Learned. In *Conference Proceedings 42: Innovations in Travel Demand Modeling, Volume 2: Papers*, Transportation Research Board of the National Academies, Washington, D.C., 2008, pp. 49–53.

based (NHB). These trip purposes were coded based on a lookup table of the 517 possible combinations of production place, production activity, attraction place, and attraction activity. The data were then coded into a tour format. Three codes were developed to support the most common approaches to tour-based modeling: tour code, with trips in the same tour given a common tour identification number; tour mode, which designated the primary travel mode for each tour; and primary destination, which designated one of the stops on each tour as the primary destination.

- A program was developed to group trips into tours. A tour is a sequence of trips starting and ending at home, defining a single round-trip. A subtour is a sequence of trips starting and ending at work defining a single round-trip. To code the tours, the program makes a forward pass through each trip, incrementing the tour identification whenever the traveler departs home. The program tracks when the traveler last departed home and last departed work for each trip. The program then makes a reverse pass through trips, identifying trips where the traveler departed work more recently than he or she departed home. These subtours are noted and the model makes one more forward pass through the trips, incrementing the identification of the subtours and of all subsequent tours.
- For each tour, one place is designated as the primary destination. In traditional tour-based models, the primary destination is important because the model structure assumes that the activity at this destination controls the behavior of the tour and that other stops are scheduled around this activity. The model has 16 different activity types that are ranked according to duration.
- The primary mode of each tour is identified by assigning a priority to the mode of each trip in the following order: school bus, kiss-and-ride, park-and-ride, walk to transit, drive alone, share ride 2, share ride 3+, bicycle, and walk. As an example, if any trip on a tour is made by a school bus, that is the primary mode for the tour. Not all trips in a tour have to use the same mode.
- The results from the household surveys were used in a trip-based format during the refresh phase, which included a partial reestimation and a full recalibration of the DRCOG trip-based model. The results are also being used in the update phase of developing the tour-based travel model. The household survey results show a high level of trip chaining. The data also show differences when coded in trip-based and tour-based formats. For example, 17% of trips are HBW trips, while 33% of the tours are work tours. This difference indicates that work is a key reason for travel even though the number of HBW trips is relatively small due to trip chaining. A comparison of trip purpose to the primary purpose of the tour for each trip record indicates that only half of all trips on work tours were coded with a HBW purpose, while the other half were HBNW or NHB trips.
- There is also a difference in mode share between trips and tours because of the method used to define the primary mode of the tour. Drive alone is a higher priority than shared rides so that any trip on a driving tour is a drive-alone trip, with the primary mode recorded as drive alone. Transit is a high priority in defining the primary tour mode, resulting in a 50% higher transit mode share for tours than for trips.
- A number of conclusions can be drawn from the experience with the different surveys in Denver. First, the experience with the home interview survey in the development of the tour codes suggests that traditional surveys are sufficient for tour-based modeling and that advanced activity-based surveys are not necessary to develop reasonable tour codes. Second, the experience in Denver suggests that a robust onboard transit survey is still needed. Using the brief onboard survey to recruit transit riders to participate in the home interview survey provided useful data. The sample size was too small to provide a comprehensive picture of transit use, however. The results from the Denver survey present a reasonable picture of travel behavior and a realistic first step. The results point out the significant degree of trip chaining and highlight the differences in trip purpose and mode.

Validation of the Atlanta Regional Commission Population Synthesizer

John Bowman and Guy Rousseau

John Bowman described the development and the validation of the population synthesizer included as part of the new activity-based travel demand model being developed at the Atlanta Regional Commission (ARC). He described the development of the population synthesizer, the validation process, and the preliminary results of the validation process. Volume 2 includes a paper on this topic.[2] The following points were covered in his presentation.

- ARC is developing a new activity-based travel demand model. It is anticipated that the model will eventually be used for travel forecasts and policy analysis. The population synthesizer is the first component of the model to be completed. A population synthesizer acts as a conduit of land use information in a travel demand model. It uses information from the census and the land use model and creates a detailed synthetic population consistent with the land use forecasts. A population synthesizer includes a record for each household in a region and a record for each person in that household. A base-year and back-cast validation was conducted on the ARC population synthe-

[2] See Bowman, J. L., and G. Rousseau. Validation of Atlanta, Georgia, Regional Commission Population Synthesizer. Volume 2, pp. 54–62.

sizer. The population synthesizer provides flexibility in use with current and future land use forecasts and it can be adjusted based on validation results.

- A population synthesizer is a powerful tool, but it should be used with caution. By design, a population synthesizer may provide misleading details about every individual in the population. A goal in the development of a population synthesizer is to synthesize, as accurately as possible, at as disaggregate a level as possible, with as many variables as possible that determine travel behavior. A population synthesizer should be used for the characteristics that it accurately represents aggregated to a level at which it is precise and accurate.
- The ARC population synthesizer uses object-oriented Java software. It consists of subprograms called classes. Inputs include census data for the base-year and population forecasts for the forecast year. The population synthesizer validates accuracy at multiple aggregation levels, including demographic and geographic levels. The results feed into the activity-based travel demand model.
- The population synthesizer creates a synthetic population for the base year and for each forecast year. A public use microdata sample (PUMS) is used for the initial distribution for the base year. For the forecast year, the distribution comes from the base-year distribution. The census tables are used for the controls for the base year, while the controls for the forecast years use the land use forecasts. A synthetic population is produced for the base year and the forecast year, along with a validation report that compares the synthetic population characteristics with known characteristics. The base year is 2000 and a back-cast to 1990 is used to validate the synthesizer's ability to generate a forecast population.
- Three versions of the population synthesizer were created for the initial testing and validation process. The simplest version of the population synthesizer has 52 household demographic categories. Two versions that are more detailed have 128 and 316 household demographic categories, respectively. More detail from the census tables for the base year and from the ARC demographic and land development forecast for the forecast year can be used as more categories are added. The computation time lengthens as categories are added, however, and the increase in the number of sparsely populated categories causes more rounding errors. The validation process helps identify the most appropriate household demographic categories to use.
- Household size is controlled at the travel analysis zone (TAZ) level. In the base year, four categories are used for the version with 52 household demographic characteristics and five categories are used with the 128 and 316 versions. Household size is controlled at the TAZ level in the forecast year, but only average household size is available. The base-year distribution is used to translate this information into the controlled categories. Age is controlled only in the version with 316 household demographic categories. Three age categories are used. These categories are whether the head of the household is over or under age 65, and for those households under age 65, whether any children under age 18 are present. In the forecast year, control is used only as the regional sizes of the subpopulations 65 years of age and older and less than age 15. The forecast control categories are sized by using relationships in the base-year census PUMS data between the available values and the control categories. Employment in the base year is controlled at the TAZ level as the number of workers in the household by four categories. For the forecast year, the control is used only for the region and only for the average number of workers per household.
- The results of the validation process indicate that the use of census data to control for more variables in the base year 316 version produces a more accurate synthetic population. For the forecast year, the additional controls in the 128 and 316 versions provide little value. The results highlight a number of aspects related to the use of population synthesizers. The accuracy of the synthesized characteristics depends on the control variables used for population synthesis, with uncontrolled variables synthesized less accurately. Accuracy also declines at more detailed levels of aggregation. Accuracy for control variables can be influenced by rounding procedures and the use of averages. It is important to validate a population synthesizer by examining these elements on a case-by-case basis. The results of the validation process can be used to improve the population synthesizer.

Microsimulation of Single-Family Residential Land Use for Market Equilibriums

Bin Zhou and Kara Kockelman

Bin Zhou described a study examining single-family residential developments for housing market equilibrium using microeconomic theory and disaggregate spatial data. She discussed the use of a logit model and notions of price competition to simulate household location choices in Austin, Texas. She summarized the background to the study, the data collection process, the model of location choice, and the market equilibration results. Volume 2 includes a paper on this topic.[3] The following points were covered in her presentation.

[3] See Zhou, B., and K. M. Kockelman. Microsimulation of Single-Family Residential Land Use for Market Equilibriums. Volume 2, pp. 63–68.

- Predicting future land use patterns is of interest to policy makers, developers, transportation planners and engineers, and other groups. Residential development accounts for approximately 60% of developed land. Residential location choice is fundamental to land use planning and travel demand forecasting. The availability of parcel-level data sets and geographic information systems (GIS) provides the ability to examine residential location issues in more detail than was previously possible.
- The study examined where new households would locate in Austin assuming a 25% percent increase in population. The study framework was based on random utilization maximization and bid-rent theory. Location choice behavior suggests that households choose the residential location offering the highest utility. Further, households trade off housing prices relative to annual income and commute costs. The housing market equilibration includes the demand side of individual households competing for spaces and the supply side of landowners selling homes to the highest bidders.
- The project examined single-family residential developments based on a microscopic equilibrium of the housing market for recent moves in Austin. Each home-seeking household was allocated to the location that offered the highest utility, and each new home was occupied by the highest bidder. The approach ensures optimal allocation of land, as each household chooses a home that most satisfies the household, and developers and landowners maximize profits.
- The data used in the study were obtained from a 2005 survey of home buyers in Travis County, which includes the City of Austin. Half of the home buyers were included in the sample, and a total of 900 completed surveys were returned, accounting for approximately 12% of all home buyers. The data set contains information on household demographics, housing characteristics, reasons for relocation, and preferences related to different housing and location choice scenarios. This information was used in the location choice model.
- A GIS-encoded parcel map was used in the analysis. Microsimulation of single-family residential developments for housing market equilibrium was applied to the City of Austin and its 2-mile, extraterritorial jurisdiction, which accounts for 420 square miles. Both the supply of homes and the demand for homes were modeled explicitly. On the supply side, the city's land use parcel map was used to draw a 10% random sample from the 16,750 undeveloped parcels in the area in 2000. The distribution of existing single-family residential parcel sizes resembles a chi-square distribution. Large undeveloped parcels were assumed to subdivide according to this distribution. The newly generated single-family sites—defined by home size, parcel-specific unit price per interior square foot, and distance to employment sites and shopping centers—were allocated to individual households based on rent-maximizing and utility-maximizing action principles.
- On the demand side, the 7,600 future households were distributed into five income levels. The new households were assumed to be demographically distributed according to the 2002 American Community Survey. Based on a 10% random sample of undeveloped land parcels and a 25% population increase, there were 1,500, 1,200, 1,200, 2,300, and 1,400 households allocated to the five income levels, respectively. The locations of 114 employment centers with at least 500 jobs and 18 retail centers were identified.
- The process focused on reaching market equilibrium for new home buyers in an iterative manner for six scenarios. Parcels located close to employment sites had higher average equilibrium unit price for households with higher values of travel time. No clear relationship emerged between the average equilibrium unit price and the distance or travel time to employment sites for households with low values of travel time.
- Additional research examining more household types and residential choices, such as single-family dwelling versus apartment, would be beneficial. Other areas for further research include simultaneous simulation of job locations and examining the spatial allocation of single-family, multifamily, and nonresidential uses.

William Upton, Oregon Department of Transportation, moderated this session.

BREAKOUT SESSION

Land Use Forecast

J. Douglas Hunt, *University of Calgary, Canada*
Paul Waddell, *University of Washington*
Becky Knudson, *Oregon Department of Transportation*

The Case for Integrated Land Use–Transport Modeling

J. Douglas Hunt

Douglas Hunt discussed the use of integrated land use–transport models. He defined different elements associated with integrated land use–transport models, described examples of feedback forms, provided a rationale for integrated land use–transport models, and described potential applications of integrated land use–transport models. Douglas covered the following points in his presentation.

- Understanding the different definitions associated with the application of integrated land use–transport models is important. The transportation system is the interaction between supply and demand that acts on price signals. A spatial activity system is supply meeting the demands of that system. How to characterize the land use system is an important consideration. Land use system is probably not the appropriate term, but was acceptable when inventories were measured by square footages. Land use system is a loose and inappropriate term for spatial economic systems. Line-process modeling addresses transportation components in a sequential manner, such as the traditional four-step model, whereas land use–transport interaction modeling incorporates critical feedbacks.
- Feedback is a key element of land use–transport interaction modeling. A number of different feedback forms may be used. Location accessibilities, which involve using log-sums to express relative accessibility, represent one approach. Other feedback forms focus on interchange disutilities and integrated models. Transport costs, with price signal changes influencing activities, represent another possible approach.
- Modeling tasks are best described as forecasting to support facility design. Policy analysis is supported by modeling how future changes arise in response to differing assumptions. Modeling imposes discipline and there are a variety of legal reasons for justifying the use of integrated land use–transport models. Essentially, land use–transport models provide a more complete representation of the real world, a more holistic or organic perspective, and thus avoid the philosophy of line-process modeling.
- Integrated land use–transport models can be used for many different types of studies and have numerous benefits. Integrated land use–transport models can support policy studies, planning assessments, and design analyses. Land use–transport models provide a more complete representation of the real world, which can enhance future planning and decision making. Examples of instances in which integrated land use–transport models were not used raise some concerns regarding the conclusions that were derived.

Challenges in Integrated Land Use and Transportation Modeling: Lessons from UrbanSim Experience

Paul Waddell

Paul Waddell discussed the use of the UrbanSim integrated land use model. He described some of the factors that appear to be limiting more widespread use of the land use model and the experience with the UrbanSim model. The following points were covered in his presentation.

- Currently, the application of land use models by metropolitan planning organizations (MPOs) and other agencies is somewhat limited. There appear to be a number of factors influencing the lack of more widespread application of integrated land use models. These factors include lack of funding and staff resources and skepticism about new models. Information on the benefits of the new models is needed to address these concerns. It is also important to show agencies that an incremental approach to implementation can be used to introduce new land use models.
- Spatial interaction models, such as DRAM/EMPAL, are still being used in many areas. These models are constrained and have limitations related to spatial details and low behavioral content. UrbanSim provides a microlevel model that is very spatially detailed. UrbanSim is being used in some applications by MPOs, state departments of transportation, consulting firms, and universities around the country. Although UrbanSim provides benefits over the spatial interaction models and other techniques, areas for improvements can be identified based on the experiences to date.
- UrbanSim requires a lot of data that may not always be available to the agency running the application. This limitation can be addressed by fitting UrbanSim to the available data. There may be issues related to geography with the use of UrbanSim, but these can be addressed by making the geography for location choice flexible. UrbanSim uses one set of tools for estimation, specification, and simulation, but this problem can be resolved by integrating these three functions. Constraint issues, such as those related to neighborhood choice, represent another possible concern. The theory of constrained choice is not a trivial problem and choice models are needed that better reflect constraints. Accessibility measures represented by log-sums are a travel model issue; however, this can be addressed by linking UrbanSim with activity-based models. Computing (or run times) is another travel model issue with sophisticated models. A breakthrough in assignment is needed to reduce run times. Additional research on travel behavior is needed to better integrate models to reflect actual behavior. Finally, concerns related to software can be addressed through open platforms.

The Path to a Staged Implementation of Integrated Models

Becky Knudson

Becky Knudson discussed key elements to consider when implementing a statewide integrated model. She described the need for outreach to decision makers, garnering internal and external support, and developing a strong implementation program. The following points were covered in her presentation.

- Development of the Oregon Department of Transportation's statewide model was initiated in response to changing planning requirements in the state, especially those related to land use. The first generation of the statewide model was implemented in the late 1990s. The experience in Oregon highlights the importance of outreach, internal and external support, and a well-thought-out implementation program to the successful introduction of new modeling tools.
- A first step in developing outreach programs is to gain a clear understanding of the needs of decision makers and stakeholders. Tools can then be developed with these needs in mind. Seeking opportunities to use models to assist decision makers in making informed policy decisions is an effective outreach technique. Making connections with decision makers and stakeholders early in the process can also help generate future support.
- Internal support within an agency for the development and ongoing use of new modeling tools is crucial. Unlike infrastructure projects, new travel demand models do not lend themselves to ribbon-cutting ceremonies. Models are not highly visible to the public or decision makers. It is important to ensure that agency management supports the development and use of the new models. External support is also very beneficial. Understanding the needs of other departments, agencies, and groups can be helpful in garnering future support.
- The experience in Oregon highlights a number of elements associated with a strong implementation program. First, it is important to select model projects wisely. The ideal project should provide good exposure and demonstrate the model's ability to provide relevant and useful information for decision makers. Second, it is critical to develop and retain skilled staff. Third, the models must be used efficiently, including automating model functions when possible. Fourth, it is essential to develop effective communication skills. Use common language and terminology to explain analytical findings. The use of everyday analogies is particularly helpful. Identifying trade-offs is very important; it gets to the heart of what decision makers care about.
- Development of the statewide-integrated model has a number of goals. The first goal is the full integration of the model with explicit representation of economy, land use, and transport. A second goal focuses on linkages to environmental analyses and performance indicators. A third goal is to build on the lessons learned from the first generation of the model. A final goal is to ensure connection and coordination with the metropolitan modeling framework. Key criteria to accomplish

these goals include flexible geographic scale, integrated components, and affordable and tractable models.

- Three distinct models were described. The statewide integrated model includes both aggregate and microsimulation elements. MetroScope, a separate urban model, includes the connection of economic, real estate, and transport models for the Portland metropolitan area. Both models include the regional econometric, residential real estate, nonresidential real estate, and transportation models, as well as geographic information system accounting and visualization. MetroScope is used for long-range land use and transportation studies. The Land Use Scenario DevelopeR (LUSDR) model is a stochastic microsimulation of household and business locations. It connects to the standard Oregon metropolitan models (JEMnR) and the Oregon small urban models (OSUM). LUSDR develops land use scenarios used for risk analysis and land use and transportation policy testing. It is being used in small metropolitan area long-range planning studies.
- Based on the experience in Oregon with developing and implementing integrated models, a number of key institutional and technical elements can be identified as critical to successful projects. Institutional elements include building internal and external support. One good method to build external support is to identify issues and questions of interest to key stakeholders and to use the model to answer these questions. Focusing early applications around key stakeholder concerns can help build support. Statewide collaboration and coordination with other agencies are also important. Investing in technical staff is critical, especially investing in development of communication skills. Think big, but start small. A good approach is to begin by developing prototypes and building blocks. Focus initially on basic projects and build on successful efforts. The use of short development cycles can also be beneficial. It is also important to design integration with other models and data systems at the outset.

Eric Miller, University of Toronto, Canada, moderated this session.

BREAKOUT SESSION

Activity-Based Models

Theo Arentz, *TU Eindhoven, the Netherlands*
Harry Timmermans, *TU Eindhoven, the Netherlands*
Davy Janssens, *Hasselt University, Transportation Research Institute, Belgium*
Geert Wets, *Hasselt University, Transportation Research Institute, Belgium*
Chandra Bhat, *University of Texas at Austin*
Abdul Pinjari, *University of Texas at Austin*
Naveen Eluru, *University of Texas at Austin*
Ipek Sener, *University of Texas at Austin*
Rachel Copperman, *University of Texas at Austin*
Jessica Guo, *University of Wisconsin, Madison*
Sivaramakrishnan Srinivasan, *University of Florida*
Kay Axhausen, *Swiss Federal Institute of Technology*
Ram Pendyala, *University of South Florida*
Ryuichi Kitamura, *Kyoto University*
Kaira Kikuchi, *Kyoto University*

Modeling Short-Term Dynamics in Activity-Travel Patterns: From Aurora to Feathers

Theo Arentz, Harry Timmermans, Davy Janssens, and Geert Wets

Davy Janssens described an ongoing research program in the Netherlands and Belgium on activity-based travel models. He discussed the Aurora model and the Forecasting Evolutionary Activity-Travel of Households and Their Environmental Repercussions (Feathers) process. Volume 2 provides a paper on the topic.[1] The following points were covered in his presentation.

- Several activity-travel demand models, including nested logit models, are in operation. These models tend to focus on activity-travel patterns. Also emerging are more robust, fully operational, activity-based models. Even with these advancements, there is still more to be accomplished to enhance activity-based models and promote their use. Areas of possible improvement include short-term dynamics or rescheduling of travelers' behavior, and incorporating uncertainty, learning, and nonstationary environments. Modeling route choice behavior and the aggregate impact of individual route choice on activity generation and rescheduling represents another area for enhancements.
- The Aurora model incorporates some of these elements. Aurora develops an agent-based microsimulation system of dynamic activity-travel choice where agents represent individuals. These individuals have limited knowledge of their environment. An activity schedule is generated for each agent for each day and implements the schedule in space and time. In making trips, individuals may experience congestion and adapt their schedules.

[1] See Arentze, T., H. Timmermans, D. Janssens, and G. Wets. Modeling Short-Term Dynamics in Activity-Travel Patterns: From Aurora to Feathers. In *Conference Proceedings 42: Innovations in Travel Demand Modeling, Volume 2: Papers*, Transportation Research Board of the National Academies, Washington, D.C., 2008, pp. 71–77.

The process results in an update of an agent's needs and gaining knowledge from the experience.

- A prototype activity-based model of transport demand for Flanders, Belgium, called Feathers, will extend the Aurora model and add complementary concepts. The project is part of a wider research program involving a number of research institutes. Other elements being examined include the application of combined Global Positioning System (GPS) and personal digital assistant (PDA) technology for collecting activity-travel data (called PARROTS for PDA system for an Activity Registration and Recording of Travel Scheduling) and the use of new technology to collect vehicle data.
- Additional contributions to Feathers expected as part of the ongoing research program include modeling route choice behavior through the data obtained from PARROTS and calibrating the current model based on real-world data. Research will also test and improve currently used concepts of Aurora, such as estimating S-curves as utility functions, estimating the effect of context variables on maximum utility, evaluating the scheduling component, and extending learning facets. Additional concepts are also anticipated to be implemented in Feathers, including the impact of life trajectory events, which include events such as getting married and starting a job. Finally, research elements will focus on guiding and helping practitioners with the transition from four-step models to activity-based models.
- Aurora is an agent-based microsimulation system in which each individual in the population is represented as an agent. It is an activity-based model that simulates the full pattern of activity and travel episodes of each agent for each day of the simulated time period. The dynamics of the Aurora system start at the beginning of the day for each agent. The schedule is implemented based on the needs and knowledge of each agent. The environment has an impact on the implementation of the schedule for each agent in time and space. There is interaction between agents who are competing against each other, which is when congestion occurs. Some agents decide to reschedule their original schedule based on their needs and knowledge.
- The scheduling and rescheduling model assumes that activities and travel are scheduled on a continuous time scale. The schedule meets a full set of scheduling constraints for each agent. Needs for activities grow over time and are satisfied by activities depending on duration. Scheduling decisions are based on heuristics, rather than on an exhaustive search. Inputs to the scheduling model include utility functions, dynamic constraints, activity needs, and knowledge of the land use and transportation systems.
- The model is based on a set of utility functions. The utility of a schedule is defined as the sum of utilities across the sequence of travel and activity episodes that it contains. Utility is dependent on the time of the day, the activity duration, when the activity was performed, and the time since the previous activity.
- The input of the scheduling heuristic is a consistent schedule in terms of duration and timing choices. The output is also a consistent schedule with utility that is higher or equal to that of the inputs. The model iteratively implements operations on an existing schedule until no further improvement is possible. Operations are evaluated under optimal duration and timing choices. Operations considered include inserting an activity, substituting an activity, and repositioning an activity. Other possible operations are changing the location of an activity, including or removing a return-home trip between activities, and changing the mode of a trip.
- Uncertainty is dependent on an agent's attitude with respect to risk. Various decision-making principles can be accommodated within the model. Agents hold beliefs or subjective probabilities with respect to the expected state of system variables. Beliefs are represented by a probability distribution across possible system states. The expected utility of a schedule alternative is the weighted sum of the utilities of the schedule, dependent on the state variables, where the weights represent the beliefs.
- There are different types of learning. Attribute learning is the simplest form of learning. Agents learn about their environment based on their expectations. Agents update their beliefs about states of single system variables. Conditional learning relates to updating causal knowledge. For example, differences in travel time can be explained by the day of the week and the time of travel. Associative learning results from generalization. It means an agent's beliefs can change or remain the same based on experience. Information-based learning is based on information sources such as the news media and agency announcements. The impact of this information depends on the credibility that agents place in the source. Social learning means that agents learn from members in their social network.
- Issues that have been identified to date relate to the synthetic population, belief updating, and other elements. The system shows how an activity-based model can be used for microsimulation of spatial behavior. The framework embraces and integrates the urgency of activities as a function of time, time budgets and competition between activities, space–time constraints, the ability to reschedule activities, the ability to learn from interaction with the environment, and the ability to deal with uncertainty. The system allows users to analyze impacts of temporal as well as spatial variables on utilities and traffic flows.
- Other aspects will be added to the system within the context of Feathers. These aspects include explicitly

modeling route choice behavior by means of detailed GPS data obtained through PARROTS. Adopting knowledge from existing route choice models and calibrating it for use in an activity-based context are also anticipated. Calibrating current models on real-world data will also be performed, along with improving computation time for large-scale simulations. The concepts currently used in Aurora, such as estimating S-curves as utility functions, estimating the effect of context variables on maximum utility, evaluating the scheduling component, and extending learning facets, will be tested and evaluated. Additional concepts will be added, including the impact of life trajectory events, the impact of regular events, and strategic decisions.

Comprehensive Econometric Microsimulator for Daily Activity-Travel Patterns: Recent Developments and Sensitivity Testing Results

Chandra Bhat, Abdul Pinjari, Naveen Eluru, Ipek Sener, Rachel Copperman, Jessica Guo, and Sivaramakrishnan Srinivasan

Chandra Bhat discussed Comprehensive Econometric Microsimulator for Daily Activity-Travel Patterns (CEMDAP), which is a continuous-time activity-travel prediction software currently being applied and evaluated in the Dallas–Fort Worth Metropolitan area. Volume 2 provides a paper on the topic.[2] The following points were covered in his presentation.

- The development and testing of CEMDAP was funded by the Texas Department of Transportation (TxDOT). Janie Bynam and Bill Knowles of TxDOT and Ken Cervenka of North Central Texas Council of Governments provide assistance on the project. CEMDAP is based on a system of econometric models, with each model corresponding to the determination of one or more activity-travel attributes. The models are applied in a systematic sequence to generate the daily activity and travel patterns of all members of each household in the study area.
- At a conceptual level, base-year inputs include aggregate sociodemographics, activity-travel environment characteristics, policy actions, and model parameters. The synthetic population generator provides input to construct the detailed individual-level sociodemographics for the base year. The socioeconomic, land use, and transportation system characteristics simulator (CEMSELTS) provides the sociodemographics and activity environment. These characteristics link to the activity-travel simulator, CEMDAP, which generates individual travel patterns. These are loaded into a dynamic traffic assignment to develop link volumes and speeds. The link volumes and speed are fed back into CEMSELTS.
- CEMDAP uses base-year inputs that include aggregate zonal-level demographic characteristics, land use patterns, the transportation network and level of service (LOS) measures, and any potential policy actions planned for a future year. The outputs for the forecast year include detailed activity-travel patterns. When the dynamic microassignment component is added, it will provide link volumes and speeds by time of day for the forecast year.
- The modeling framework characterizes the activity-travel patterns of all household members, including adults, children, workers, nonworkers, students, and nonstudents. It explicitly considers space–time interactions and constraints. It models the allocation of maintenance activities, such as shopping, to household members and models parents' escorting children to and from school. It generates and links joint activities of parents and children. CEMDAP adopts an interleaved approach to the generation of activity-travel patterns of all household members. It models 11 out-of-home activity purposes for adults and three out-of-home activity purposes for children.
- The temporal resolution is a continuous time scale. The LOS data can be provided at any temporal resolution. Five time-of-day periods are being used in the Dallas–Fort Worth area application. The spatial resolution allows for any number of zones. The Dallas–Fort Worth application uses 4,874 zones. A standard Windows-based graphic user interface is used with CEMDAP. This interface allows users to modify model parameters and also provides a diagrammatic interface to help the user understand the logic of the system and the underlying models.
- The CEMDAP software architecture allows for rapid implementation of system variants and expansions. Recent enhancements include the ability to model both adults and children incorporating spatiotemporal interdependencies, the incorporation of additional policy-sensitive variables to LOS, and the ability to process larger samples.
- The synthetic population generator provides flexibility in how variables are aggregated. It supports different variable combinations to be synthesized and provides synthetic population for census tracks, block groups, or blocks. The synthetic population generator accounts for both household- and person-travel control totals.
- CEMDAP was applied to examine a 10% and a 25% increase in in-vehicle travel times and a 10% and a

[2] See Bhat, C., A. Pinjari, N. Eluru, I. Sener, R. Copperman, J. Guo, and S. Srinivasan. Comprehensive Econometric Microsimulator for Daily Activity-Travel Patterns: Recent Developments and Sensitivity Testing Results. Volume 2, pp. 78–81.

25% decrease in in-vehicle travel times in the Dallas–Fort Worth area. This analysis was conducted to assess the reasonableness of the predications. The activity-travel patterns were predicted for the entire synthetic population of 3,452,751 from 1,754,674 households for the base case and each of the four changes in vehicle travel times. The impact of the changes in in-vehicle travel time on aggregate activity-travel patterns was examined for trip frequency, person miles of travel, vehicle miles of travel (VMT), and person hours of travel (PHT).

- The 10% increase in in-vehicle travel times reduced the total number of trips by 1%, whereas a 25% increase in in-vehicle travel times decreased the total number of trips by 2.4%. A 10% decrease in the in-vehicle travel time increased total trips by 1.1% and a 25% decrease resulted in an increase in total trips of 3.1%. An increase in in-vehicle travel times decreases VMT and a decrease in in-vehicle travel times results in an increase in VMT. An increase in in-vehicle travel times increases the PHT for work and decreases the PHT for nonwork purposes, resulting in an overall increase in PHT. A decrease in in-vehicle travel times reduces the PHT for work and increases the PHT for nonwork purposes, resulting in an overall decrease in PHT.

MATSIM/Planomat: A Microsimulation System of Activity Demand

Kay Axhausen

Kay Axhausen described an open-door Java-based toolkit, which provides the user with various instruments to implement activity-based models and scheduling-based models. The model is called Multi-Agent Transportation SIMulation Toolbox (MATSIM-T). The following points were covered in his presentation.

- First, it is beneficial to examine how current behavior is being modeled at the microscopic level. Elements include generalized costs of the route-mode-location alternative. Budgets and long-term commitments are included. Tastes include values, attitudes, and life style by sociodemographics. One of the big attractions of using microsimulation is that there is a national framework to account for differences in tastes between persons. There is also an increased awareness that the choices that individuals make are driven not only at the individual level and at the household level, but also within the larger social network, which will decide and influence location choices and activity choices.
- The generalized cost of a route-mode-destination alternative includes time and reliability, adjusted for both comfort and risk. Reliability is such a large element of the travel experience that individuals who are risk adverse will have a different behavior than those who are risk prone. Monetary expenditures are also included. Numerous activities have a social content, which may focus on doing things with or for others. Agent-based microsimulation might offer the opportunity to address these issues.
- Microsimulation models should include a learning approach. On the one hand, they model scheduling—what an agent does, by which mode and route, and with whom. On the other hand, they model competition for slots on networks and facilities. Initially, iterations between scheduling, the mental map, and the competition will help revise the cost estimates. The parameter estimation is typically not included because of complexity, but it should really be included.
- A first step in the use of microsimulation models is creating a description of the world. The availability of accurate data is critical in this step. MATSIM-T provides various tools to deal with these and other issues. MATSIM-T implements numerous elements to create the world and to manage the different resolutions. It provides an agent database, which is in memory. It provides various tools to implement the competition for a slot on the network. Various dynamic traffic assignment tools can be selected. There are also various tools to schedule activities.
- The focus is on modeling household interaction. This household interaction includes choosing an optional allocation of time over a day and decisions on joint activities, journey destination, and journey mode. A tool searches for the optimum schedule, which takes numerous iterations. These iterations currently take a lot of time to run.
- Zurich is being used as a test bed because it has a detailed navigation network, available timetables for public transport, and information on facilities available for each mode. The agent population has been generated using seven dimensions. Estimates of travel demand are available from a national travel survey and from observed counts. The initial analysis indicated that the smarter the agent and the more variability of adjustment by the agent, the faster convergence or a steady state is reached. If the agents in the optimization are allowed a wider search base, they find solutions quicker. This analysis indicates that fewer interactions may be needed to reach a steady-state system.
- The software will be available at www.sourceforge.org for others to use. Efforts are under way to regain the capabilities of the full scheduler. Parameter estimation also needs to be performed. Visualization and analysis tools are also being considered, along with methods to integrate social networks.

Recent Developments with the Prism-Constrained Activity-Travel Simulator and Integration with the Dynamic Event-Based Network Simulator

Ram Pendyala, Ryuichi Kitamura, and Kaira Kikuchi

Ram Pendyala discussed recent developments with the Prism-Constrained Activity-Travel Simulator (PCATS) and the integration of PCATS with the Dynamic Event-Based Network Simulator (DEBNetS). He summarized the background to the development of PCATS, recent efforts, and future activities. The following points were covered in his presentation.

- There has been rapid progress in activity-based model development over the past decade. The Activity Mobility Simulator (AMOS) was developed with initial funding from the Travel Model Improvement Program. Components of AMOS include Household Attributes Generation System (HAGS), PCATS, and DEBNetS. In addition, the Florida Activity Mobility Simulator (FAMOS) is the Florida application of AMOS. It represents the calibration of HAGS and PCATS using Florida data. It was tested using area data and networks from southeast Florida. It was funded by the Florida Department of Transportation and completed in 2004.
- AMOS includes the household travel survey data, the zonal socioeconomic data, and the network LOS data. All of these data feed into HAGS. HAGS generates a synthetic population of households and persons. All of the elements feed into PCATS, which in turn generates detailed activity-travel records for each person. There is also an output processor, which generates origin–destination matrices by trip purpose, time of day, and mode. A new feature is DEBNetS.
- HAGS populates each zone with a synthetic population of households and persons based on marginal and joint distribution determined by survey data and census data. There are two components to HAGS. One component is the household distributor that provides the household distributions and attributes. The second component is the fixed-activity generator. This component determines mandatory activities fixed in time and space for each individual. It simulates beginning and ending times of time–space prisms and of fixed activities. There are also multinominal logit models of work and school location choice.
- PCATS is a system of behavioral models that simulate an individual's daily activity-travel patterns. The output consists of a series of activity-travel records for each individual. PCATS defines open and blocked periods for each individual. It incorporates modal constraints related to availability, speed, and captivity.
- The structure of PCATS is a series of models to simulate activity-travel patterns. These models include activity-type choice models, joint destination–mode choice models, and split population survival models of activity duration. There are also models by market segment focusing on workers, nonworkers, students, and other groups. The origin–destination matrix creator aggregates activity-travel records to create origin–destination matrices by purpose, mode, and time of day. It can also be imported into any traffic assignment program.
- There are a number of recent developments related to these models and technical tools. One of the major efforts focused on developing an interface and integration with UrbanSim into the OPUS platform. The effort represents a major enterprise. PCATS is also being refined to incorporate quasi-continuous representation of the time–space domain. The model's interactions among household members are also being enhanced. The integration with DEBNetS is focusing on enhancing the visualization capabilities. There are also plans to integrate a pedestrian movement simulator.
- The dynamic network simulator considers activities and trips as events that occur in the time–space domain. DEBNetS loads events on the multimodal network and dynamically updates paths based on network conditions. Standard speed–flow relationships are used to compute speeds and travel times. Enhancements to the visual displays and animations capabilities are underway.
- Integrating PCATS, DEBNetS, and UrbanSim represents an innovative approach in land use and transportation modeling. The OPUS initiative is an international collaboration initiated by Paul Waddell at the University of Washington. It will interface UrbanSim with a host of model systems and analytical and visualization tools. OPUS will create an integrated open source platform with land use and urban systems simulation; activity-based travel models; population, demographic, and economic simulators; and visualization and spatial analysis tools.
- These activities focus on linking land use and transportation and the use of activity-based measures of accessibility. Activity-based modeling opens new opportunities to integrate long-, medium-, and short-term choices related to residence, work, and school locations, as well as vehicle ownership and fixed and discretionary activity engagement. It also includes destination accessibility accounting for time, cost, and reliability. The higher spatial resolution provides improved representation of nonmotorized accessibility.
- Work is under way in Japan to introduce a microspatial coordinate system into PCATS. The capability to analyze and microsimulate pedestrian move-

ment is being developed. Issues with aggregate zone systems are being addressed. These issues include inaccuracies introduced by spatial aggregation and limited applications to nonmotorized transport analysis. Considerable work is focused on overcoming limitations of zonal aggregation.

- PCATS has been applied to the central portion of the City of Kyoto. The rectangular area is approximately 13 km (east–west) and 11 km (north–south). The area contains approximately 1.4 million 10-m × 10-m parcels. A little over half of these parcels, or approximately 740,000, qualify as destination opportunities. The analysis examined alternative planning measures. These alternatives included a downtown automobile-restricted zone, a reduction in transit fares, a combination of both the automobile-restricted zone and transit fare reduction, and a do-nothing option. The PCATS graphical display system can be used to highlight the alternatives. The application results show that automobile trips decrease significantly and transit trips increase slightly with the automobile-restricted zone. Transit trips increase slightly and automobile trips decrease slightly with the fare-reduction option. The combined alternative has the highest impact of reducing automobile trips and increasing transit trips.
- Pedestrian movement simulation represents another area of research. To evaluate the allocation of facilities and transportation policies in commercial areas, it is necessary to analyze the behavior of pedestrians in more detail. Elements to examine include street choice, shop choice, and consumption patterns. A pedestrian simulator is under development for integration with PCATS and DEBNetS.
- A very simple model of pedestrian shopping behavior has been developed. It is difficult to predict a "sudden or spur-of-the-moment" shopping event. A simple nested logit model structure is being developed to address spur-of-the-moment shopping behavior. Elements, such as the attraction of a store by floor space and number of employees; environmental information, such as traffic volumes around the store; and information on the individual, such as available time, are included. The pedestrian simulator is being developed to consider individuals' economic activities in stores. Integrating the pedestrian simulator into PCATS will enable the evaluation of transportation planning measures at a microscale or individual level.
- In summary, a number of activities have been completed integrating PCATS with DEBNetS. Activities are underway related to continuous representation of the time–space domain and interactions among household members. A dynamic network simulator is fully integrated. The pedestrian movement simulator for shopping activity is in use. Complete re-engineering of the software is underway to make it more robust and to address computing power issues. Enhanced visualization and animation displays are also being developed. There is extensive application to policy analysis at the microscale.

Konstadinos Goulias, University of California, Santa Barbara, moderated this session.

BREAKOUT SESSION

Survey Methods

Eric Petersen, *RAND Europe*
Peter Vovsha, *PB Consult, Inc.*
Stacey Bricka, *NuStats Partners, LP*
Chandra Bhat, *University of Texas at Austin*
Bruno Kochan, *Transportation Research Institute, Hasselt University, Belgium*
Tom Bellemans, *Transportation Research Institute, Hasselt University, Belgium*
Davy Janssens, *Transportation Research Institute, Hasselt University, Belgium*
Geert Wets, *Transportation Research Institute, Hasselt University, Belgium*

Directions for Coordinated Improvement of Travel Surveys and Models

Eric Petersen and Peter Vovsha

Peter Vovsha discussed data requirements to support the estimation process of activity-based models and improvements to travel surveys. He described the demands of the new models and promising areas of research related to travel surveys. Volume 2 includes a paper on the topic.[1] The following points were covered in his presentation.

- Household travel surveys remain the major source of data needed for activity-based models. The basic surveys required for activity-based modeling applications are similar to those required to update and revalidate conventional models, although some additions are desirable. The development of the new generation of activity-based models has provided the opportunity to examine the various types of travel surveys. This examination has identified some data inconsistency not previously noted. The development of new models has also created demands for new data and possible changes to travel surveys. Trips represent the unit of analysis in traditional four-step models. The units of analysis in activity-based models include trips, tours, activity episodes, and time allocation.
- Household surveys were conducted as part of the development of new activity-based models in New York, Columbus, Atlanta, and the San Francisco Bay area. The New York survey included approximately 11,000 households in a 1-day survey. The Columbus survey was also a 1-day effort involving 5,555 households. Two-day surveys were conducted in both the San Francisco Bay area and Atlanta, covering 15,064 households and 8,069 households, respectively. A review of these surveys identified concerns related to missing and miscoded locations, in-home activities, conflicting joint activities and travel, underreporting of multiple activities, underreporting of nonmandatory activities, and underreporting of preschool children. One example of underreporting relates to the percentage of workers making at-work subtours for lunch, banking, shopping, and business activities.
- Conducting on-the-spot checks represents one approach to improving household survey results. Items to check include consistent trip time locations and modes and consistent departure and arrival times. Joint travel by drivers and passengers can be checked for intrahousehold trip synchronization and interhousehold trips with colleagues, friends, relatives, and casual carpoolers. Joint intrahousehold and interhousehold synchronization can also be monitored. The presence of routine activities

[1] See Petersen E., and P. Vovsha. Directions for Coordinated Improvement of Travel Surveys and Models. In *Conference Proceedings 42: Innovations in Travel Demand Modeling, Volume 2: Papers*, Transportation Research Board of the National Academies, Washington, D.C., 2008, pp. 85–88.

relating to work, school, child care, and eating out can be checked. Unusual time allocations can be examined.

- While the structure of travel surveys has traditionally focused on supporting the needs of four-step travel models, more information is obtained than is typically used in the modeling process. Only about 3% of the information obtained from travel surveys is actually used in traditional four-step models. The matrix structure of the trip distribution and model split submodels of four-step models limits the model segmentation and the number of explanatory variables. Aggregate dependent variables include household trip generation, trip distribution, and mode choice by three to four purposes and two to three time periods. Explanatory variables are typically limited to household size, number of workers, number of automobiles, and household income.
- Activity-based models have unlimited segmentation by travel, person, and household attributes. Activity-based models address logical linkages of activities and trips of the same person in time and space, as well as logical joint activities and travel linkages across members of the same household.
- New variables could be added to household surveys to add significant explanatory power to mode and destination choice portions of travel models. Examples of these variables include substituting out-of-home activities with in-home activities related to telecommuting, teleshopping, and telebanking; individual and joint trip substitutions; and evening trips. Addressing the use of high-occupancy vehicles, high-occupancy tolls, managed lanes, toll payment methods, and the toll amount could provide a higher level of detail about automobile trips. Additional transit trip information might address the sequence of routes and transfers, the use of park-and-ride lots, and the influence of seat availability, air conditioning, and other amenities. Mode details might include eligibility for employer-subsidized parking, parking charges for all trips, the availability of parking and walking distance to destination, actual automobile availability per trip, and pedestrian and bicycle conditions. Information on income by person, rather than by household would also be of benefit.
- There is a change in the conceptual unit with activity-based models. The four-step model tends to focus on location. A survey would ask the question, "What was the next location and associated activity?" Activity-based models focus on activity by asking the question, "What was the next activity and associated location?" Focusing on causality represents a constructive intermediate stage between the standard outcome-based approach and the new process-based approach. Causality focuses on why individuals make a specific choice or decision. In practical terms, causality is simple and free of chronological details and intermediate steps of decision making. Short-term model improvements could address sequencing and conditionality of choices, alternatives considered for each choice, and factors or attributes considered. This approach would provide an enhanced understanding of individual decision making and would move toward behavioral models.
- Modeling location choices is difficult because of the large number of alternatives and zones and complicated substitution structure. Unrealistic modeling assumptions are typically used, which include consideration of all zones and locations. A simple utility combines size variables and impedance measures. Using a spatial domain or cognitive map may be a logical approach. In terms of activity locations, perceptions of a location may relate to closeness to home, work, or school. Reasons for the choice of a nonmandatory activity may relate to the proximity to a routine activity or a unique attraction at the location. The role of the activity may be the primary destination in a travel tour or it may be a secondary stop. Variations from the normal work or school location or schedule could be probed in household surveys.
- Mode choice causality focuses on whether alternative modes are ever considered or used for the same trip, the reasons for discarding alternative modes, transit reliability, and automobile reliability. Possible structural variables include time pressure and the willingness to pay a toll for time savings, as well as weather-related driving conditions.
- Attitudinal and stated preference extensions to conventional revealed preference surveys provides one approach for enhancing current practices. Household surveys provide a full picture of daily activity patterns. They also provide a good basis for stated preference extensions to provide a better understanding of choices.
- Household surveys remain the main source of data needed for travel models. The completeness and the quality of household surveys have been improving. Technical fixes have related primarily to questions relating to in-home activities and joint activities and travel. Further conceptual development associated with activity-based models focuses on causality and decision-making, wider ranges of explanatory variables, and attitudinal and stated preference extensions.

Using Global Positioning System Data to Inform Travel Survey Methods

Stacey Bricka and Chandra Bhat

Stacey Bricka discussed the application of Global Positioning System (GPS) technology with travel survey data collection activities. She provided an overview of the use of GPS with different aspects of travel surveys and highlighted some of the key findings from these efforts. She described a recent research project examining the use of GPS with the regional household survey conducted in the Kansas City area in 2004. Volume 2 includes a paper on this topic.[2] The following points were covered in her presentation.

- GPS has been used in at least 12 regional travel surveys over the past 10 years. The primary use of GPS in these surveys has been to audit trip reporting, to assess the level of trip underreporting, and to develop correction factors for the data. Most applications have used in-vehicle devices to obtain data on both the driver and passengers. A few surveys, such as the Portland, Oregon, survey, focused only on the driver. Thus, GPS has been used mostly for passive data collection, although personal digital assistants (PDAs) were used with surveys in Los Angeles and Ohio. Different processes have been used for detecting missed trips. Rates for missed trips have ranged from 5% in Reno, Nevada, to 81% in Laredo, Texas. Also, time thresholds and other considerations have varied.
- Key findings can be identified from the use of GPS in the 12 regional travel surveys. First, GPS participants are a select group of respondents. GPS participants tend to have higher incomes and higher home ownership rates. Second, different methods have been used to process GPS data. These methods appear to influence the rates of trip underreporting. The instructions provided to participants also appear to influence underreporting. In most cases, participants are instructed not to report trips out of a specifically defined area and trips for commercial purposes.
- A research project was conducted to examine the use of GPS in the 2004 Kansas City regional household survey. The project had four research objectives. The first objective was to identify the likelihood and the magnitude of trip underreporting at the person level. The second objective was to develop a joint model that recognizes the implicit relationship between the likelihood and the level of underreporting. The third objective focused on examining a comprehensive set of variables related to driver demographics, driver travel characteristics, and driver adherence to survey protocol. The final objective was to identify methodological improvements to reduce underreporting in future travel surveys based on the research results.
- The Kansas City regional travel survey was conducted in 2004 under the sponsorship of the Mid-America Regional Council and the Kansas and Missouri Departments of Transportation. The survey included 3,049 randomly sampled households, 7,570 persons, and 32,011 trips. The GPS component involved equipping the vehicles of 294 households with GPS devices to record all vehicle travel during the survey period. Both computer-assisted telephone interviewing (CATI) and GPS data are available for 228 of the 294 households. The analysis focused on the 228 households and the corresponding 377 drivers and 2,359 vehicles trips. The GPS participants were more likely to own more vehicles, to have higher incomes, and to live in single-family dwellings than non-GPS participants.
- Of the 377 drivers participating in the GPS component, 71% accurately reported all travel in their CATI survey, while 29% had at least one nonreported trip. Of those drivers who underreported trips, 49% missed one trip, 20% missed two trips, 10% missed three trips, and 20% missed more than four trips.
- The hypothesis underlying the empirical analysis was that trip underreporting is influenced by three major factors: the demographic characteristics of the driver, the characteristics of the trip, and the level of adherence to the survey protocol. Examples of driver demographics include age, type of household, employment status, and the number of vehicles in the household. Trip characteristics included the total number of trips, the average trip distance, and the level of trip chaining. Elements associated with following the survey protocol included use of the travel survey to record all trips and talking directly with the interviewer.
- A joint binary choice-ordered response discrete model of underreporting and an ordered-response model for level of underreporting among underreporting individuals were developed by adopting a systematic procedure of eliminating statistically insignificant variables. The exogenous inputs to the model are classified according to the three areas of influence. The binary choice-ordered response discrete model includes two equations—one addressing likelihood and one addressing magnitude—and accounts for correlation in error terms.
- The results of the modeling effort help identify underreporting tendencies with household travel surveys. The underlying mechanism that represents whether an individual underreports is different from the mechanism that determines the level of underreporting. There are factors that influence both the underreporting propensity and the propensity associated with the level of underreporting. The effect of driver demographics indicates that adults under the age of 30, men, individuals with less than a high school education, unemployed individuals, individuals working in clerical and manufacturing positions, and individuals working at residential, industrial, and medical facilities are more likely to underreport trips than other respondents. Driver travel characteristics that influence underreporting include higher trip rates on the survey day, traveling long distances per trip, and high levels of trip chaining. Also, drivers who do not use their travel diary to record their travel are more likely to miss trips than those who use the travel diary. Based on elasticities, the most important

[2] See Bricka, S., and C. Bhat. Using Global Positioning System Data to Inform Travel Survey Methods. Volume 2, pp. 89–93.

determinations are the use of a travel diary and working in residential land use, while the least important determinates are being a male and traveling long distances.

• The model results can be used to identify possible approaches to address the underreporting by various groups. Providing a clear definition of what to record may address individuals working in residential land use. Providing travelers with high trip rates with more room to record trips on the forms may help. These individuals should be identified during recruitment. Probing for trips during lunch and stops along the way should be performed for unemployed individuals in the same way as for workers.

• The model results indicate a need to better engage drivers under the age of 30 in the surveys, as well as individuals with high school educations. More challenging is addressing the underreporting of the proxy-reported travel. Not allowing proxy reporting has significant cost implications and may introduce more bias into the survey data than that introduced by allowing proxy reporting. Strengthening the telephone interview may help address this issue, as well as those related to unemployed individuals.

Dynamic Activity-Travel Diary Data Collection Using a Global Positioning System–Enabled Personal Digital Assistant

Bruno Kochan, Tom Bellemans, Davy Janssens, and Geert Wets

Davy Janssens described the use of a GPS-enabled PDA device to improve travel diary data collection efforts with activity-based travel models. He discussed data collection needs with activity-based travel models, available computerized travel survey data collection tools, the advantages and limitations of different approaches, and a new GPS-enabled activity-travel diary data collection tool. Volume 2 contains a paper on this topic.[3] The following points were covered in his presentation.

• The traditional four-step models were developed in the 1950s to predict travel demand for different transportation options. Recently, activity-based models have been developed to address some of the limitations associated with four-step models. Activity-based models predict interdependencies between several facets of activity profiles. These facets include the type of activity, when and where the activity is conducted, the duration of the activity, and the mode of transportation used to travel to and from the activity. The participation of other individuals in the activity and travel represents still another facet included in activity-based models. More robust activity-based models also incorporate learning effects and other advanced elements.

• Activity-based models require more sophisticated and more detailed data than the traditional travel models. To accommodate the calibration and validation data requirements of dynamic activity-based models, more detailed activity-travel diary information is needed. Travel diaries consist of a sequence of activities and journeys completed by each individual in a household. The diaries focus on all the activities and journeys completed by an individual. Completing activity-travel diaries requires a lot of effort on the part of the respondent. Travel diaries take time to fill out and require individuals to remember and record numerous activities.

• A number of methods have been used to collect travel-diary information over the years. The basic paper-and-pencil method is still used in many areas. Advantages to this approach are that the diaries can be filled out at any time and place and are relatively easy to complete. This method can be prone to errors and inconsistencies, however. It can also be complex and tedious for some individuals.

• A second approach is using computer-aided self-interviews to record activity-travel scheduling behavior. The Computerized Household Activity Scheduling Elicitor (CHASE) provides an example of this approach. This method includes a multiday computerized scheduling interface, which allows individuals to record their scheduling decisions by adding, modifying, and deleting activities to their schedule. Possible advantages to this method include the ability to obtain more detailed information and improved data quality. Potential limitations include the need to access a computer at specific places and times.

• A third approach is using Internet-based travel diaries. This method provides greater flexibility for the individual, because the diaries can be completed at different locations that have Internet access and at times that are convenient to the participant. A possible limitation with this approach is the need for participants to have Internet access.

• Building on these efforts, research in Belgium is focusing on the development and application of an integrated travel diary approach using GPS in a PDA application. This approach involves a participant recording their planned activities in a PDA and collecting information on the participant's actual activities through the use of GPS. The planned and actual activities can be compared and additional information concerning differences can be gathered as needed.

• A number of advantages may be realized through the use of a GPS-enabled PDA travel survey. First, trip

[3] See Kochan, B., T. Bellemans, D. Janssens, and G. Wets. Dynamic Activity-Travel Diary Data Collection Using a Global Positioning System–Enabled Personal Digital Assistant. Volume 2, pp. 94–97.

origin, destination, and route data are automatically collected by the GPS, relieving the participant of recording this information. Second, all trips are automatically recorded, reducing potential issues with unreported trips. Third, trip start and trip duration entries are automatically recorded. Fourth, the GPS data can be used to verify the reported trips and activities. Finally, this approach allows data to be downloaded from the PDAs in a format that can be directly used for analysis, reducing postprocessing data reduction costs. Possible issues associated with this approach relate to potential errors and reliability concerns with GPS, the storage capacity of PDAs, the battery life of PDAs, and the costs of PDAs. None of these issues should be major concerns.

- The conceptual design of the system includes two geographical user interfaces (GUIs), a GPS logger, a data structure, a data quality control module, a trip identifier module, a geographic information system (GIS) module, and a communication module. The modular structure allows for customization to specific applications. The GUI contains the household and activity-based surveys. Participants enter demographic and activity-travel information in the household survey GUI at the start of the survey period. This information is stored in the activity diary and household data module. The GPS logger receives and stores location and time data. If an individual forgets to record a trip or activity, the trip is automatically recorded in the GPS data log. During the survey period, participants enter activity information into the GUI. The activities and trips are monitored by the GPS. The data integrity checks module detects inconsistencies between the information entered by the participant and the GPS data log. Data on the PDA is downloaded through the communication module. The data can be processed and analyzed through the use of GIS and other analysis tools. The system can also be programmed to query the participant about changes in planned activities and trips.
- The GPS-enabled PDA system is being deployed as part of a large-scale activity-travel survey in Flanders, Belgium. The results from this survey will be used in other activity-based modeling and research activities. The results will also be used to fine-tune the GPS-enabled PDA system and make any needed modifications.

Johanna Zmud, NuStats Partners, LP, moderated this session.

BREAKOUT SESSION

Assignment Advances

James Hicks, *PB Consult, Inc.*
Richard Dowling, *Dowling Associates*
Alexander Skabardonis, *University of California, Berkeley*
Stephen Boyles, *University of Texas at Austin*
Satish Ukkusuri, *Rensselaer Polytechnic Institute*
S. Travis Waller, *University of Texas at Austin*
Kara Kockelman, *University of Texas at Austin*

A Dynamic Traffic Assignment Model Breakdown

James Hicks

James Hicks described the use of a dynamic traffic assignment (DTA) model in Atlanta. He discussed the application of the VISTA DTA software package, the data requirements and specifications, and the analysis process and preliminary results. Volume 2 contains a paper on the topic.[1] The following points were covered in his presentation.

- The Georgia Department of Transportation is conducting operational planning studies of different freeway sections in the Atlanta area. Microsimulation models of freeway sections are being used to evaluate operational alternatives. A DTA model provides a method to calculate realistic time-dependent flows through the areas. The DTA model uses input data from the regional travel demand modeling process and produces data required by the microscopic simulation method.
- DTA model inputs include the regional highway network, regional trip matrices, and traffic control information. The regional highway network includes posted speed and capacities by facility type. The regional trip matrices convert to discrete vehicle trips and assign departure times for trips. The traffic control input includes phasing and timing plans. DTA specifications include the demand period, the simulation period, and the assignment interval. The link-time aggregation interval, the results interval, the warm-up interval, and the cool-down interval are other specifications.
- The input data for VISTA DTA includes the Atlanta regional highway network described as a link table and a node table. Input tables also define the location and operational characteristics of signalized intersections in the network, as well as an input table for the demand to be simulated for the network.
- The vehicle simulation is based on the propagation of vehicles according to the cell transmission model network links, which are divided into cells. Vehicles are moved from cell to cell along links and between links. The propagation of vehicles depends on the posted speed for the links, saturation flow rates, and jam sensitivities for the links.
- A 1-hour warm-up period was used in this analysis. Three 1-hour analysis periods were used. These analysis periods were 6:00 a.m. to 7:00 a.m., 7:00 a.m. to 8:00 a.m., and 8:00 a.m. to 9:00 a.m. Flows were tabulated for these time periods and compared with observed 1-hour counts. A cool-down period sufficient to allow all vehicles to be simulated entirely from their origins to their destinations was also used.
- DTA models typically determine the equilibrium solution by first identifying a feasible or reasonable path set and allocating flow between those paths in a manner

[1] See Hicks, J. E. A Dynamic Traffic Assignment Model Breakdown. In *Conference Proceedings 42: Innovations in Travel Demand Modeling, Volume 2: Papers*, Transportation Research Board of the National Academies, Washington, D.C., 2008, pp. 101–108.

that causes the path times to be equal. After the reasonable path set is determined, an allocation mechanism can be used to try to achieve a more exact equilibrium solution over the fixed set of reasonable paths.

- The Atlanta study included iteratively building a reasonable rate set and solving the dynamic user-equilibrium for that route set. After each dynamic user-equilibrium solution, routes that had previously received vehicles but no longer did were pruned from the rate set and new reasonable rates were determined. The initial simulation results included a small number of links with travel times exceeding 1 hour. A time–space diagram of vehicles arriving at specific links was plotted. After cells in the Atlanta network became saturated while vehicles continued to arrive, the cell saturation effect moved upstream. The overcongested link caused other links upstream to become oversaturated.
- Preliminary results from the VISTA model for the 6:00 a.m. to 7:00 a.m. period were examined. Summary statistics for the number of links, total observed count, and total estimated flow for volume ranges, along with relative error and percent root-mean-square error, were reviewed. Scatter plots of the DTA results were also examined. Preliminary results from four iterations indicated a relatively good fit with observed data.
- The work in Atlanta is ongoing. Efforts are focusing on resolving discrepancies between demand and network counts and examining routes between origins and destinations that could use these links but do not. Other activities are reviewing travel time data and the reasonableness of the network times. Time-dependent origin–destination estimation and the use of subareas to reduce the size of DTA are also being explored.

Urban Arterial Speed–Flow Equations for Travel Demand Models

Richard Dowling and Alexander Skabardonis

Richard Dowling discussed a recent study conducted for the Southern California Association of Governments (SCAG) to improve the accuracy of peak-period speeds predicted by the SCAG travel demand model. He described the purpose of the study, the data collection activities conducted for the study, and the analysis of the data. Volume 2 contains a paper on the topic.[2] The following points were covered in his presentation.

- The objective of the study was to develop improved field-calibrated speed–flow equations for use in the SCAG travel demand model to predict the mean speed of traffic on signalized urban arterials in the Los Angeles metropolitan area. Intersection turning movement counts and GPS-equipped vehicles were used to obtain a total of 216 hourly observations of speed and traffic flow on 54 directional street segments at eight different sites in the Los Angeles metropolitan area. In addition, 45 observations were conducted on the I-10 Freeway.
- The data collection method measured intersection discharge rates rather than demand. If demand is less than the discharge capacity for an intersection approach, then the discharge rate and demand are identical. If demand exceeds capacity, the demand diverges from the observed discharge rate. The data points with observed volumes not equaling the demand were identified and excluded from the data set.
- Several candidate speed–flow equations were examined in the study. Five candidate equations—linear, logarithmic, exponential, power, and polynomial—are standard mathematical functions commonly used in data analysis. Two candidate equation forms—the Bureau of Public Roads (BPR) equation and the Akcelik equation—are specific to travel time and delay analysis. To allow capacity constrained equilibrium assignments to be performed by travel demand models, speed–flow equations must meet several behavioral requirements. The equations must be monotonically decreasing and continuous functions of the volume–capacity ratio in order for all equilibrium assignment processes to arrive at a single unique solution. To prevent the travel model from confronting a request to divide by zero, the equations should never intersect the x-axis, which would mean the predicted speed would be zero.
- The exponential, BPR, and Akcelik equations were fitted through a least-squared error fitting process to the observed speed–flow data. All three functional forms appear to account for some of the observed variation in speed. Because the field data could not be used to evaluate speed–flow curve candidates for demands greater than capacity, a theoretical evaluation was conducted comparing their predicted delays for volumes greater than capacity against the delays predicted by queuing theory. Based on queuing theory, when demand is greater than capacity, vehicles must wait their turn in line for the vehicles in front to pass through the intersection. The theoretical average delay can be graphed and compared with the predictions produced by the candidate speed–flow curves.
- The fitted BPR and fitted Akcelik equations were calibrated for a volume–capacity ratio of greater than 1.0. The fitted BPR curve underestimated the delay due to queuing when demand exceeded the real-world capacity of an intersection at the end of a link. The fitted Akcelik curve is consistent with the queue delay line because it is derived from classical queuing theory. The analysis also examined the impact of a 10% error in

[2] See Dowling, R., and A. Skabardonis. Urban Arterial Speed–Flow Equations for Travel Demand Models. Volume 2, pp. 109–113.

capacity using artificial links, splitting a link in two, and using dummy links.

• The analysis conducted in this study indicates that speed modeling is intertwined with model calibration. The results suggest that insensitive speed–flow equations give less accurate queue delays, but they tolerate inaccurate capacities, dummy links, and inaccurate link flows. Conversely, sensitive speed–flow equations give more accurate queue delays, but cannot tolerate inaccurate capacities and flows.

• To obtain more accurate queue delays, more accurate speed–flow equations should be used in combination with accurate capacities, coding to distinguish dummy links, and peak-period analysis. In the future, using DTA with simulation—including programs such as Dynasmart(P), DynaMIT(P), or Dynameq—may address some of the limitations identified in this study.

A Comparison of Static and Dynamic Traffic Assignment Under Tolls in the Dallas–Fort Worth Region

Stephen Boyles, Satish Ukkusuri, S. Travis Waller, and Kara Kockelman

Stephen Boyles discussed the use of static and dynamic assignment models in the Dallas–Fort Worth region to analyze congestion pricing alternatives. He described a study comparing the use of three models: traditional static traffic assignment (STA), the TransCAD approximator, and VISTA's simulation-based dynamic traffic assignment (DTA). Volume 2 includes a paper on this topic.[3] The following points were covered in his presentation.

• Use of DTA models provides the capability to account for time-varying properties of traffic flow. Although differences exist among DTA models in how traffic flow is modeled and how the mathematical program is described, all DTA approaches provide the ability to model traffic flow changes over time. DTA models require more input data than STA models, including time-dependent travel demand data. DTA models also introduce other issues, such as ensuring first-in-first-out queuing disciplines. The use of DTA models requires substantial computational time when applied to a major metropolitan area with large networks, such as the Dallas–Fort Worth region.

• A comparison was conducted in the Dallas–Fort Worth area using three different traffic assignment models. The first model was a traditional STA model. The second model was the TransCAD approximator, which uses analytical, link performance-function-based approximation to DTA. The third model was VISTA, which uses a simulation-based DTA approach.

• The traditional STA models use a steady-state approach, with no concept of time. STA models use total demand in a single time period. STA models include link performance functions. The TransCAD DTA approximator is an add-in to the TransCAD software. It is based on an iterative algorithm. It uses link performance functions to calculate vehicle delay, which is a major difference from the VISTA model. The link performance functions are less computationally intensive, and the approximator runs faster than VISTA. It does not model traffic flow at the same level of detail, however.

• VISTA is network-enabled software that integrates temporal network data and models for a wide range of transportation applications. It is based on a cell transmission model (CTM) that divides links into smaller cells, which can be modeled individually at fine resolution of approximately 5 to 10 seconds. A key feature of CTM is that flows are explicitly prohibited from exceeding capacity. If demand for a cell exceeds the available capacity, queues form to maintain flow less than capacity. This ability to model queues in a more realistic manner is a main attraction of VISTA.

• The parameters used by the models are different. The link performance function used by STA and the DTA approximator requires that the capacity and free-flow time for each link be specified. The two calibration parameters must also be specified. The CTM requires the jam density and the length of each cell to be specified. The two parameters indicating the slopes of the flow-density curve when flow is increasing or decreasing with volume must also be specified.

• Comparing STA and DTA is not easy because of the fundamental differences in the modeling approaches. The presence of clearance intervals in DTA bias travel times is low compared with static assignment. Clearance intervals account for vehicles that depart near the end of the model period and arrive at their destination beyond the model period. No additional vehicles are assigned during these intervals, but vehicles remaining on the network are allowed to complete their trips. The result is that some links experience flows for longer periods of time than in STA, effectively increasing link capacities. This issue does not occur with STA because of the inability to distinguish when vehicles depart and assume a steady-static condition.

• The three approaches were applied to analyze toll alternatives in the Dallas–Fort Worth metropolitan area. A total of 92 links (of the 56,574 total links) were tolled in this application. A 3-hour morning peak period from 6:00 a.m. to 9:00 a.m. was used in the analysis. This

[3] See Boyles, S., S. Ukkusuri, S. T. Waller, and K. Kockelman. A Comparison of Static and Dynamic Traffic Assignment Under Tolls in the Dallas–Fort Worth Region. Volume 2, pp. 114–117.

time period was divided into 18 10-minute intervals. Three additional 10-minute intervals were used for network clearance. A total of 2.56 million vehicle trips were assigned to the network. The TransCAD approximator cannot directly recognize tolls, so the delay-based tolls were added to the free-flow travel time for each link using an assumed value of travel time of $10 per vehicle hour. The computation time for the three models varied, ranging from approximately 30 minutes for STA to 3 weeks for VISTA.

- The most noticeable difference in the results from the STA and the DTA approximator is in projection of links to be congested under static conditions. The DTA approximator predicts a higher level of congestion. The STA predicted total system travel time of 1.27 million vehicle hours. The DTA approximator prediction of 2.53 million vehicle hours was nearly double the STA estimate. VISTA predicted a total system travel time of 3.09 million vehicle hours. These results indicate that STA models may underpredict congestion due to changes in demand over the peak period. The three applications also resulted in different traffic routing. STA assigns more vehicles to freeways, VISTA assigns more vehicles to arterials and collectors, and the DTA approximator distributed traffic more comparably among the roadway types. These differences result from the fundamental distinctions between the link performance function-based approach and the capacity-constrained cell transmission model.
- The assessment shows that it is possible to compare the results from the three different models based on global measures of system performance. It is more difficult to compare the results on a link-by-link basis because of the fundamental differences in the models. The results from both dynamic models showed much higher congestion levels than the results from the static model. Additionally, the cell transmission model and link performance functions provided very different results. The suitability of each model depends on the particular application.

S. Travis Waller moderated this session.

BREAKOUT SESSION

Education and Outreach

Robert Donnelly, *PB Consult, Inc.*
Donald Hubbard, *Fehr & Peers Associates*

Lifelong Education as a Necessary Foundation for Success in Travel Modeling

Robert Donnelly

Robert Donnelly discussed training and education needs associated with advancing the state of the practice in travel demand modeling. He outlined possible elements of a lifelong educational approach as a foundation for successful advancements in travel modeling. A paper on this topic is provided in Volume 2.[1] The following points were covered in his presentation.

- There is a gap between the current skills of most metropolitan planning organization (MPO) staff and the skill sets needed to implement and use new travel modeling techniques. With the rapid change in technologies, models, and analysis techniques, the necessary skill sets also continue to change. Unlike the previous generation of civil engineers and planners, who could count on the skills that they learned in college to be appropriate for 20 years, graduates today are lucky if the techniques that they learn are appropriate after 10 years.
- It is difficult to keep university curriculum on travel modeling current given rapid changes in tools and techniques. The skill sets that travel modelers need today are very different from the skill sets needed in the past. The use of large-scale traffic simulation models, such as TRANSIMS, requires an understanding of travel choice behavior, activity-based travel analysis, traffic science, traffic control systems, intelligent transportation systems, network dynamics and disequilibrium, and simulation analysis and modeling. These skills are in addition to a solid background in mathematics, statistics, and microeconomics. Microeconomics is typically not required for civil engineers, and individuals with a social science education may not have a background in some of these subject areas.
- Currently, there are limited training opportunities available to practitioners covering some of these topics. Examples of these training opportunities include the week-long National Highway Institute (NHI) course on travel forecasting and the 3-day NHI advanced travel demand forecasting course. There are also conferences, such as this one, and workshops on travel modeling. A self-instruction text on mode choice modeling is also available. All of these efforts provide a good base to communicate ideas and concepts, but they do not provide the comprehensive skill sets needed by modelers. There are also more intensive activities, such as the week-long advanced modeling course at the Massachusetts Institute of Technology. Further, distance-based learning courses are available on the Internet. Some of these courses may be intimidating for many people, however, because they are very mathematically oriented.
- Mentoring provides an informal learning process that occurs over a longer period of time. This approach

[1] See Donnelly, R. Lifelong Education as a Necessary Foundation for Success in Travel Modeling. In *Conference Proceedings 42: Innovations in Travel Demand Modeling, Volume 2: Papers*, Transportation Research Board of the National Academies, Washington, D.C., 2008, pp. 121–123.

is sometimes used with consultants providing on-site assistance in the development and use of new travel demand models. The mentoring approach appears to be used less today than it was in the past. Medicine and other fields use internships and fellowships as part of the training process. These methods may not work well with travel forecasting, because it would be difficult to find universities, agencies, or consulting firms where an individual could be exposed to all the skill sets noted previously. Contract training is another possible approach. Contract training involves one or two experts providing on-site training at an agency or consulting firm for a few weeks. The Oregon Department of Transportation has used this approach.

- The executive Masters of Business Administration (MBA) model may provide the best approach. Many of the executive MBA programs use distance-based learning techniques. Using this approach, most of the work is done by students remotely, with participants meeting once a month on campus for 4 or 5 days. The on-campus sessions, which are typically scheduled for Thursday through Sunday, provide extensive interaction with faculty and other students. This approach could be used with travel modeling. There are only a few universities that have the range of expertise needed to address all of the topics noted previously, however. This model may also not be feasible without a significant investment of resources to develop and maintain the program. Supporting the tuition and travel for public-sector participants, who would be the major target group, may also be a significant issue. A source of funding for this type of program would be necessary. The program would also have to establish creditability with public-sector managers, because they would need to authorize agency staff to attend and to be absent from work. These issues may limit the viability of this approach.
- Training and staff development in travel forecasting appear to be low priorities at some agencies. Staffs do not always see the need for training, and those agencies that do support training often do not have funding available for staff development. It is difficult to advance the state of the practice without additional training and staff development. Staff at MPOs and other agencies must have the skills to use the new models and techniques or the state of the practice will not change.
- Many speakers at this conference have suggested that the four-step model does not address the questions being asked by policy makers and other groups related to economic competitiveness, market accessibility, sustainability, and equitability. If modelers cannot answer these and other related questions, they will not be able to contribute constructively to the public policy debate on critical transportation issues. It would be a tragedy if advanced models of all types are available, but are not used because of lack of enough individuals with the skills needed to operate the models, tools, and techniques. Training is critical to ensure that this problem does not happen.

Traffic Forecasting in a Visioning Workshop Setting

Donald Hubbard

Donald Hubbard discussed the use of travel forecasting methods in public workshops. He described the possible advantages of this approach and summarized two visioning workshops in California that used this technique. A paper on this topic is provided in Volume 2.[2] The following points were covered in his presentation.

- The basic premise with using travel models in public workshops is that a good travel forecasting model is one that leads to good decisions. Good decisions may come from complex models, as well as from simple models that provide results quicker. Travel models are typically used in a private, unhurried setting. Modelers typically work on computers in their own office. This environment provides ample time to analyze and scrutinize the inputs and outputs, make adjustments, and rerun the models as needed. Travel models provide a rich assortment of outputs.
- Using travel models in a public workshop provides a much different work environment. Using traffic forecasting models in a workshop setting may be considered for a number of reasons. Visioning workshops are an effective technique to help create a consensus on a project or program. Workshops are also a democratic and legitimate method to obtain public involvement in public decisions.
- The impact of land use and development on the transportation system is not always considered in the decision-making process. Visioning workshops are frequently used with land use planning. Decisions in these settings have a major impact on the transportation system. Traffic forecasters need to participate in these workshops so that a consensus forms around a workable plan, rather than a plan that does not work from a transportation standpoint. At least two negative consequences may result if a consensus is reached around an unworkable plan. First, the public participating in the workshop may get angry and may feel they have been betrayed if an agency cannot implement the plan. Second, the public agency may be forced into a position of trying to implement an unworkable plan.
- The only way to ensure that an unworkable consensus does not emerge from a visioning workshop is to have modelers participating in the session and to have

[2] See Hubbard, D. Traffic Forecasting in a Visioning Workshop Setting. Volume 2, pp. 124–126.

traffic forecasting capabilities at the workshop. These capabilities can be used to provide workshop participants with immediate feedback on the traffic impacts of different plans and projects, as well as changes in specific elements of a proposed development or land use plan. This approach allows participants to see the consequences of different alternatives.

- Traffic models used in workshops must be able to provide realistic results within approximately 15 minutes. Participants will lose interest if the process takes longer and most workshop schedules could not accommodate more time. The 15-minute estimate includes all aspects of running the model, including data input, processing, and printing out or displaying the results. The model must be reliable and easy to use. The outputs should focus on a few key performance measures. Thus, simplified models are most appropriate for use in workshops.
- A traffic forecasting model was used to examine the impacts of land use changes in visioning workshops sponsored by the San Luis Obispo Council of Governments (SLOCOG) in California. San Luis Obispo, located in the central coastal region, is a very environmentally sensitive area. The workshops were held as part of the 2050 visioning process. The main purpose of the workshops was to build awareness and consensus, not policy analysis. The general public was invited to the workshops, and numerous elected officials and planning commission members also attended. The discussions focused on alternative land use patterns to accommodate 180,000 new residents in the county.
- The goal of the traffic modeling portion of the workshops was to provide immediate feedback on the relationship between land use choices and traffic impacts. The traffic forecasting was conducted using a combination of geographic information system (GIS), Excel, TransCAD, Word, and PowerPoint software programs. The output was presented in flow maps that showed traffic volumes and the volume–capacity ratio. The results were also presented in table format so participants could see the differences from the base condition. The whole modeling process took approximately 15 minutes. Changes made to the model to accommodate use in the workshops included using only daily forecasts and reducing the number of traffic assignment zones.
- Participants discussed the traffic forecasting results for different land use scenarios. Many participants were surprised to learn that land use location has a big impact on traffic conditions. Previous discussions had focused primarily on how much development would occur and how close it would be to specific individuals. The location of the development in the larger sense had not been addressed. The same number of jobs and households produced different traffic impacts depending on where they were located. Most of the scenarios proposed by participants focused on locating new dwelling units in the northern portion of the county and new jobs in the southern portion of the county. After participants understood the negative traffic impacts of these options, smart growth alternatives, with mixed-use developments and balanced land uses, became the preferred alternative.
- The use of the traffic forecasting model made the workshops more effective and enjoyable. It also strengthened SLOCOG's credentials in addressing land use issues. Feedback from participants, including the public and policy makers, was very positive.
- The Sacramento Area Council of Governments (SACOG) included traffic forecasting in workshops examining roadway and transit projects for the 25-year Metropolitan Transportation Plan. A consensus had already been reached on future land uses through the SACOG Blueprint Project. Workshop participants included the public, elected officials, and planning commissioners. The goal of the traffic forecasting component of the workshops was to provide immediate feedback on the effectiveness of different transportation elements.
- In the SACOG workshop, the inputs were road and transit projects, which are more difficult to enter into the model. The model results are also more subtle, making it difficult to identify appropriate indicators. Participants were provided with a maximum funding level and a list of projects and roadway types. SACOG uses an older, more complicated travel model. For use in the workshop, the PLACE^{3}s land use program was modified to display and manipulate the Cube/Voyager networks and to prepare the files for Cube/Voyager runs. Cube/Voyager was run with the PLACE^{3}s shell and the outputs were displayed using the GIS function.
- Use of the model added a great deal to the workshops. Participants quickly learned that the available budget did not result in significant improvements to the transportation system. The elected officials learned that the public participating in the workshop supported new toll projects and additional river crossings.
- These two case studies highlight that traffic modeling can be incorporated successfully into workshops. This approach requires a different type of model, however. Attempting to perform complex modeling quickly in front of an audience is inherently risky. It is important to practice before using a model in a workshop and to have backups for hardware and software. Using travel forecasting models in the SLOCOG and SACOG workshops helped reveal a disconnect between public preferences and projects that agencies felt the public wanted. It also provided the public and policy makers with a more realistic picture of the importance of different land use options.

Susan Handy, University of California, Davis, moderated this session.

BREAKOUT SESSION

Emerging Modeling Considerations

Sivaramakrishnan Srinivasan, *University of Florida*
Chandra Bhat, *University of Texas at Austin*
Jessica Guo, *University of Wisconsin, Madison*
Arun Kuppam, *Cambridge Systematics, Inc.*
Maren Outwater, *Cambridge Systematics, Inc.*
Rob Hranac, *Cambridge Systematics, Inc.*

Companionship for Leisure Activities: An Empirical Analysis Using the American Time Use Survey

Sivaramakrishnan Srinivasan and Chandra Bhat

Sivaramakrishnan Srinivasan discussed the use of the Census Bureau's American Time Use Survey (ATUS) to examine joint activity and travel trends. He described possible impacts of joint activities and travel on travel demand forecasting models, information on the ATUS concerning joint activities with household and non-household members, and possible enhancements to the modeling process. Volume 2 includes a paper on the topic.[1] The following points were covered in his presentation.

- A number of practical considerations relate to modeling joint activities and travel. For example, vehicle-occupancy levels are determined by joint activity-travel decisions and the ability of individuals to synchronize their travel. As a result, the modeling of joint activity-travel is needed to evaluate the vehicular travel in the system and policies related to high-occupancy vehicle and high-occupancy toll lanes, responses to carpooling incentives, and other related programs. It is also needed for assessing demand management actions such as early release, compressed work weeks, and telecommuting. These strategies can alter travel patterns of individuals not directly impacted by the action. These secondary impacts are missed by individual-based models.
- Other practical considerations include the impact of joint activities on travel distances, travel duration, and time of travel. Individuals may be more willing to travel longer distances for activities pursued jointly with family and friends. These trends have implications for air quality and congestion. Additional travel for pickup and drop-off of companions may not be captured effectively if joint activities are not modeled. Social activities may not be as flexible as they have traditionally been treated.
- Further practical considerations include the implications of the increasing use of information and communication technologies, which may influence the substitution of virtual socializing for social travel and the facilitation of travel coordination. Interest in modeling travel during weekends and for special events further highlights the need for explicitly accommodating joint activity and travel patterns in travel models.
- The overall goal of the study is to contribute to the empirical understanding of activities and travel pursued by individuals jointly with household and nonhousehold members. Study objectives included examining the content of travel that is pursued jointly, household versus non-household companions for joint episodes, and variations by activity type and by day of the week. Three types of leisure activities were examined and the impacts of demographic characteristics, activity episode characteristics, and day of the week on companion choice were assessed.

[1] See Srinivasan, S., and C. R. Bhat. Companionship for Leisure Activities: An Empirical Analysis Using the American Time Use Survey. In *Conference Proceedings 42: Innovations in Travel Demand Modeling, Volume 2: Papers*, Transportation Research Board of the National Academies, Washington, D.C., 2008, pp. 129–136.

- The research used the ATUS, which is conducted by the Census Bureau under contract with the Bureau of Labor Statistics. The sample is drawn from a subset of households responding to the Current Population Survey interviews. One individual, age 15 years or older, is selected from each household. A 1-day time-of-use survey is collected from these individuals. An elaborate three-tier activity classification scheme is used. Data are also collected for weekdays and weekend days. The sample for analysis is large. It includes 412,611 episodes from 20,720 persons in the 2003 survey and 279,042 episodes from 13,973 persons in the 2004 survey. One limitation with the use of ATUS for examining joint activity participation is the lack of time use information for the respondents' companions. While this limitation does not allow assessing the impacts of time constraints of all individuals on the joint time investment decision, it is possible to examine the impacts of individuals and household socioeconomic characteristics and day of the week and seasonal factors.
- The ATUS includes classifications of companions for household members and nonhousehold members. Household members include a spouse, unmarried partner, children, grandchildren, and parents. Other household members include siblings, other related people, foster children, housemates or roommates, roomers or boarders, and other nonrelatives. Nonhousehold members include nonhousehold children, parents or parents-in-law, and other nonhousehold family members. Additional nonhousehold members include friends, coworkers, colleagues, clients, neighbors or acquaintances, other nonhousehold children, and other nonhousehold adults.
- The total number of episodes of each activity type in the sample and the percentage of joint activities by each type were examined for weekdays and weekend days. During weekdays, 32% of all in-house episodes are joint activities, while 35% of all weekend days in-home episodes are joint activities. Some activities, such as caregiving and socializing, are by their nature always joint activities. Other activities, such as personal care, sleeping, work, and school, are defined as solo activities. Eating and drinking and watching television and listening to music are the most frequently reported joint in-home activities. These activities include both household and nonhousehold members.
- The survey results indicate that out-of-home activity episodes are more likely to be joint activities than in-home episodes. Some 47 percent of all weekday episodes and 71 percent of all weekend activities are joint episodes. Socializing and serve-passenger are considered to be joint activities, while work and school are considered solo activities. Eating and drinking, leisure, and religious, civic, and volunteer episodes are most likely to be pursued with household and nonhousehold individuals.
- The survey results indicate that 42% of weekday travel episodes and 62% of weekend travel episodes are with other people. Some 60% of all joint travel is undertaken with only household members. Travel with nonhousehold members is more likely to occur on weekends than on weekdays.
- A review of the survey results indicates some general trends. Joint activity-travel participation levels are significantly high on both weekdays and weekends. The levels of joint participation vary by activity type. For in-home episodes, nonhousehold members are more likely companions during weekends than weekdays. For out-of-home travel episodes, nonhousehold members are more likely companions during weekdays than weekends. Joint leisure activities are more likely to be pursued with nonhousehold members than joint maintenance activities.
- The results also indicate that episodes of longer duration are more likely to be jointly undertaken with other persons. Weekday joint episodes are more likely to involve only nonhousehold companions than weekend episodes. Caucasians are more likely to pursue joint activities. Employed persons and students are likely to pursue leisure activities with colleagues. Marital status and presence of children in the household negatively impact undertaking leisure with only nonhousehold persons.
- The study results suggest that the social aspect of travel behavior is not currently suitably accommodated in travel forecasting, which could potentially lead to erroneous forecasts of responses to policy actions. The empirical analysis undertaken in this study using ATUS highlights the continued and critical need to explicitly incorporate interpersonal interactions in travel modeling. Enhancements in travel surveys might include activity-type classification schemes and querying of activity and travel companions for both household and nonhousehold members.

An Innovative Methodological Framework to Analyze the Impact of Built Environment Characteristics on Activity-Travel Choices

Jessica Guo and Chandra Bhat

Jessica Guo described a methodological framework to analyze the impact of the built environment on activity. She provided an overview of land use and travel demand interactions and discussed some of the issues associated with understanding the relationship between land use and travel demand. She presented a proposed methodology for analyzing the impacts of the built environment on activity and described the results of an empirical analysis using the framework. Volume 2 contains a paper on the topic.[2] The following points were covered in her presentation.

- There continues to be increased interest in land use and urban form policies, including the ability to influence travel behavior through the design of the built environment. Smart growth strategies and new urbanism concepts reflect this interest. These approaches to land use and transportation planning are more proactive and policy oriented than those in the past. Questions related to the effectiveness of built environment policies still need to be examined, including the causal thread versus statistical association and the magnitude of the causal effect.
- The relationship between the built environment and travel behavior has been examined recently in different studies. The causal effect argument has been considered in some studies, including those addressing the new urbanism and smart growth. Groups that favor these approaches suggest that automobile dependence-reducing built environment strategies will lead to tangible reductions in motorized vehicle use, as well as providing friendlier and socially vibrant neighborhoods. The associative effect argument suggests that certain types of people choose to live in particular built environments and that the automobile-dependent orientation of the population is due to demographic shifts and lifestyle preferences.
- Previous literature addressing the relationship between the built environment and travel behavior has highlighted both mixed and inconclusive results. Some studies have found significant elasticity effects of built environment attributes on travel demand variables, others have identified significant effects of the built environment on one or more dimensions of activity and travel behavior, and others have found no significant effects of the built environment on activity and trip frequency and nonmotorized mode use.
- There appear to be two major issues in understanding the relationship between the built environment and travel behavior. First, the relationship between the built environment and travel behavior can be very complex. This relationship appears to be multidimensional in nature and may be affected by the moderating influence of the individual trip decision maker characteristics. The spatial scale of analysis may also influence the relationship.
  - The first element of the complex relationship is that both the built environment and travel are multidimensional in nature. Questions related to what dimensions of the built environment impact different dimensions of travel are not easy to answer. Further, some built environment measures act as proxies for other built environment measures. Also, focusing on the impacts of the built environment on narrow dimensions of travel may miss other elements of the overall effect on travel.
  - The second element of the complex relationship is the moderating influence of the characteristics of individual traveler decision makers on travel behavior. Characteristics of the decision maker, which include individuals and households, relate to sociodemographic factors, travel-related and environmental attitudes, and perceptions regarding different attributes of the built environment. There may be two kinds of moderating influences. One relates to direct influence on travel behavior and the other relates to indirect influence on travel behavior by modifying the sensitivity to built environment characteristics. Additional studies are needed to control for these observed and unobserved influences.
  - The third element of the complex relationship between the built environment and travel behavior relates to the spatial scale of analysis. Determining the shape and scale of neighborhoods or other geographic areas needs to be considered. Most studies use predefined spatial units based on census tracts, zip code zones, or traffic analysis zones. Individuals may not perceive neighborhood shape and scale by these units, however. The spatial extents of influence on travel choices may be different for various built environment attributes.

  The second major issue in the built environment and travel behavior relationship relates to residential sorting based on travel behavior preferences. Most early research assumed there was a one-way causal flow from built environment characteristics to travel behavior. This approach assumes that individuals and households locate in neighborhoods and then determine their travel behavior based on the attributes of the area. This assumption does not consider that individuals and households select neighborhoods based on travel preferences and the availability of different modes.
- Possible approaches to account for residential sorting include controlling for trip decision maker attributes that jointly impact residential and travel choices, using instrumental variable methods, and using before–after household relocation data.
  - A first approach is to control for the demographic and other travel-related attitudes impacting the neighborhood location choice of individuals and households. This approach can be accomplished by incorporating decision-making characteristics as explanatory variables in models. The remaining effect of built environment mea-

[2] See Bhat, C. R., and J. Y. Guo. An Innovative Methodological Framework to Analyze the Impact of Built Environment Characteristics on Activity-Travel Choices. Volume 2, pp. 137–141.

sures may be closer to the true causal effect. A problem with this approach is that most travel survey data sets do not collect attitudinal data.

– A second method is to use a two-stage instrumental variable approach in which the endogenous explanatory built environment attributes are first regressed on instruments that are related to built environment attributes but have little correlation with the randomness of the primary travel behavior of interest. The instrumental variable method is not applicable to a nonlinear structure, however. Also, ignoring the sampling variance in the predicted values of built environment attributes can lead to incorrect conclusions.

– A third approach is to examine travel patterns of households immediately before and after a household relocation. This approach assumes that households move because of factors unrelated to their built environment attribute preferences. One potential problem with this approach is that relocating households are themselves a self-selected group.

• A proposed modeling framework was developed to address these concerns. The general methodology controls for residential sorting due to observed and unobserved attributes. It considers the direct and indirect effects of individual and household attributes on travel decisions as well as recognizes unobserved taste variation. It focuses on automobile ownership as a travel decision because automobile ownership impacts almost all aspects of daily activity-travel patterns. The framework does not consider attitudinal variables and it uses traffic analysis zones as surrogates for neighborhoods.

• There are a number of reasons for studying automobile ownership related to the built environment. Automobile ownership is an intervening variable in the effect of the built environment on travel decisions. There is less research on the effect of built environment characteristics on automobile ownership. Automobile ownership impacts almost all aspects of daily activity-travel patterns.

• The joint residential choice and automobile ownership model was developed and tested on an empirical analysis of residential choice and automobile ownership decisions in the San Francisco Bay area. The analysis indicates that the built environment attributes affect residential location decisions, as well as automobile ownership decisions. There are random variations in sensitivity to built environment attributes, however. Household demographics appear to have a more dominant effect on automobile ownership than built environment factors, although both are important. Use of the population or density measures or both as proxy variables for built environment measures, such as street block density and transit accessibility, appears appropriate. There is variation in sensitivity to build environment attributes due to both demographic and unobserved factors in both residential choice and automobile ownership decisions.

Innovative Methods for Pricing Studies

Arun Kuppam, Maren Outwater, and Rob Hranac

Arun Kuppam discussed the innovative methods for examining pricing strategies used in the Washington State Comprehensive Toll Study. He provided an overview of the limitations of using traditional modeling techniques in pricing studies, the approach used in the study, and preliminary results. Volume 2 contains a paper on the topic.[3] The following points were covered in his presentation.

• Current forecasting models have limitations for use with pricing studies. One concern relates to possible inaccurate traveler values of time by trip purpose, mode, and time period. The lack of temporal detail in time-of-day choice models is also a problem. There is also a need to model strategies to optimize tolls for pricing studies.

• This element of the Washington State Comprehensive Toll Study had five objectives. The first objective was to apply values of time for different market segments in a trip-based model. The second objective was to capture variations in time of day by 30-minute time periods. The third objective was to develop an approach that is sensitive to pricing scenarios. The fourth objective was to capture travel behavior that reflects the tendency to shift to nearby time periods. The fifth objective was to develop a tool to optimize tolls by time periods.

• Market segmentation was used in the model. The four general categories were work trips by income group, nonwork trips by purpose, truck trips by class, and automobile trips by mode. Four income groups were used: income less than \$25,000, \$25,000 to \$45,000, \$45,000 to \$75,000, and more than \$75,000. The nonwork trip purposes were home-based college, home-based school, home-based shop, home-based other, non-home-based work, and non-home-based other. The truck trips by class were light duty, medium duty, and heavy duty. The automobile trips by mode were single-occupant vehicles, high-occupancy vehicles (HOV-2 and HOV-3+), and vanpool.

• The value of time by market segment was calculated for peak and off-peak periods. The equivalent minutes for a \$3.00 toll were also estimated. For example, the value of time for drive-alone work trips by individuals in the over \$75,000 income group was \$37.04 and the equivalent minutes for a \$3.00 toll were 4.9. For individuals in the

[3] See Kuppam, A. R., M. L. Outwater, and R. C. Hranac. Innovative Methods for Pricing Studies. Volume 2, pp. 142–149.

less than $25,000 income group, the value of time was $10.64 and the equivalent minutes for a $3.00 toll were 16.9. The value of time for a heavy-duty truck was $40.00 and the equivalent minutes for a $3.00 toll were 4.4.

- The impact of pricing on model components—trip distribution, mode choice, time-of-day choice, and trip assignment—was examined. The trip distribution component incorporates generalized cost in minutes for travel time. The cost was converted to time based on the value of time by market segment. Four feedback loops are used to equilibrate congested times. The modal representation in the distribution are work trips based on log-sum or weighted average of times and costs by mode. Nonwork carpool and transit trips are distributed based on no-toll travel patterns. In mode choice, travel time and cost are considered separately by mode and trip purpose. Lower values of time were used in the final assignments.
- A logit time-of-day choice model was applied after mode choice to automobile trips. There are 32 time periods. The time periods are in half-hour increments, except for the first and last periods. Variables include demographics, trip characteristics, and delay. The model also includes costs measured in units of time and the use of a nonlinear shift variable within three larger time periods.
- The time periods included the morning peak, midday, the afternoon peak, evening, and night. The morning peak includes 10 time periods in 30-minute increments from 5:00 a.m. to 10:00 a.m. The midday includes 10 time periods in 30-minute increments from 10:00 a.m. to 3:00 p.m. The afternoon peak includes 10 time periods in 30-minute increments from 3:00 p.m. to 8:00 p.m. The evening includes one 3-hour time period from 8:00 p.m. to 11:00 p.m. The night includes one 6-hour time period from 11:00 p.m. to 5:00 a.m.
- The model specification is a multinomial logit structure with 32 alternatives. The trip assignment uses four feedback loops to equilibrate congested times based on lower values of time. Final iteration is based on higher values of time by market segment. The iterative assignments are based on the five time periods. The objective of the toll optimization tool is throughput or revenue maximization with the constraints of achieving a target level of service.
- A number of conclusions emerged from the study. First, the use of values of time by market segment enables better evaluation of pricing scenarios. Second, time-of-day choice models can be estimated with 30+ time periods with existing data. Third, models are sensitive to time and cost trade-offs, as well as demographic factors and bridge constraints. Fourth, calibration by mode, trip purpose, and direction, as well as for volumes, provides more behavioral understanding of results.
- A number of areas for additional research were identified. These areas include examining the lack of representation of modal options in distribution models and the lack of representation of reliability in evaluating travel choices. The inability of static-demand models to represent dynamic pricing options represents another area for further research. The study identified the need to evaluate fairness as an important factor in implementation and to represent overall societal benefits for road pricing strategies. It was also noted that there was a need to represent safety as a performance measure and to better understand and communicate risk and uncertainty.

Rachel Gossen, Oakland Metropolitan Transportation Commission, moderated this session.

BREAKOUT SESSION

Validation

David Kurth, *Parsons Transportation Group*
Suzanne Childress, *Parsons Transportation Group*
Erik Sabina, *Denver Regional Council of Governments*
Thomas Rossi, *Cambridge Systematics, Inc.*
Ram Pendyala, *University of South Florida*
Chandra Bhat, *University of Texas at Austin*
Rebekah Anderson, *Ohio Department of Transportation*
Robert Donnelly, *PB Consult, Inc.*

PROPOSED VALIDATION AND SENSITIVITY TESTING OF DENVER REGION ACTIVITY-BASED MODELS

David Kurth, Suzanne Childress, Erik Sabina, and Thomas Rossi

David Kurth described the proposed validation process and sensitivity testing to be used with the new Denver Regional Council of Governments (DRCOG) activity-based modeling system. He summarized the development of the new activity-based model, the validation philosophy, and the validation and sensitivity testing plan. Volume 2 includes a paper on this topic.[1] The following points were covered in his presentation.

- During the 4-year period from 1997 through 2000, DRCOG collected a variety of survey data for use in refreshing the agency's traditional four-step travel model. The actual refreshing of the model took place from 2002 to 2004. Activities conducted in this phase included model component validation, validation to the 1997 base year, and validation to travel conditions in 2001. The light rail system in Denver doubled in length between 1997 and 2001, enhancing the effectiveness of the transit component calibration and validation.
- The Integrated Regional Model vision phase occurred during 2004 and 2005. The vision phase included a review of other advanced modeling projects in the country, convening panels of experts to provide overall guidance and developing a list of the top 10 core planning issues that models must support. The development of the activity-based model was initiated in 2005.
- Although the activity-based model is still being finalized, it is anticipated that it will include 13 components. These components will include a synthetic population generator, a regular work place location choice model for each worker, a regular school location choice model for each student, and a household automobile ownership choice model. Other components include a daily activity pattern choice model for each person day, a number of tours choice model for each person day, and a work-based subtour generation model. Still other components include the tour-level destination choice, the tour-level mode choice, the tour-level time-of-day choice, and the trip-level destination choice models. The final two components are a trip-level mode choice model, which is conditional on tour mode choice, and a trip-level time-of-day choice model, which is conditional on time windows remaining after all previous choices.
- The validation plan, which outlined the validation tests to be conducted for the model components and the overall model system, was developed at the same time as the specifications of the model. It is anticipated that the val-

[1] See Kurth, D. L., S. Childress, E. Sabina, and T. Rossi. Proposed Validation and Sensitivity Testing of Denver Region Activity-Based Models. In *Conference Proceedings 42: Innovations in Travel Demand Modeling, Volume 2: Papers*, Transportation Research Board of the National Academies, Washington, D.C., 2008, pp. 153–156.

idation process will include model estimation tests and model application tests. The anticipated validation tests for the model components include (*a*) checks to ensure that the model component is producing the correct results, (*b*) comparisons of model parameters to comparable parameters in similar models in other areas, (*c*) disaggregate validation of all model components, (*d*) testing of each model's sensitivity to variables through controlled modification of those input variables, (*e*) comparisons of the model component output to the results from the survey data set, and (*f*) comparisons of base year outputs from model components to available independent observed data.

- The second set of tests will focus on model applications. The model application tests will address aggregate comparisons to the Travel Behavior Inventory (TBI) survey results, comparisons to independent data, and assessments of the individual model components.
- A number of issues may need to be addressed in developing and conducting validation tests of new activity-based models. Possible issues include the lack of experience with activity-based models and available comparisons and the lack of established standards, acceptable error ranges, and elasticity standards. Other possible issues may emerge during the aggregate comparison to the TBI survey results and the aggregate comparison to independent data.
- The overall model validation will be performed for the model estimation year 1997 and for 2005 against independent observed data. Examples of elements to be included in these traditional checks are the root-mean-square error of modeled to observed traffic volumes, matching observed vehicle miles of travel with approximately 1% error, matching highway and transit screenline volumes, and matching total transit boardings. Other traditional checks include park-and-ride lot usage, matching of peak and off-peak roadway speeds, toll road usage, and highway volumes on individual freeways.
- The validation process includes validating the new model against observed travel data for 1997 and 2005. While these tests are important for model validation, they do not address the potential true value of activity-based models, which is the ability to provide better assessments and travel forecasts based on a more appropriate representation of the actual decision-making process. Two approaches will be used to test the sensitivity of the activity-based model.
- The first approach for testing the sensitivity of the new activity-based model will be to compare the forecast year results to those results obtained by the calibrated trip-based model. The second approach will focus on developing a model that is more sensitive to policy variables. These policy-oriented tests, which will be subjective, will include evaluating transit-oriented development areas, different regional development densities, development in known industrial areas, development of specific greenfield areas, and redevelopment efforts in targeted areas.

Validation and Assessment of Activity-Based Travel Demand Modeling Systems

Ram Pendyala and Chandra Bhat

Ram Pendyala discussed validation and assessment of activity-based travel demand models. He described various approaches to validating and assessing activity-based models, potential issues, and topics for further consideration. Volume 2 contains a paper on the topic.[2] The following points were covered in his presentation.

- While there continues to be growing interest in the use of activity-based travel models, actual application of these models has been limited. The lack of detailed validation and assessment of these new models may be a contributing factor to their slow introduction. Given the costs associated with the new models, information on their benefits is needed for widespread use.
- Validation of travel demand models typically involves the refinement and adjustment of model components and parameters to ensure that the forecasts replicate base-year travel conditions and statistics within an acceptable margin of error. Examples of measures frequently used in the validation process include aggregate measures of travel such as vehicle miles traveled (VMT), vehicle hours traveled, mode split, trip length distribution, and total trips and trip rates. The traditional approach has focused on replicating observed base-year conditions within a certain margin of acceptable error.
- At a basic level, validation of activity-based travel models will focus on replicating base-year travel conditions comparable to those achieved with existing four-step models. A number of issues may need to be addressed in validating new models. There may be an expectation that a higher standard of validation should be used with activity-based models and that fewer adjustments and refinements will be needed. Currently, there is an absence of performance assessment standards for validating activity-based models. There is a need to develop techniques and approaches for comparing the results from traditional four-step models with the results from activity-based models.
- While it is important to consider the accuracy of replicating base-year conditions, one of the benefits of activity-based models is their use in analyzing a wide range of policies and scenarios. To address these elements, an assessment of an activity-based model might focus on a variety of policies and scenarios. Examples might include examining changes in land use, socioeconomic

[2] See Pendyala, R. M., and C. R. Bhat. Validation and Assessment of Activity-Based Travel Demand Modeling Systems. Volume 2, pp. 157–160.

and demographic characteristics, and changes in multimodal transportation network characteristics. Other assessments might examine the impact of pricing policies, alternative work schedules, development patterns, transit fare changes, and other policy measures. The impact of new technologies on travel might also be examined.

- Many of the current tour-based models use the traditional zone-based spatial representation of a region and discrete time-of-day periods. Although this approach is expected to continue, activity-based models have the potential to provide a more continuous representation of the space–time domain. These models may also be better able to accommodate emerging behavioral paradigms and concepts.
- Potential areas for further work and research include the development of guidelines for validation and assessing activity-based travel demand models, as well as guidelines for model comparisons. There is also a need for designing and conducting comprehensive experiments for performing controlled comparisons of activity-based travel model outputs and existing four-step model outputs under a variety of scenarios and policies.

Modeling of Peak-Hour Spreading with a Disaggregate Tour-Based Model

Rebekah Anderson and Robert Donnelly

Rebekah Anderson discussed the basic elements of the Mid-Ohio Regional Planning Commission (MORPC) model and the validation process. More detailed information on the development of the MORPC is provided in other sessions. Volume 2 provides a paper on the topic.[3] The following points were covered in her presentation.

- The MORPC model is a disaggregate tour-based model applied with the microsimulation of each individual household, person, or tour. The model consists of nine separate models that are linked and applied sequentially. In order, these nine models are population synthesis, automobile ownership, daily activity pattern, joint tour generation, individual nonmandatory tour generation, tour destination choice, time-of-day choice, tour mode choice, and stops and trip mode choice.
- The choice mode hierarchy produces a record for every household and every person in the household. The time-of-day model is based on the "time windows" concept, accounting for the use of a person's time budget over the day, with 16 hours available per person. It is a hybrid discrete choice departure time and duration model. The model has a temporal resolution of 1 hour for the modeled period between 5 a.m. and 11 p.m. The time-of-day model is applied sequentially among tours, with mandatory work, university, and school tours scheduled first. The model determines the departure time of each tour and the duration of the activity associated with the tour. The 190 departure and arrival time combinations can be applied with relatively few variables.
- In the development of the time-of-day model, a disaggregate validation was achieved using the Home Interview Survey (HIS) data records. The model results compared favorably with the observed values from the HIS. The time-of-day model has not yet been fully validated against external data because MORPC does not have a sufficient number of traffic counts by peak hour or peak period.
- The model area is divided into 1,805 internal and 72 external zones covering three counties and portions of four other counties. The validation process in 2000 focused on the entire model area and Licking County only. Examples of elements included in the validation were work trip distribution, volumes, and transit trips. The results from the MORPC model were compared to the 2000 Census Transportation Planning Package (CTPP). On a regionwide basis, the MORPC model estimated 660,031 work tours compared to 630,550 CTPP records—a difference of 4.7%. A comparison of district-to-district work tours revealed similarities and differences between the MORPC model and the CTPP. The MORPC model estimate of all work trips to the central business district (CBD) was within 1% of the CTPP, whereas work trips in the North Corridor to the CBD were underrepresented by 5%. Regionally, the model overrepresented trips to Ohio State University (OSU) by 3%, but OSU trips in the North Corridor were overreported by 27%.
- The MORPC model was also validated against traffic counts processed to represent directional average daily traffic for 2000. The criteria used to examine the accuracy of the MORPC model validation included the percent VMT error, the percent VMT root-mean-square error, and the percent volume root-mean-square error by facility type and volume group. The highway assignment validation was geographically structured by rings, sectors, and per districts. The results of this assessment indicate that model results are comparable to observed volumes.
- Additional data and research are needed related to validating the time-of-day feature and other elements of the MORPC model for planning and policy analysis. Additional data on hourly traffic counts and vehicle classification counts are needed for more extensive validation.

Thomas Rossi moderated this session.

[3] See Anderson, R. S., and R. M. Donnelly. Modeling of Peak-Hour Spreading with a Disaggregate Tour-Based Model. Volume 2, pp. 161–164.

BREAKOUT SESSION

The Secret Is in the Segue

Transitioning to a New Model Framework

Kuo-Ann Chiao, *New York Metropolitan Transportation Council*
Ali Mohseni, *New York Metropolitan Transportation Council*
Sangeeta Bhowmick, *New York Metropolitan Transportation Council*
Erik Sabina, *Denver Regional Council of Governments*
Thomas Rossi, *Cambridge Systematics, Inc.*
Rebekah Anderson, *Ohio Department of Transportation*
Zhuojun Jiang, *Mid-Ohio Regional Planning Commission*
Chandra Parasa, *Mid-Ohio Regional Planning Commission*
Bruce Griesenbeck, *Sacramento Area Council of Governments*

Lessons Learned from the Implementation of New York Activity-Based Travel Models

Kuo-Ann Chiao, Ali Mohseni, and Sangeeta Bhowmick

Kuo-Ann Chiao and Ali Mohseni described the development and use of the New York activity-based travel demand model. They discussed the study area, data collection activities, the highway and transit networks, the general structure of the model, and applications of the model. Volume 2 includes a paper on the topic.[1] The following points were covered in their presentation.

- The New York Best Practice Model (NYBPM) study area includes 28 counties in the three states of New York, New Jersey, and Connecticut. The area encompasses 9,738 square miles. The population of the area is approximately 20 million and there are 8 million households. There are 3,586 transportation analysis zones. The model analyzes travel patterns by four time periods, eight trip purposes, 10 motorized modes, and four urban types.
- Data collection activities supporting the development of the new model included a household travel survey and obtaining socioeconomic and demographic data. A 24-hour place-based diary was completed for 11,264 households. The diaries were completed by all of the household members. The diary included information on the places visited, the activities at each place, the modes of travel, and the time of travel.
- Socioeconomic and demographic data collection efforts focused on land use, population, households, employment, and labor force. Forecasts for each of these items were generated for 5-year periods.
- Other data collection efforts included traffic counts for 2,300 screenline locations, origin–destination surveys, and travel time observations. An origin–destination survey was conducted at 12 cordon stations in New York State. A total of 50,000 questionnaires were distributed and 6,000 were returned. Travel time data were collected between 5:00 a.m. and 9:00 p.m. on 4,500 roadway segments, with 40,000 travel time observations obtained.
- The household travel survey was conducted in 1997 and 1998, as a joint project between the New York Metropolitan Transportation Council (NYMTC) and the New Jersey Transportation Planning Agency. The location-based travel survey included 11,000 households, 28,000 people, and 118,000 trips.
- The three-state area includes a large highway network. There are 52,794 links in the 28 counties. These links include 4,950 high-level facilities, 26,385 arterials,

[1] See Chiao, K.-A., A. Mohseni, and S. Bhowmick. Lessons Learned from the Implementation of New York Activity-Based Travel Models. In *Conference Proceedings 42: Innovations in Travel Demand Modeling, Volume 2: Papers*, Transportation Research Board of the National Academies, Washington, D.C., 2008, pp. 173–176.

10,694 centroid and external connectors, and 10,765 facilities classified as other. The network uses unidirectional or dualized coding. The geographic information system street network is based in TIGER or LION using TransCAD software. The modes included in the highway network are single-occupant vehicles, two-person high-occupancy vehicles (HOV-2), three-person high-occupancy vehicles (HOV-3), taxi, truck, and other commercial vehicles. The network is classified by 21 physical link types for capacities, initial speeds, and volume-delay functions.

- The transit network includes extremely detailed transit coding based on information from the Metropolitan Transit Authority and New Jersey Transit. The network was developed in TransCAD 4.0. Each route variation is coded as a distinct route. There are 100 New York City subway routes, 900 commuter rail routes, 2,300 bus routes, 73,000 transit stops, and 50 ferry routes. The system also includes the sidewalk network in Manhattan, walk access and egress links, and park-and-ride facilities.
- The NYBPM is a microsimulation choice model. It uses population synthesis and intrahousehold travel interactions. Journey-based travel units are modeled. Nonmotorized modes are included in the premode choice portion of the model. Mode destination choice uses a nested logit model. There is a stop frequency and location submodel, which uses full multimodal analysis and assignment.
- Traditional travel demand models focus on the trip origin and the trip destination, not intermediate stops. The NYBPM uses the journey as the unit of travel. A journey reflects the real travel characteristics. A traditional four-step model is also available. The general modeling structure includes journey generation, mode and destination choice, time of day, and assignment. Microsimulation is used in the first three steps.
- Journey generation consists of three submodels: synthetic population, automobile ownership, and journey frequency. The synthetic population submodel forecasts the number and the distribution of households by income, size, number of workers, number of nonworking adults, and number of children in each zone. The source of the data is the 5% census public use microdata sample (PUMS) files. The automobile ownership submodel determines the number of automobiles available for each household. The model considers the influence of household income, the household composition, vehicle maintenance costs, parking availability, highway and transit accessibility, and density and residential area type. The journey frequency submodel determines the daily number of journeys for each individual in each household for each purpose. Individuals are categorized as working adults, nonworking adults, or children. The submodel evaluates the intrahousehold interrelationship across different household members, transit accessibility, and automobile availability to determine the number of journeys for each individual.
- The next step in the model is mode and destination choice, which also consists of three submodels: destination and mode choice, stop frequency, and stop location. The model distinguishes between motorized and nonmotorized travel based on household characteristics and the density related to the journey and the region. The concept of intermediate stops is also presented in the submodel. The number of intermediate stops on both legs of the journey is estimated.
- The NYBPM is being used in a number of applications. Examples of applications included air quality conformity analyses, regional transportation plans, congestion management system plans, and testing scenarios for emission reduction strategies. The NYBPM has also been used for data manipulation and analyses requested by other agencies in the area.
- The model has been used with major investment studies on the Tappan Zee Bridge, the Gowanus Expressway, and the Bruckner Sheriden Expressway. It has also been applied in the Long Island East Side study, the Canal Area Transportation study, the Southern Brooklyn Transportation study, the Bronx Arterial Needs study, and the Regional Freight Plan study. It has been used to assist the Hackensack Meadowland Development Corporation and the Lower Manhattan Development Corporation with studies.
- The NYBPM is important for a number of reasons. It was one of the first activity-based models to be used in air quality conformity analysis. It covers one of the most complex regions in the world. The NYMTC's staff experience with NYBPM is of benefit to other metropolitan planning organizations. A rigorous review process involving all the stakeholders was conducted on the model. Topics covered with experience to date include model-related issues, user training, staffing issues, institutional issues, and future improvements.
- One of the model-related issues focuses on the timeliness and the completeness of input data. The development of the model was initiated in the mid-to-late 1990s. The model was completed and implemented in 2002. The September 11, 2001, attack on the World Trade Center had a major impact on the model because of the resulting changes in travel in the region. Additional data collection activities were conducted to better understand these impacts.
- Other modeling issues relate to the need for a different level of details and modeling documentation. The consultant or model developers' view of documentation is often different from the needs of the end user. The gap between the availability of proper documentation and the completion of the model can also be an issue. The modeler is frequently not the best person to complete the

documentation. There is also an issue with the lack of full integration of transit and highway networks. LION is used in New York City, while TIGER is used in other parts of the region. The lack of integration of land use models and proper feedback to NYBPM is another issue. There is a land use model, but it is not yet integrated into the NYBPM. Also, the processing time for the NYPBM is very long. Initially it was taking up to 7 days to run the model. The computer processing time alone has been reduced to approximately 4 days. A current project is examining approaches to reduce this time further.

• The modeling environment also presents challenges. These challenges include the diversity of the large region, software issues, and hardware issues. The region encompasses almost 10,000 square miles. There is also diversity in the size, population, and employment of each zone, as well as variation of available modes and connections. There is variation in the travel behavior and travel patterns of different population subgroups and there is a large group of temporary workers who are continually on the move. The travel behavior of people in New Jersey is very different from that of people in New York. The term “Manhattan Syndrome” is used for unexplained travel behavior.

• The software issues include changes in TransCAD and the compatibility of various software packages. The NYBPM was developed using TransCAD 4.0. The NYBPM modules are not compatible with the newer version of TransCAD. An ongoing challenge has been that users have different versions of TransCAD. Some users have experienced difficulties in running the model because of this problem.

• One hardware issue relates to data storage needs. With nearly 9 million households in the base year, the journey production files are over 500 megabytes. The mode destination choice model processes over 25 million paired journeys by eight trip purposes. The output files are over 300 megabytes. There are six highway classes and four transit trip tables for each of the four time periods. The combined file size is approximately 2.5 gigabytes.

• There is an ongoing need to provide training to various stakeholders and users. A 1-day training course is provided for decision makers. A 3- to 5-day training course is available for individuals with some modeling background. Hands-on training, spanning several weeks, is provided for staff of member agencies who will be using the model for specific projects. These training courses focus on the purpose and use of the activity-based models and the specific use of the NYBPM. Staff from other agencies can also use the NYMTC’s computer facilities. The lack of trained and experienced modeling staff at many agencies is an ongoing challenge. Many public agencies experience high staff turnover rates.

• Working with stakeholders is an ongoing priority. Involving stakeholders in defining the model needs and applications is important. It is also important to involve stakeholders in the model calibration and validation processes and in the discussion of model usage and improvements. Gaining consensus on the definition of the zonal system, the survey design, and the forecasts and calibration results was also accomplished by working with stakeholders. It took time to reach an agreement on the socioeconomic and demographic data at the county level.

• A number of model improvements are planned and a new wave of data collection is scheduled for in 2007. These efforts include a household travel survey, an airport survey, a taxi survey, and a work place survey. Transit origin–destination surveys and bridge and tunnel origin–destination surveys are also planned. Other efforts include a cordon survey, a travel time survey, and traffic counts and occupancy surveys. The results from these surveys will be used to update the NYBPM.

• In addition to incorporating the results of the new surveys, other planned activities include improving the highway-transit connection, improving transit models, and integrating NYBPM with the land use model. Possible web applications are being explored, including providing model output analysis capabilities and model run capabilities for more of a distributed process. A plan has also been made to provide improved flowchart-based, online help and documentation. More project applications in the region are anticipated. The NYBPM user’s group support will continue to meet every 2 months to help with these improvements.

Using Activity-Based Models for Policy Decision Making

Erik Sabina and Thomas Rossi

Erik Sabina discussed the development of a new activity-based travel forecasting model for the Denver metropolitan area by the Denver Regional Council of Governments (DRCOG). He described the planning process in the Denver area and the proposed activity-based model. Volume 2 includes a paper on the topic.[2] The following points were covered in his presentation.

• A number of factors influenced consideration of a new activity-based travel forecasting model for the Denver area, including the Integrated Regional Model (IRM) vision phase conducted by DRCOG, the new Colorado Tolling Enterprise (CTE) within the Colorado Depart-

[2] See Sabina, E., and T. Rossi. Using Activity-Based Models for Policy Decision Making. Volume 2, pp. 177–180.

ment of Transportation (CDOT), the FasTracks rapid transit ballot initiate, and DRCOG's MetroVision Plan.

• DRCOG conducted the IRM vision phase to ensure that the new model would address the Denver Region MetroVision Plan. The vision phase included an evaluation of other advanced modeling projects in North America and Europe. A panel composed of modeling experts, regional planners and engineers, and regional policy makers provided guidance throughout the model development process. The vision phase identified the top 10 core planning issues that the travel demand model should support. These core planning issues included (*a*) the effects of development patterns on travel behavior, (*b*) the sensitivity to price and behavioral change, (*c*) the effects of the transportation system and system condition, (*d*) improved validity and reliability, (*e*) the ability to evaluate policy initiatives, (*f*) better analysis of freight movements, (*g*) the ability to evaluate environmental effects, (*h*) the ability to model low-share alternatives, (*i*) an enhanced ability to evaluate the effects on specific population subgroups, and (*j*) the ability to reflect intelligent transportations system and transportation demand management and other nonsystem policy changes.

• The CTE, which was established by the state legislature within CDOT, has been analyzing corridors in the Denver area for potential toll facilities. Six possible corridors have been identified to date. The need for a new activity-based model to analyze toll facilities was identified as important in the IRM vision phase. Toll options are also being considered in several environmental impact statements under way in the region.

• The FasTracks ballot initiative, which was approved by voters in 2004, includes approximately 130 miles of rapid transit. The FasTracks projects are scheduled to be completed by 2017. The ability for the new model to evaluate the impacts of the FasTracks system was identified as important in the IRM vision phase.

• The ability to analyze the effects of the MetroVision Urban Growth Boundary was also identified as an important feature for the new model. Approximately 750 square miles are included inside the 2030 urban growth boundary. The need to expand the boundary to accommodate forecast growth will be examined as part of the MetroVision 2035 process.

• There is also a need to model the effects of the MetroVision urban centers and transit-oriented developments, which are intended to foster a more balanced transportation system. The MetroVision 2030 plan includes approximately 70 centers. Other needed model capabilities include the ability to assess air quality and environmental impacts, as well as lower-density development patterns and traditional highway projects.

• Activity-based models would be expected to produce more accurate results for policy analysis because these models are able to consider a wider range of variables and interactions than conventional trip-based models. Trip-based models tend to be relatively insensitive to many input data changes and do not include enough detail to respond fully to these changes. Activity-based models are expected to provide improved forecasting for various types of policy analysis.

• One advantage of activity-based models is that modeling individuals in the synthetic population allows for distributed values of time rather than fixed values for a relatively small number of market segments. For example, if the value of time is $12 an hour for a specific geographic market to find using a toll road desirable, and the average value of time for that market segment is $10 an hour, the model would estimate that no one from that market segment would use the facility. If value of time distribution were used with an average value of $10 an hour with a 20% probability of having a value of time greater than $12 an hour, there would be demand estimated for the market segment. Demand for toll roads with tolls varying by time of day can also be modeled more accurately.

• There are also benefits to modeling travel to urban centers and transit-oriented development from use of the proposed activity-based approach. Activity-based models permit descriptions of individuals using a richer set of variables than traditional models. The tour-based approach also captures the effects of trip chaining. Disaggregate models can accommodate more demographic variables than traditional models.

• The proposed activity-based approach appears practical. It greatly enhances sensitivity to trip–tour interactions and provides improved demographic detail, geographic detail, and interaction between model components. There are some limits with the proposed approach, however. A conventional static traffic assignment process will be used. The lack of a fully disaggregate or at least a dynamic traffic assignment procedure will limit the ability to analyze the effects of traffic queuing and variations of traffic flow within peak periods. Even with these limitations, the new model will greatly enhance travel forecasting in the Denver area.

Hardware Requirements and Running Time for the Mid-Ohio Regional Planning Commission Travel Forecasting Model

Rebekah Anderson, Zhuojun Jiang, and Chandra Parasa

Rebekah Anderson discussed the model formulation, the hardware requirements, and the running times for the Mid-Ohio Regional Planning Commission (MORPC) disaggregate tour-based travel model. Volume 2 includes a paper on the topic.[3] The following points were covered in her presentation.

- MORPC, in cooperation with the Licking County Area Transportation Study, contracted with PB Consult, Inc. for the development of a new travel model in 2001. The MORPC area covers all of Franklin, Delaware, and Licking counties and portions of Fairfield, Pickang, Madison, and Union counties. The area includes 1,805 internal and 72 external traffic assignment zones. The 2000 population was approximately 1.5 million. The population is forecast to increase to 2 million by 2030.
- The new model is a disaggregate tour-based model applied with microsimulation of each individual household, person, or tour. The model was completed in 2004 and further refined in 2005. The model consists of nine separate linked models and other network processing steps. The linked models include population synthesis, automobile ownership, daily activity pattern, joint tour generation, individual nonmandatory tour generation, tour destination choice, time-of-day choice, tour mode choice, and stops and trip mode choice. The core models are applied in a disaggregate manner.
- The model is applied with the microsimulation of each household, person, or tour, mostly using Monte Carlo realization of each possibility, estimated by the models and a random number series to determine which possibility is chosen for that record. There are three global feedback loops for consistency between highway travel times that are used as input to, and as forecast outputs of, the model. Cube is used as the main model application package and TP+ is used for network management, assignment, external and commercial vehicle models, and other processing. After generating the networks and initial skims in TP+ and creating input files for a specific scenario, the custom Java programs are executed to implement the tour-based microsimulation models. The microsimulation results are aggregated in a preassignment process or step, which also integrates the commercial and external models to produce standard TP+ trip tables for four time periods, which are morning, midday, afternoon, and night. Vehicles are assigned from the final trip table with a multiclass equilibrium assignment utilizing 21 volume and delay functions by facility and area type for each of the four time periods. There are three classes of commercial vehicles, four highway modes, and five transit modes. Nonmotorized modes are not assigned.
- The MORPC travel forecasting model can currently run on three operational systems. One system is at PB Consult, one system is at MORPC, and one system was purchased by the Central Ohio Transit Authority (COTA). A system is also being developed at the Ohio Department of Transportation (ODOT), but is not yet operational. The initial system at MORPC was installed in 2004 and included one server and three worker computers. A fourth worker computer was added in 2005. The worker computers are directly networked and are isolated from the general MORPC network to make them less susceptible to viruses. This system is running a 32-bit Windows operating system and Java.
- COTA purchased a system to support the North Corridor Transit Project Draft Environmental Impact Statement. This system includes one server and four worker stations all running 64-bit Windows and Java. The system being implemented at ODOT will include one server and eight worker stations. It will use a distributive version of Cube Voyager.
- The running times for the MORPC travel forecasting model for 2000 and 2030 vary by computer system. The total running time for the core model for 2000 ranges from approximately 20 hours to 35 hours. The total running time for the core model for 2030 ranges from approximately 26 hours to 48 hours. The 2000 model includes 1.5 synthetic individuals making 2 million tours and the 2030 model has 2 million synthetic individuals making 3 million tours. The COTA system, which uses 64-bit computing, provides the shortest running times. Experience indicates that running antivirus software imposes a 15% penalty on the run time and that Windows will only allocate a maximum of 50% of memory to any one application. Planned future upgrades include installing Cube on the COTA work stations and sending TP+ scripts to run in parallel on the work stations.

Preparing Parcel-Level Input Data for the Activity-Based Travel Model in Sacramento

Bruce Griesenbeck

Bruce Griesenbeck described the use of parcel-level data in the development of a new activity-based travel model for the Sacramento Area Council of Governments (SACOG). He described the reasons for the use of parcel-level data, the general structure of the new model, and the approaches for forecasting street pattern and transit accessibility data used in the model. The following points were covered in his presentation.

- A major focus at SACOG over the past few years has been on land use policy and land use planning. The policy board recently adopted a long-range land use vision for the region, called the Blueprint. The vision provides a basis for other land use planning activities in the region. It promotes ideas related to urban containment and devel-

[3] See Anderson, R. S., Z. Jiang, and C. Parasa. Hardware Requirements and Running Time for the Mid-Ohio Regional Planning Commission Travel Forecasting Model. Volume 2, pp. 181–184.

oping denser activity centers. The Blueprint focuses on the four Ds: density, diversity in the mix of land uses, design related to pedestrian- and transit-friendly approaches, and destination or the utility clustering of complementary land uses. Activity-based modeling has a natural link to this land use policy focus. Activity-based models provide the level of detail needed to evaluate the impact of different land use plans and different land use patterns.

• The new SACOG activity-based travel demand model uses parcel-level data, rather than traffic analysis zones. The main reason for using the parcel-level data is that the data provide the detail needed to assess questions related to development patterns, street patterns, and proximity to transit services. SACOG used PLACE^{3}s, which is a parcel-based land use scenario analysis package, in the development of Blueprint. Since PLACE^{3}s is parcel based, most of the land use data have been transitioned to the parcel level over the past few years. At the same time, SACOG coordinated a regional roadway geographic information system (GIS) cooperative focused on protocols and data standards for a regional roadway centerline GIS. SACOG has also developed a transit GIS, which includes routes and stops, as part of a regional traveler information system.

• Based on these factors and other needs, SACOG initiated the development of an activity-based travel demand model at the parcel level. This approach does present data production challenges. Activity-based models are data intensive, especially when they include the capability to capture the effects of land use, street patterns, and transit proximity. PLACE^{3}s provides the capability to display and analyze land use changes. It contains dwelling unit yields and constraint layers. Forecasts are developed starting at the parcel level.

• The estimation of the activity-based model was based on a 2000 household survey, and parcel- and point-level data on dwelling units, employment levels, street patterns, and accessibility to transit services. A comparison of the place type and development density between 2000 and 2030 can be made. In these areas, the forecast has to generate an equivalent parcel-level detail on the street pattern and transit proximity. This task is a challenge.

• The street pattern is a geographical representation of how the streets appear and how supportive they are of nonmotorized travel and accessibility measures. Intersections are used to help define street patterns. Three types of intersections or nodes are included in the GIS. These types include 1-link nodes, which are cul-de-sacs or dead-end streets; 3-link nodes, which are T-street intersections; and 4-link nodes, which are four-legged street intersections. Based on the GIS definition, higher density or the prevalence of 3- and 4-link nodes is associated with "good" street design and the prevalence of 1-link nodes is associated with "bad" street patterns. A number of formulas are actually used in the model related to the street pattern. The most frequently used formula is the good intersection ratio, which is the sum of 3- and 4-link node intersections divided by the sum of all intersections, for a particular area. The reverse of this ratio is the bad intersection ratio, which is the sum of all 1-link node intersections divided by the sum of all intersections.

• The street pattern variables are critical inputs to many of the choice submodels and are very predictive. For work locations, work tour destinations, and nonwork and nonschool tour destinations, the good intersection ratio is a highly significant, positive variable. For school and other tour mode choice models, intersection density at the tour origin is a highly significantly positive variable for walk-to-transit, walk, and bicycle modes. The bad or dead-end street ratio is a highly significant negative variable for the intermediate stop location model. The difficulty is in forecasting street patterns at the parcel level.

• Generation of forecast street pattern data that vary by parcel is used for input elements. These elements are the parcel-level dwelling and employment for the base year, the parcel-level dwelling and employment for the forecast year, the base-year roadway GIS, and a look-up table of densities of the three intersection types for different types of areas. The generation process includes five steps. First, land use in the base year and the forecast year are compared by parcel, and parcels with changes are identified. Second, for parcels that are expected to change in use and are over a threshold acreage, synthetic points are generated in a grid pattern throughout the parcel. Third, each synthetic subparcel is populated with a computed number of each type of intersection using a look-up table. Fourth, the synthetic subparcel points in change parcels are merged with the real intersections from the base-year GIS for nonchange parcels. Finally, the merged points are buffered to parcel according to the specific street pattern variable definitions.

• A different approach is used with the transit proximity variables. The transit proximity variables are defined by straight-line distance or time from each parcel to the nearest transit stop in the GIS. Actual transit stop locations are used for estimation. For forecasts, transit stops must be added at reasonable locations. The future transit lines are overlaid on the existing routes. There are different methods of synthesizing future stop locations depending on the type of transit mode. There is a program to generate stops at reasonable spacing for fixed-route bus service. Most of the station locations for future light rail transit lines are known. These station locations are manually added depending on the alternative being modeled. For express routes, stops are only located in the neighborhoods being served.

Julie Dunbar, Dunbar Transportation Consulting, moderated this session.

BREAKOUT SESSION

The Future of Travel Behavior and Data Collection

Larry Blain, *Puget Sound Regional Council*
Konstadinos Goulias, *University of California, Santa Barbara*
Neil Kilgren, *Puget Sound Regional Council*
Terry Michalowski, *Puget Sound Regional Council*
Elaine Murakami, *Federal Highway Administration*
Kay Axhausen, *Swiss Federal Institute of Technology*
Eiji Hato, *University of Tokyo*
Ryuichi Kitamura, *Kyoto University*

Catching the Next Big Wave: Are the Baby Boomers Forcing Us to Change Our Regional Travel Demand Forecasts?

Larry Blain, Konstadinos Goulias, Neil Kilgren, Terry Michalowski, and Elaine Murakami

Larry Blain discussed an ongoing study at the Puget Sound Regional Council (PSRC) examining possible changes in travel behavior of individuals in the baby boom generation as they retire or near retirement. He described the general demographic trends in Washington State, the panel survey of households in the Puget Sound region, and the preliminary assessment of factors to consider in possible changes in travel behavior due to retirement. The following points were covered in his presentation.

- PSRC covers four counties and has a population of approximately 3.5 million. Seattle is the largest city in the region. From 1989 to 2002, PSRC conducted a panel survey of 1,700 households in the metropolitan area. The survey included 10 waves, with replacement households added during each wave if households dropped out. A 2-day travel diary was completed for each household member 15 years of age and older for all waves. A total of 259 households continued through all 10 waves.
- The panel survey provides a good longitude data set that has been used for numerous studies. One of the studies examined potential changes in behavior as individuals retired or neared retirement. Information on individuals 50 years of age and older who appeared in more than one wave was examined. The behavior of these individuals was examined over time as they retired or neared retirement.
- TRB's recent *Critical Issues in Transportation* addresses the aging population in the country.[1] The TRB report notes the following: "As the population ages, more people will have to give up driving, and with it the mobility that defined their adult life. Most people are aging in place—that is, staying on where they have resided as adults—so that the majority of older Americans are remaining in automobile-dependent areas. Losing the ability to drive poses a hardship, particularly when adult children live far away."
- Before discussing the next big wave in demographics and socioeconomic trends, it is important to examine the last big wave. Important recent trends in the Puget Sound Region focused on increases in employment and decreases in average household size. In the 1960s, approximately 40% of the population in the region was employed. From 1970 to 1990, the employed population in the region increased to 52%, which represents a major shift. At the same time, the average household size declined. As a result of these two trends, the number of workers per household may be similar, but there are some important demographic shifts. These shifts include an increase in single-parent households, an increase in

[1] http://onlinepubs.trb.org/Onlinepubs/general/CriticalIssues06.pdf.

single households, an increase in dual-worker households, and more women entering the workforce.

- From 1980 to 1992, vehicle miles of travel (VMT) in the region increased by approximately 80%, while employment grew by 40%, and population increased by less than 5%. Thus, growth in VMT far outpaced growth in population and employment. Part of the increase in VMT was due to changing demographics and part was probably due to the available capacity on many freeways and roadways in the Puget Sound Region in the early 1980s. Much of the Interstate system in the area was constructed in the 1960s and 1970s. By the late 1980s and early 1990s, traffic congestion was becoming a problem, however.
- At the time, some policy makers and other groups focused on using this percentage growth in VMT in planning future project needs. If 1992 is used as the base year for VMT increases, however, a different picture emerges. From 1992 to 2004, VMT increased by approximately 22%, while employment grew by 20% and population increased by about 19%. Over the same period, lane miles increased by approximately 12%.
- Tracking the population in Washington State by gender and age since the late 1800s highlights some interesting trends. In 1880, the population was fairly small. Washington became a state in 1889 and the gold rush in Alaska, which contributed to the growth in Seattle, occurred in the 1890s. By 1890, the population of Washington was increasing due to immigration. The increase was primarily in males between the ages of 24 to 39. These growth trends continued to 1910, along with an increase in females in the same age groups. From the 1920s through the 1940s, the population remained relatively stable in number with an aging trend. In the 1940s, Washington experienced population increases due to the military bases in the state. In 1950, the number of births increased significantly, reflecting the start of the baby boom. The population in 1960 reflected a further increase in births, as well as continued immigration. The trends from 1960 through 2000 reflected the aging of the baby boom generation, the continued immigration, and more people living longer.
- The aging of the baby boom generation raises interesting questions concerning potential similarities to and differences from the travel behavior of individuals currently in older age brackets. The panel survey data were examined to provide insights into the travel behavior of baby boomers as they retire or near retirement.
- A cluster analysis was conducted using the 2-day travel diaries of individuals 50 years of age and older. Cluster 1 comprised individuals who made close to 5.6 trips on each of the 2 days, with approximately 7 hours a day out of the home. About half of these trips were made with family members. Cluster 2 included individuals who made a little over four trips each day, with 8.4 hours a day spent out of the home and only 0.02 of the trips made with relatives. Cluster 3 included individuals who made about three trips each day, spent about 1.9 hours each day out of the home, and made 0.7 of the trips with family members. Cluster 4 included individuals who made 3.9 trips on Day 1, but no trips on Day 2. These individuals spent 3.7 hours out of the house on Day 1 and 1.6 trips were made with family members. Individuals in Cluster 5 made no trips on Day 1 and 3.9 trips on Day 2, with 3.4 hours spent out of the house and 1.6 of the trips made with family members. Cluster 6 included individuals who made no trips on Day 1 or Day 2.
- Clusters 4, 5, and 6, which were the clusters with infrequent trip makers and no trip makers, were examined for possible weekly patterns. Cluster transitions from 1999 to 2000 were also explored. Approximately 70% of the individuals in Clusters 1 and 2 in 1999 stayed in the same clusters in 2000. In comparison, only 32% of the individuals in Cluster 3 in 1999 stayed in Cluster 3 in 2000 and 47% of the individuals in Clusters 4, 5, and 6 in 1999 stayed in the same cluster in 2000. These results indicate that 5-day or 2-week travel diaries are needed to capture the behavior patterns of individuals 50 years of age and older.
- The most important factor correlating to a transition among clusters was a change in employment status. This change might include retirement, working part-time, and volunteering. Other factors that correlated with cluster transitions were a change in driver's license status, a change in available vehicles, and a change in the number of children in the household. Factors that did not correlate well with a transition in clusters were gender, land use mix, and a change in home location. One implication for travel demand modeling is that it is important to first forecast the employment status of the baby boom generation before forecasting their trip making.
- The number of trips and miles traveled per day correlated with changes in the number of automobiles in the household, the number of drivers in the household, children becoming adults, older adults moving into the household, and household location. These results indicate that to forecast baby boomers at the household level, information on available vehicles, number of drivers, demographic shifts with different travel requirements, and the relocation of households is needed.

New Survey Items for a Fuller Description of Traveler Behavior: Biographies and Social Networks

Kay Axhausen

Kay Axhausen discussed research related to travel surveys in Switzerland. He described elements that may influence travel behavior, factors to consider in defining an individual's personal world, and technologies for conducting surveys. The following points were covered in his presentation.

- A number of trends can be identified relating to transportation, travel, and telecommunications in Switzerland. The number of people or locations that can be reached within 1 hour of travel time on the roadway system in Switzerland has quadrupled in the 50 years from 1950 to 2000. This trend has "shrunk" the country. The trend in the real cost of telecommunications has declined dramatically over the past 70 years. The real cost of driving an automobile has also declined, although it is difficult to believe. Switzerland has experienced the suburbanization trend. Since 1980, the catchment areas of the largest 10 cities have increased in size. The forecast is for continued suburbanization and the overlapping or growing together of some regions.
- A number of elements can be used to help explain travel behavior at the microscopic level. These elements include the generalized cost of the route-mode-location alternative, as well as budgets and longer-term commitments. Other elements include values, attitudes, and lifestyles by sociodemographics, an individual's personal world or mental map, and an individual's social network membership. Individuals are influenced by these elements, which are not easily captured in travel diaries and other survey methods. Examining methods to obtain information on these elements is important to help advance activity-based travel models and other new forecasting techniques.
- A number of elements might be considered in the generalized cost of a route-mode-destination alternative. These elements include the time spent traveling, including schedule delays relative to the intended arrival time, monetary expenditures, the time spent at the location by type, activity expenditures, and the social content. Some of these elements address comfort and risk, while others are decision and time frame relevant. Including questions in surveys to obtain information on these elements would be beneficial. For example, the risks associated with being late on trips for some activities may be higher than for others.
- Considering individuals as "network actors" in a dynamic social context represents one possible approach. An individual's personal world is influenced by his or her background and learning. Household location, social network geography, and mobility tools are linked to an individual's personal world. One individual's personal world is linked to the personal worlds of others through social capital, which includes elements related to stock of joint abilities and shared histories and commitments.
- This concept raises a number of new research questions. These questions relate to the ability to measure the social content of travel, the social network of geography, and the activity spaces. Other potential research questions focus on techniques to measure the personal world and mobility biographies and on assessing changes in the transportation systems and the social costs associated with these changes.
- The personal world may include local, national, and international transportation links. One possible approach to measure an individual's personal world focuses on the personal world as a mental map and an expectation space. Potential techniques to measure these elements include sketching, think-aloud protocols, and spatial tasks. The personal world may also be thought of in terms of the activity space of visited locations. Potential techniques to measure activity space include diaries and Global Positioning System tracing. Tracing by other techniques, such as payment methods, closed-circuit television, and telephone and computer use, raises privacy issues.
- Travel surveys have been used to collect information on individuals' trips and travel patterns. For example, a 6-week travel diary of a 24-year-old single woman, employed full time, reported a total of 216 trips. Possible techniques for collecting information on social network geographies include name generators and interpreters, diary-based prompting, and tracing contacts through e-mail, letters, telephone records, and other technologies. Obviously there are privacy concerns associated with the use of these technologies. Measuring social content will also require new questions on travel surveys to obtain information on the individuals participating in the travel and activity and who is paying. Questions to obtain information on when the trip and activity were planned, who was responsible for making the arrangements, and if the activity has been undertaken previously are also needed. It is also important to obtain information on pets being taken on trips. One study found that a dog altered the travel behavior of a household. It is also important to obtain information on repetitive activities and trips, such as work, and infrequent or new activities and trips. Experience with the initial surveys indicated a 10% response rate for the long-duration travel diaries and a 10% response rate to the social network interviews, with the use of incentives on both the diary and the survey. A 15% response rate was obtained on mobility biographies without motivational calls, whereas a 30% response rate was obtained with motivational calls. No difference in travel and trip behavior was detected between the mobility biographies completed with and without the motivational calls.
- A number of further efforts are being pursued and considered. These activities include semiautomatic extraction of data from e-mails and other written traces, experiments with social content questions in travel surveys and diaries, and integration of social network geographies and mobility biographies. Experiments with activity and travel summary questionnaires represent another future effort.

Data-Oriented Travel Behavior Analysis Based on Probe Person Systems

Eiji Hato and Ryuichi Kitamura

Eiji Hato discussed the probe person survey concept to obtain travel behavior data for activity-based models. He described the concept, possible approaches for a mobile activity logger (MoAL), and pilot tests of these applications in Japan. Appendix B contains a paper on this topic. The following points were covered in his presentation.

- Individual travel patterns vary on a day-to-day basis. Although much travel, such as commuting to work or school, is repetitive, other travel is highly variable depending on activities and needs. Travel surveys are used to obtain information on trip origins and destinations, time of travel, trip purpose, and mode. More extensive information on individual travel patterns is needed for activity-based models. Information on activity location, activity duration, travel route, changes in travel due to external conditions, and other trip characteristics is of use in activity-based models.
- A number of survey methods are available to collect travel behavior information. Possible techniques include traditional questionnaire surveys and travel diaries, web-based surveys and diaries, probe person surveys, and surveys using multiple sensors. Each method has advantages and disadvantages, as well as cost implications.
- The probe person survey technique is intended to ensure accurate travel records by determining space–time position using the Global Positioning System (GPS) and reducing recording omissions through timely reporting of travel behavior by cellular telephone or the Internet. This approach improves the efficiency of data coding and improves the participation of survey respondents. The probe person survey system takes advantage of recent market, social, and technology changes. First, mobile communication systems have penetrated the market. Second, cellular telephones, computers, electronic mail, and other communication technology are in widespread use. Third, advances in GPS, sensors, and other technologies continue to occur.
- The probe person survey system uses cellular telephones and web-based travel diaries to allow participants to easily record trips and activities. Participants can also check and correct travel records. Combining GPS and other sensors with the system allows the automatic recording of key trip characteristics. The main elements of the system include GPS-equipped cellular telephones with specially designed software, a web-based travel diary system, and a data management server. A participant activates the cellular telephone at the start of a trip. Data on the location, time, and other characteristics are recorded automatically and transmitted to the server. Position data are automatically recorded every 20 seconds while the participant is traveling. A participant presses the end key on the cellular telephone upon arrival at his or her destination. The characteristics of the trip are automatically recorded in a web diary system, which the participant can edit at a later time. The software for MoALs uses Brew. Oracle and Microsoft are used for the online analytical processing and the Internet information system.
- The MoAL system was tested in Japan over a 3-year period beginning in 2003 as part of the Matsuyama Probe Person Panel (MPPP) survey. The survey included three waves. The MPPP is a panel-type survey, with a successive diary system. Each survey period covered approximately 1 month, and new panels were added in the second and the third waves. Wave 1 of the MPPP covered 4 weeks in 2003, Wave 2 included 5 weeks in 2004, and Wave 3 covered 4 weeks in 2006. Each wave included approximately 1 million records. The participant withdrawal rate was approximately 2% in Wave 1 and 9% in Wave 2. Measures were taken to protect personal information.
- The MPPP results were compared with those of the national transportation census and person trip survey, which both cover 1 day. The MPPP results record higher numbers of trips. The average number of trips for one participant increased from 3.6 in the 2003 MPPP to 3.8 in the 2004 MPPP, while the trip omission rate declined.
- A limitation of the MoALs approach is that participants must enter and edit their trip activity information. Another limitation relates to the accuracy of GPS in some areas and under some conditions. A second approach, called Behavioral Context Addressable Loggers in the Shell (BCALs), attempts to address these limitations. The BCALs approach uses an automatic recording system with multisensors. The system obtains data on atmospheric pressure, sound, position, acceleration, and other elements. It may be possible to develop an automatic estimation model for behavioral contexts from these data without requiring any action on the part of participants.
- The results from the three waves of the MoALs pilot indicate that the use of a GPS cellular telephone and web diary system enhances the accuracy of trip reporting compared with traditional questionnaires. Location positioning can be estimated accurately with 100 meters both indoors and outside. This approach is useful for long-term detailed travel diaries. The BCALs approach holds promise as a new survey method, but privacy issues will need to be addressed.

Ram Pendyala, University of South Florida, and Kay Axhausen, Swiss Federal Institute of Technology, moderated this session.

CLOSING PLENARY SESSION

Next Steps

Institutional Issues

Ken Cervenka, *North Central Texas Council of Governments*
Larry Blain, *Puget Sound Regional Council*
Ronald Milone, *Metropolitan Washington Council of Governments*
Chuck Purvis, *Metropolitan Transportation Commission*
Aichong Sun, *Pima Association of Governments*
Richard Walker, *Portland Metro*
Kermit Wies, *Chicago Area Transportation Study*

Ken Cervenka

It is a pleasure to moderate this closing session. We have an excellent group of speakers, who were asked to address the following four questions in their remarks.

- What did you learn from this conference that you did not previously know?
- What were you hoping to learn that is still not fully answered?
- What do you see as the obstacles that most agencies will need to overcome to move forward with more advanced land use and travel modeling procedures?
- What are the expectations of your agencies for moving forward with more advanced land use and travel modeling procedures?

Larry Blain

My comments focus on the four questions outlined by Ken Cervenka, which I thought about as I listened to speakers during the different sessions. While I did not learn anything brand new at the conference, a number of things that I have been thinking about were reaffirmed by speakers and by the discussion in the different sessions. The impact of changing demographics, including the baby boomers moving into retirement and the impact of their retirement on travel behavior, was one of those elements. Other points that were reaffirmed by speakers included the globalization of issues, the resettlement of central business districts (CBDs) by higher-income groups, and the increasing number of one-person households. The next step after understanding these issues is to better anticipate and respond to resulting changes in travel needs.

I was pleased to learn about the increasing prevalence of tools, such as the population synthesizer and the tour analysis tools that are now available for use. I wish there had been more discussion about the transferability of models from one area to another. I would also have liked to have heard more on the use of dynamic traffic assignment at the regional level and risk analysis, including the multiple uses of stochastic runs to obtain a better idea of the range of possible outcomes.

I was not able to attend the education session, but it seemed to focus on educating modelers. I think we also need to educate policy makers about travel modeling tools and techniques, especially the appropriate use of the results from these models. It is important to build a better understanding among policy makers about the benefits of travel models.

The lack of funding and limited staff resources were two major obstacles discussed in many of the sessions. Data analysis needs were also noted as obstacles by many speakers. Data on day-to-day individual travel behavior are critical with the use of disaggregate models. Multiday individual travel diaries and other related data collection techniques are needed with disaggregate models.

Another obstacle is the fragmented development of models and analysis techniques, with work under way in many urban areas. While there is communication among different groups, a central focus for sharing information and consolidating results is lacking. I would suggest that

NCHRP, a consortium of metropolitan planning organizations and state departments of transportation, or possibly software firms take the lead in helping bring a central focus to model development, testing, and deployment. Practitioners, academics, and consultants all need to be involved in the process.

I think the lack of stochastic models is also an obstacle, as is the need for techniques to conduct risk analyses. At the Puget Sound Regional Council, we are just beginning a 1-year testing phase of the UrbanSim land use model. We have an enhanced four-step model that is being used to test pricing and high-occupancy toll lane alternatives. It appears to be working well. We are also conducting a new 2-day travel diary survey. We may try microsimulation tour-based modeling in 2 or 3 years. Along with the 2-day travel survey, we have a major problem of converting all our data from the standard industrial classification system to the North American Industrial Classification System. We are compiling a 2006 base year for UrbanSim and we will recalibrate our travel model to 2006. We would also like to add a regionwide dynamic traffic assignment model or a sketch accessibility calculator, if these tools are developed.

Ronald Milone

Thank you for inviting me to offer comments on what it will take to bring advanced travel modeling methods into practice. This is certainly an important and timely conference, and TRB is to be commended for bringing us all together. Both the practitioners and the research community have a great deal to gain by working more closely together in the coming years. Earlier, Frank Koppelman made the interesting comment that many of the groups involved in the planning process are increasingly talking past each other and not really listening to each other. I think the same phenomenon has been occurring between practitioners and researchers. This conference has helped to close the gap between research and practice, and that is needed for progress in the travel forecasting field.

The Metropolitan Washington Council of Governments Transportation Planning Board (TPB) employs a conventional four-step travel demand model that is typical of such models applied at most metropolitan planning organizations (MPOs) around the country. We are working hard to address a wide variety of complex transportation issues in the capital region, and we are increasingly pushing the travel model to go beyond what it was originally designed to do. In addition, our modeling process has received a great deal of technical scrutiny, particularly by environmental groups. As a result, much time has been spent examining and refining our methods used in application.

The motivation of this conference is to facilitate the implementation of advanced methods into practice. Yet, there have been many indications from conference speakers that existing practices are inadequate. Bill Woodford's session on FTA-sponsored research touched on problems associated with existing traffic assignment procedures. Martin Wachs's presentation on the results of a recent state-of-the-practice survey indicated that many MPOs are behind the curve with respect to reasonable modeling practice. How can we realistically bring advanced methods into practice when we are not doing an adequate job with existing methods?

The TPB adheres to a multitrack model development process. We have an applications track, which focuses on short-term improvements to existing methods, and we also have a methods development track, which focuses on the development of more advanced models and techniques. The methods track activities proceed in parallel with the applications track so that advanced methods may be phased in when deemed appropriate. If resources are available, I would strongly encourage MPOs to adopt a similar approach. We feel the "dual track" approach is reasonable for incrementally phasing improvements into production when the improvements are ready. We also believe in the development of empirically based models and the use of locally collected data.

One obstacle to moving advanced methods into practice is the grueling production schedule faced by many MPOs, which includes periodic plan updates, air quality state implementation plan and conformity work, and project planning studies. Given this busy schedule, I feel that there must be a firm understanding about the amount of time and resources that will be required to develop new methods. In order to secure time and resources, our staff and board also need to understand how the advanced methods are superior to existing methods.

Another obstacle to moving forward is the lack of observed data. Several speakers highlighted both the lack of data and the limitations of existing data used in model development work. It is important that the data needed to calibrate and validate advanced methods are clearly understood. I would submit that understanding observed data and input data is just as important as understanding the model itself. There was a great deal of discussion at the conference about what makes one model "better" than another model. I do not think that is a useful discussion. I would submit that the "best" model is the model that is calibrated with quality data and is driven by quality inputs: accurate land use forecasts, accurate network coding, and accurate policy assumptions.

Finally, the advanced methods need to be fully transparent to practitioners before they are used in application. Practitioners presently understand the four-step model very well. They know how to develop four-step models and how to interpret results. They understand the limitations of the four-step approach. As advanced methods are introduced, the practicing community will face many uncertainties relating to needed data, model development procedures, and application software. There is also uncertainty about how consultants should be selected and used in developing advanced techniques. It will take time for the practitioners to become educated and comfortable with new methods.

The TPB is planning to conduct a survey of 10,000 households in the coming year to obtain current travel behavior data. We plan to use the survey data to support the update of our trip-based models, and, in the longer term, to support the development of activity-based models. While we can discuss the advantages of activity models over conventional models, I still want to stress the point that no model will operate well if the inputs to the model are of poor quality. It is important to remember that the inputs to the model are critical to arriving at realistic results. We should ensure that adequate resources are focused not only on modeling improvements, but also on striving to improve input data to the model.

Chuck Purvis

The papers and presentations have been interesting and informative. I would give the best paper award to Ram Pendyala and Chandra Bhat for their paper, "Validation and Assessment of Activity-Based Travel Demand Modeling Systems." I also found the information on the work under way at the Denver Regional Council of Governments and the Sacramento Area Council of Governments to be very interesting. We can all learn from their experiences as we move forward with model estimation with the next generation of activity-based models. I also learned about clock-time savings that one can accrue by freezing an activity-based model process after certain steps in the model application.

One topic I would like to learn more about is the level of uncertainty in our activity-based models. We need to present a range of values to represent this uncertainty. I would also like to hear more about the validation of the synthetic population generation component. We do have multiple years of public use microdata sample data and we need to thoroughly test the population synthesizers using past census data and the new American Commuters Survey that should be available this fall.

I think training and education is the number one obstacle to advancing the use of activity models and other techniques. We also need a summary of the issues related to the non-market-segmented trip-based models, the market-segmented trip-based models, and the microsimulated models. We need a discussion of the issues related to ecological fallacies associated with moving from a naive segmentation to the full microsimulation.

A second obstacle relates to the limited experience that we currently have with the use of activity models and other advanced techniques. Experience is limited at MPOs and in the consultant community. For widespread application of these techniques, we need widespread dissemination of information on experiences with the use of different models.

The Metropolitan Transportation Commission (MTC) held a peer-review panel funded through the Travel Model Improvement Program in December 2004. Our next activity was a model specification and training study. We are in the process of reviewing our specification plan. We have gone through some very intensive in-house training over the past few months. The MTC staff will estimate the activity-based model. We will use consultant assistance with the specification plan, the oversight of staff estimation of the models, and the software construction after we are done with the estimated models. We are using a work-sharing approach to these activities. I am very excited about the process.

The training effort focused on multimodal logit models, nested logit models, destination choice models, estimation of daily activity patterns, interhousehold interaction models, and tour departure and duration choice models. This approach gives MTC staff a pride of ownership and an excellent understanding of the models. This approach may not work for all MPOs, but for us, estimating the models in house and working in partnership with consultants is an excellent way to implement a new set of travel behavior models.

I also have a concern over whether we should refresh our trip-based models. Our approach of using staff rather than consultants to implement activity-based models will probably take longer than relying totally on consultants. I think that in the end we will have a better model, a better process, and a better-trained staff.

Aichong Sun

I appreciate the opportunity to provide a perspective from a medium-sized MPO. Voters in Pima County, Arizona, recently approved an increase in the sales tax that is dedicated to transportation projects in the county. The sales tax is expected to generate approximately $2.1 billion over the next 20 years.

We use a conventional four-step travel model at the Pima Association of Governments. We just completed a model update with the assistance of consultants. Three components were added to the model as part of this update. These components are a household model, a time-of-day model, and a mode choice model.

The outputs of the household model include household income, automobile ownership, and the number of workers. Previously, we could only model 24-hour traffic volumes. The time-of-day model allows us to model different times of the day, such as the morning and afternoon peak periods. The mode choice model is the most important of the three components.

We have been using a very simplistic approach to the land use elements in the model. We use data from local jurisdictions on population, employment, school enrollment, land use, and other socioeconomic characteristics. The Maricopa Association of Governments in the Phoenix area is leading an effort to develop a new land use model. The Pima Association of Governments will be one of the major users of the new land use model.

We do not have any plans at this point to move toward the use of activity-based or tour-based models, primarily because of budget, staffing, and data constraints. We do have a number of surveys scheduled and we have an ongoing traffic count program. On an annual basis, we conduct traffic counts at 380 sites and 16 intersections. We also conduct regular vehicle classification counts. An external station survey is scheduled for 2007. A travel speed and travel time savings survey using a Global Positioning System is also scheduled for 2007. We hope to conduct another household travel survey in 2008.

I found the papers to be very interesting and learned a good deal about the capabilities of activity-based models at the sessions. Given the resources to develop and maintain activity-based models, however, we need to be able to show that the results are superior to those produced by the traditional four-step model before we are able to make a significant investment in these models.

Richard Walker

I have been fortunate to have had the opportunity to work with activity models throughout my career. Keith Lawton, formerly with Portland Metro, has been a national leader in applying activity-based models. Having worked extensively with activity-based models, I did not really learn anything new at the conference. A number of important points were reinforced and expanded upon by speakers, however.

I would like to highlight a few of the points made throughout the conference. First, "one size does not fit all" in dealing with models, model forms, and the needs of MPOs. Agencies should look at the issues in their areas, as well as their staff and financial capabilities when determining the best models and techniques to use. The model approach for one MPO may be very different from the model approach for another MPO.

Second, speakers described the different activity-based models available for practical application, as well as those in the development stage. In considering an activity-based model, it is important to review the elements used in the models, the data needs, and the model capabilities. We are at a point where we can establish a benchmark and compare different models to ensure that MPOs select a model that best meets their needs.

Third, we are seeing changes in the types of questions in household travel surveys. Rather than just simply asking the standard questions related to individual travel behavior, additional questions are being included to obtain a better idea of why people are making certain travel choices.

The reliability of the transportation system is becoming a more important issue. We are developing a regional transportation plan in Portland. With limited funding for projects, congestion, especially in the peak periods, will continue to be an issue in the area. A 20-minute trip in the off-peak period typically takes 40 minutes in the peak period. The consistency of the peak travel times is also an issue. Trip time reliability appears to be more important to commuters than the travel time. As a result, trip time reliability is also becoming an important factor in the decision-making process. We need to have trip time reliability in our modeling tools to provide accurate information to decision makers.

Another important issue is assignments under saturation conditions. I was not able to attend the session where this topic was discussed, but clearly traffic congestion is a way of life in urban areas. As a result, assignment techniques with saturation are very important.

I would suggest using the word "challenges" rather than "obstacles" in describing the key issues we face in advancing the state of the practice. An important challenge is that we need to be aware that activity-based models may produce different results than traditional four-step models. These differences may not be evident in the base year, but the future year results from an activity-based model will be different from those obtained through a traditional four-step model. While it is to be expected that there will be differences, it can be a challenge to explain the reasons for these variations to policy makers and other groups. We need to be very strategic in implementing activity-based models and in presenting the results.

Another challenge relates to future survey methods. Issues related to cellular telephones versus land-line telephones, freight data, and nonresponse levels all represent challenges. We are working to update our regional freight data model. Obtaining accurate data on freight movement at the zone level is difficult.

Guidelines at the federal level continue to change as a result of SAFETEA-LU and other programs. Addressing new and modified guidelines and requirements related to travel forecasting for different programs and projects will continue to be a challenge.

It is also important to think about key elements with the introduction of activity-based models. Examples of these elements include changes in coding, model run-time differences, and hardware needs. Providing training to staff in the use of new software is also critical.

We are actually taking a step backwards at Metro. We have an activity-based model that has been used on a number of studies. We are working with the Oregon Department of Transportation and other MPOs in the state to conduct a new travel survey over the next few years. At Metro, we plan to use the results in a number of different ways. First, we will use the results to check the parameters of our four-step model and update the model as needed. We will continue to use this model. Second, we will use the survey data to help develop our new activity model. We will then be able to compare the results from the two models and help advance the discussion related to activity models.

Kermit Wies

The previous speakers did an excellent job of highlighting many of the key issues discussed by speakers and summarizing the critical challenges that we face in advancing the state of the practice. Because the title of this session includes institutional issues, my comments focus on what a cultural anthropologist attending the conference might observe related to what the modeling community is trying to do about what we think is the problem.

A number of comments have been made at the conference that modelers focus on the modeling process and the model results and that we do not become actively involved in the decision-making process. Suggestions were made that we let others make decisions on issues in which we have expertise and that we are not proactive in participating in the decision-making process.

Frank Koppelman suggested in the opening session that we may be talking at each other rather than talking with each other. Speakers in a number of sessions further suggested that the largest obstacle we face may be that the product we are selling is not exactly what our customers want to buy. This situation places modelers in a reactive position and makes our jobs more difficult. As planners, we want to look ahead and have a proactive role in shaping the future direction of the transportation system. We need to be sure that travel demand models help address key questions and enhance the discussion of future transportation needs.

Regional planning reform is moving forward in Chicago. One of my favorite icons for Chicago, New York City, or any other large metropolitan area with a significant financial market is the picture of the floor of the stock exchange with people shouting and waving their arms. There seems to be a blind faith that whatever the situation is when the closing bell rings, it is the best thing that could have happened. This same situation may exist with travel models. I think we are doing a better job of listening to each other. I think we hear what relates to our agency and situation. What I have been most inspired by is that the biggest success stories seem to be tied to a person or a team of people, rather than an agency, who really want to implement a new model or a new approach. I think significant advances in the modeling practice will be made by committed individuals. I would like to see the modeling profession continue to focus on moving beyond reacting to issues and to become more proactive in policy discussions.

Ken Cervenka moderated this session.

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