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STATEWIDE TRAVEL DEMAND FORECASTING CONFERENCE PROCEEDINGS

Sponsored by Committee on Statewide Multimodal Transportation Planning

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Overview

Neil J. Pedersen, Chair, TRB Committee on Statewide Multimodal Planning, and Maryland Department of Transportation

This Transportation Research Circular reports on the proceedings of a workshop sponsored by the Transportation Research Board on statewide travel forecasting issues. The workshop was held in Irvine, California December 6 - 8, 1998 and was attended by participants from 35 state departments of transportation, the U. S. Department of Transportation, private consulting firms and several universities. The purpose of the conference was to provide practitioners in the field of statewide travel forecasting the opportunity to exchange information and experiences on methods for forecasting statewide travel for both persons and freight. The objective of the conference was to identify the state of the practice in the field of statewide travel demand forecasting, critical issues in developing and applying forecasting procedures and research needs in the field.

Several states have undertaken major efforts to develop statewide travel demand forecasting models. A number of other states are considering making such an investment. All states are facing planning and policy questions to which the statewide travel demand forecasting procedures can help provide answers. FHWA has contracted with the University of Wisconsin at Milwaukee to develop a "Guidebook on Statewide Travel Forecasting." Given the current situation it was felt that a workshop to bring together practitioners in the field would be timely.

Prior to the workshop a survey was distributed to all state departments of transportation by Texas Transportation Institute. The purpose of the survey was to identify current practices and issues in the field of statewide travel demand forecasting. A summary of the results of this survey are presented in the appendix of this report. Based on the input received from the survey a series of issues were identified in the broad categories of management/administrative issues, federal requirement issues, data issues, freight, geographic information systems, model applications and technical process. A list of the specific issues in each of these categories identified from the survey responses is contained on page 192.

The workshop began with a briefing by Dr. Alan Horowitz from the University of Wisconsin, Milwaukee on FHWA's draft "Guidebook on Statewide Travel Forecasting." This guidebook is expected to be issued by FHWA in early 1999 and will be used by FHWA in a training course that is currently being piloted.

Following the briefing on the guidebook, a panel of state DOT planning directors discussed the policy context in which statewide travel demand forecasting is being undertaken. It was felt that it was important to set a context for the workshop by discussing the types of policy and planning questions that the statewide travel forecasting process is being asked to answer. Highlights of some of the issues raised by the panelists included:

- The types of investment decisions being made today are quite different than in the past when they were primarily highway project level decisions.

- Statewide forecasting methods are being asked to provide information to support investment decisions among modes and between capacity and operational improvements. They need to be able to tie directly into asset management systems.

- Decisions are being tied much more to performance measures. We need to understand the performance measures that will be used for decision making before designing our forecasting processes. We need to be able to demonstrate what we will get in terms of performance when we seek additional funding.

- We need to ensure that policy issues and questions are driving the technical process, and not let the models drive the policy process.

- We need to be able to answer the question "What can we expect to get in return for alternative investment strategies?"

- Knowledge, not just data, needs to come from the information produced by forecasting process.

- There is a need to integrate economic activities into the forecasting process.

- As certain modal facilities such as airports and intercity highways reach capacity, we need to be able to test modes that may not exist today, such as high speed rail.

- More and more, statewide forecasting methods are being called upon to address land use policy issues such as growth management concurrency requirements.

- We need to find cost-effective means to develop methods and data through use of secondary data such as national databases and transferable parameters. Otherwise it will be difficult to obtain the resources necessary for model development.

- Development of statewide models may not be justifiable in all states. Ultimately a decision needs to be made whether the information produced is worth the cost and effort involved in model development.

- Many states cannot retain qualified staff to manage model development and application work.

- We need to better understand long term future trends. Too often models are designed to answer the questions and conditions that existed five to ten years ago rather than future conditions.

- We need to be able to produce forecasts much faster than in the past and to ensure that results are presented clearly in terms that laymen will understand.

Presentations were made by forecasting practitioners representing 14 states, and four workshop sessions were held to discuss a series of issues that had been identified in the survey conducted prior to the workshop regarding current practices in the field. Summaries of the presentations are presented on pages 32-169, and summaries of the workshop conclusions are presented on pages 170-174. Some common themes that came across in the presentations and workshop discussions included:

- To be effective statewide models must use networks that go beyond state boundaries and often will include a skeleton national network.

! The cost of primary data collection and network building is so high that it has almost become a necessity to use national data bases and networks for model development.

! Challenges in getting survey data for model development range from difficulty in doing roadside interviews to poor response rates to mailback and telephone surveys.

! It is important to get local and regional cooperation with statewide efforts and to closely coordinate with regional forecasting efforts.

! Although statewide models in many states are still primarily being used to support highway project and corridor level decision making, the questions that need answers from these models relate to policy issues beyond traditional highway project level decisions.

! Among the questions being asked are tests of alternative land use strategies, intercity modal tradeoffs, and alternative investment strategies.

! Trip purposes are different at the statewide level than metropolitan level with much more emphasis on recreational travel and freight movements.

! The Bureau of Transportation Statistics' Commodity Flow Survey is a rich data source for freight model development, but it is missing key movements.

! Analyses must be structured to provide information on the performance of the system and be able to compare past, current and future conditions.

! It is important to understand the limitations of models and under what circumstances they can be appropriately used.

! We should not expect models to be able to do everything and answer all questions that may be posed.

! It may be appropriate to use expert panels to better understand the underlying trends, assumptions and methods of the modeling.

! It is useful to cross check model results with simplified alternative techniques to increase confidence in the model results.

! There should be no national standards or federal requirements for statewide travel forecasting since special circumstances in each state dictate what is best for each state's needs.

! There is value in sharing experiences among states and practitioners in the field, and it was recommended that there be a Travel Model Improvement Program (TMIP) web site for statewide travel forecasting as well as a follow-up conference on the subject in two or three years.

One of the key products of the workshop sessions was identifying research needs. A more comprehensive list of research needs is contained on pages 174-191. Highlights of the research needs identified include:

- Identify appropriate uses and limitations of national databases and networks for use in statewide travel demand forecasting.

- Perform a nationwide survey to better determine passenger and goods movements across state lines and national borders.
- Perform a well designed stated and revealed preference national survey for intercity travel for forecasting use of modes not currently available (e.g., high speed rail, maglev).

- Identify goods movement patterns and demands not currently captured in national databases (e.g., import goods, deadheading, company owned fleets).

- Investigate differences and commonalities between statewide and urban travel demand forecasting.

- Develop a synthesis document of current practices that provides guidelines for appropriateness of procedures for various applications. That document should build on FHWA's "Guidebook on Statewide Travel Forecasting."

- Develop a better understanding of changes occurring in statewide travel demand that may be related to larger national and international economic trends.

- Identify transferable parameters and simplified procedures for statewide travel forecasting similar to those developed for urban travel demand forecasting in NCHRP Report 187.

- Develop models that can be used for strategic policy level analyses and that would not require the level of detail that is needed for project level analyses.

- Develop national level transportation network data that can connect to more detailed statewide networks.

- Identify methods to use ITS data for statewide travel forecasting.

- Develop a toolbox of methods for use in statewide travel analyses similar in concept to the ITE toolbox for urban travel.

The conference proved useful to those who participated both for comparing experiences and learning from others, but also for identifying areas of needed improvement and research in forecasting methods. Hopefully these conference proceedings will also prove useful for those who were not able to participate in the conference. My thanks to the conference steering committee, TRB and TTI staff and all conference participants for a useful exchange of information on statewide travel forecasting.

Questions and Issues
for Statewide Forecasting Policy Discussion

From a policy perspective, what are the main questions being asked that the statewide forecasting process should answer?

! Who are the policymakers asking questions, and are the questions being asked by legislators different from those being asked by DOT policymakers?

! How are the policymakers' questions being answered today?

! How are the results of a statewide forecasting process used for planning and programming issues?

! Have ISTEA and TEA-21 statewide planning and programming requirements affected the need for and requirements of a statewide forecasting process?

! Is it worth the effort and cost to invest in a statewide modeling process, or can adequate answers be derived in a more cost effective way?

! How are multi-state forecasting issues being dealt with?

! How are states addressing statewide freight and intermodal forecasting issues?

! How are states handling some of the major changes occurring in commodity movements as a result of NAFTA, shifts in global economy, major changes in seaborne commerce and port activities, rail mergers and consolidation among freight companies?

! What policy issues are being faced regarding tourism and recreational travel on a statewide level?

! What do statewide and metropolitan forecasting issues relate from a policy perspective?

! How can there be consistency in dealing with forecasting issues throughout different areas of the state?

Additional Policy Questions and Issues

ADMINISTRATIVE-RESOURCES [Ac]

1. What staffing levels are necessary to develop and maintain a statewide passenger travel demand model? (LA) - [Ac]

2. How does the cost of data collection for a statewide model and its related sensitivity relate to the cost of the project with or without the data? (MN) - [Ac]

3. Is utility cost of data recovered with the project benefits? (MN) - [Ac]

4. What internal resources are required to operate and maintain a statewide model? (MO) - [Ac]

5. In addition to time and costs to develop and maintain statewide forecasting procedures, what staffing requirements exist or are anticipated? (TX) - [Ac]

6. Will existing staff view the statewide model as a tool to expedite their work or an additional burden

to maintain and, if so, how will this be accomplished? (TX) - [Ac]

7. What are the tradeoffs between the expenses of building and maintaining a model and any increase in accuracy compared to current procedures? (AZ) - [Ac]

8. What kind of financial support can be provided on the model development to other states who are just developing or exploring model application to upgrade it to the continuing phase? (ID) - [Ac]

9. What are the costs of these models? (WI) - [Ac]

10. Teaching statewide travel demand in university engineering courses. (KY) - [Ac]

RULES [Ar]

1. What is the Federal perspective on statewide travel forecasting? (OH) - [Ar]

2. What incentives/rules/funding is planned for future statewide traffic forecasting? (OH) - [Ar]

3. Which states currently have statewide forecasting Guideline? (CA) - [Ar]

4. Are the Guidelines published? (CA) - [Ar]

5. What should be contained in these Guidelines? (CA) - [Ar]

6. Are the Guidelines standard? (CA) - [Ar]

7. Do they advocate or direct modeling acceptability for the State or are they just truly a guideline which may or may not be followed? (CA) - [Ar]

8. Does the Guideline discuss and present acceptable practices, consistent methodologies, parameters and assumptions? (CA) - [Ar]

9. Are the models policy sensitive? (WI) - [Ar]

10. Greater cooperation between states concerning TAZ data maintenance. (KY) - [Ar]

FREIGHT [F]

1. A statewide freight/goods movement model? (LA) - [F]

2. What considerations has the EPA voiced concerning the possibility of credits based on freight modeling in air quality determinations? (TX) - [F]

3. Commodity flow/truck/rail issues. (IN) - [F]

4. Need/demand for additional intermodal facilities. (AR) - [F]

GIS [G]

1. Geographic Information System Applications in Statewide Travel Demand - many areas, states have been reluctant to establish this process due to overwhelming

2. data requirements - is this the answer? (NV) - [G]

3. Integration of Statewide Models with GIS and other Planning/Policy databases. (FL) - [G]

LAND USE [L]

1. What is the relationship between travel demand forecasting and land use planning currently, and where is it moving? (HI) - [L]

2. Land Use Models in Forecasting. (NJ) - [L]

PLANNING PROCESS [P]

1. How have other states used their models to drive their transportation policies and plans, identify and evaluate transportation demands and alternative solutions? (OH) -[P]

2. What is the best level of application? Route, corridor, community, etc? (NV) - [P]

3. There are multi-state models being used on specific corridor purposes (Avenue of the Saints corridor, I-35 Canada to Mexico, NHS System, etc.) Any relationship? (IA) - [P]

4. How are connections made with MPO models that are different? (MO) - [P]

5. Can/should all areas within state be effectively analyzed with one tool? (KS) - [P]

6. Should the tool be tiered? (KS) - [P]

7. Obviously it already is with Metro and Rural, but are there more (common corridor)? (KS) - [P]

8. What is the potential for simulation models and will they work at the macro- level (i.e., state and regional)? (CA) - [P]

9. How to fill in the missing pieces in the transportation puzzle. Travel demand modeling is great for part of what we plan for highway capacity piece - need service modeling as well as activities? (DE) [P]

10. Transit and roads; need to be able to model various mode scenario - i.e., rail freight vs. Truck freight and the impacts of each. (DE) - [P]

11. The development of procedures to use statewide model based traffic forecasts for project level traffic forecasts. (IN) - [P]

12. The level of analysis that travel models are an appropriate tool for. (CT) - [P]

13. Combining and refining modeling results with other tools (post analysis, spreadsheet calculations, manual adjustments, consensus building, etc.) (CT) - [P]

14. Is there a source or replacement for household O and D study? A traditional O/D study is very expensive. (ID) - [P]

15. What future issues or policy questions are anticipated that may require statewide procedures? (IA) - [P]

16. Standardization of traffic models. At least make them portable between different software packages. (KY) - [P]

Additional Technical Issues

ADMINISTRATIVE [A]

1. What are the hardware and software requirements for statewide multimodal passenger travel demand models; for multimodal freight/goods movement models? (LA) - [A]

2. For any model proposed, an issue is the ability of staff to maintain and update the model over the long term. This needs to be evaluated for many of the above issues. (IA) - [A]

DATA [D]

1. What methods are in use and planned for future data collection to collect the data that drives the statewide travel demand models? (OH) - [D]

2. Are states utilizing federal funds to collect household survey data? (OH) - [D]

3. Are travel time studies performed regularly? (OH) - [D]

4. Are there any unique modifications to the regular traffic counting program to accommodate statewide travel modes? (OH) - [G]

5. What are the minimum data requirements needed as input to the models? (CO) - [D]

FREIGHT [F]

1. What are the critical parameters, assumptions, and data requirements necessary to develop an acceptable truck model? (CA) - [F]

2. What are the transferability and compatibility issues between light duty vehicle models and heavy duty vehicle models? (CA) - [F]

GIS [G]

1. Model/GIS Interfaces. (VT) - [G]

2. Use of GIS in developing and maintaining travel demand network and related data. (OH) - [G]

PROCESS [P]

1. How have external passenger and freight movements been addressed in statewide models? (LA) - [P]

2. What are the states' experiences in incorporating special generators and non-peak data (i.e., weekend traffic) into models? Software requirements for statewide multimodal passenger travel demand models for multimodal freight/goods movement models? (HI) - [P]

3. How can statewide models be responsive to changes in economic conditions and cycles? (NC) - [P]

4. How are long distance, occasional purpose trips which accumulate on a statewide network accounted for in the model? (NC) - [P]

5. Which of the model processes or programs in use now are considered to be most successful? (NV) - [P]

6. What happens when the error of the model and data exceeds the expected volumes/traffic of the project? (MN) - [P]

7. How to handle externals particularly with relaxation of the federal speed limit and states selecting different speed limits. Route selection for long trips may now be impacted. This would also be true for heavy commercial tax structures. Truck routes may be influenced by some other state's policies. Is there a good mechanism to handle externals? (KS) - [P]

8. What is the potential to develop 100% compatible statewide transportation and air quality models and factors into one package of models? (CA) - [P]

9. How is the relationship addressed between the zone structure required for a passenger flow model (relatively fine) vs. that required for a commodity flow freight model (typically less detailed)? (TX)

- [P]

10. Regional models: The first step to building a statewide model. (FL) - [P]

11. What are the tradeoffs between time series analysis and cross-sectional analyses? (AZ) - [P]

12. What level of statistical accuracy is obtained? ((AZ) - [P]

13. The interface between travel and emission models. (CT) - [P]

14. The transferability of modeling assumptions and relationships. (CT) - [P]

15. How are mode split, HOV and TDM elements included and estimated? (CO) - [P]

16. What network assumption (size, number of links, etc.) Are necessary? (CO) - [P]

17. Do economic models, such as REMI need to be recalibrated using assignments based on proposed developments, if so, how many times should they be recalibrated with new assignments? (KY) - [P]

18 Should corridor study refinements (network, calibration) be put in base STM network? Guidelines for doing this? (KY) - [P]

19. What is the optimal update period (every ? years)? (KY) - [P]

General Welcome

Allan Hendrix
California Department of Transportation

Welcome to California. To start things off, I want to share some facts and problems we are facing concerning statewide modeling in California.

We are the seventh largest economic entity in the world. In 1997 the gross state product was just over a trillion dollars, and it will go up by 10 percent in 1998.

We exported $110 billion worth of products and services in 1997. That is also increasing. That is just what goes out of California. There is more that comes in, and a tremendous amount that goes through California. When you start talking about modeling goods movement, the data will tell you sometimes what comes in and what goes out, but it does not tell you what goes through.

Over 800 million tons of freight moves into, out of and within the state every year, and that estimate may only be a third of the actual total. In terms of volume of shipping containers, the largest seaports in the

United States are the ports at Long Beach and the port of Los Angeles.

We have three of the busiest airports in the United States. I think they are three of the ten busiest airports in the world: L.A. International, San Francisco International, and John Wayne, right here in Orange County.

At least 3.8 billion tons of air cargo are enplaned and deplaned annually in our ten largest airports. We have just done a goods-movement study focusing on airports. The interesting thing about what comes in and out of our airports, is that the dollar volume is more now than any other mode of transportation. The stuff we send by airplane is incredibly expensive

In 1942, our population was about six million. In 1990, it was about 30 million. We are at 33 million today and, by 2020 we could have an estimated 50 million. That means a population the size of the state of Florida's will be coming to California in the next few years.

Half of that will be from natural increase -- people born here, and half will be from migration. We have 12 percent of the nation's population. We have 58 counties in California. The smallest has 1200 people. The largest has 9.6 million. 50 percent of the state's population, 16 million, is down here in Southern California.

We have the largest urban population in the nation -- almost double that of New York or Texas. However, 92 percent of our population lives on 6 percent of the land. Thus, we are a very rural state since 94 percent of our land use is not urban.

We have the largest number of licensed drivers in the nation -- 20 million. We have the largest number of registered vehicles in the nation -- 25 million, one and a quarter vehicles per registered licensed driver in California.

We have the highest average in the nation for daily vehicle mileage travel -- 405 million. Actually, I have two numbers, and I took the lower one. It may be closer to 700 million. But it does not matter because it will only increase anyway.

We have 15,200 miles of state highways and 155,000 miles of non-Interstate roadways. A very small amount of the state's road infrastructure is state highway. The number of lane miles in California is almost the same between rural and urban, about 200,000 lane miles of urban and 181,000 of rural.

Motor fuel usage in California is greater than 10 percent of the national usage; but remember we have 12 percent of the population. We have an even higher percentage of the total miles traveled. We have plenty of vehicles in our fleet that are very fuel-efficient and that pulls us down interms of fuel sales and revenue.

On our freeways, on one section of I-10 in Los Angeles, we have 325,000 vehicles per day. 600,000 vehicles a day travel through the interchange of I-10 and I-405. So we have big numbers, lots of people, and lots of data. Doing urban modeling is hard, but doing statewide modeling is almost impossible.

That is a view of California to tell you where you are and what is going on here. Again, we appreciate your coming to this conference. I hope you enjoy the area down here and benefit from any information we

can give you. Thank you very much.

Introduction

Neil Pedersen

This conference is co-sponsored by the TRB Committee on Statewide Multimodal Transportation Planning and by the Statewide Transportation Data and Information Systems Committee, chaired by Ron Tweedie of New York State DOT. Unfortunately, Ron could not be here today.

Our Statewide Planning Committee has been very active over the past few years. In order to better understand what we are learning from each other, we have conducted peer reviews in several states. We have now had three peer reviews, one each in Wisconsin, Montana and Washington state. This has been very useful to us and we will share the information from those peer reviews at the TRB Annual Meeting in January. The committee has begun a synthesis project to determine what technical tools are needed in the area of statewide planning. Henry Peyrebrune is the consultant who will be undertaking that effort over the next several months, and several of our committee members are on the panel guiding that effort.

Several members of the committee also proposed an NCHRP project that was accepted this year. It is an open-ended contract for planning activities. Ken Leonard from Wisconsin DOT chairs the panel for that project, and the panel selected several topics for funding in the area of state and local planning.

At the Annual Meeting our committee will sponsor or co-sponsor nine presentation sessions.

For the past three years we have been working with the Federal Highway Administration and Federal Transit Association on their research program, to improve research funded by those two federal administrations.

I am also chairman of an advisory panel to the U.S. Department of Transportation and EPA for their Travel Model Improvement Program. For several years now, they have undertaken improvement to existing models and development of a new set of travel models. A consultant with that effort is Texas Transportation Institute, and I've asked Gordon Shunk to come up briefly to tell you about that program.

Gordon Shunk
Texas Transportation Institute

I hope that, through our efforts, you have heard about us. TMIP is the Travel Model Improvement Program. If you want information about TMIP, our website is TMIP.TAMU.EDU. That website has an amazing amount of information. We have abstracts of reports, full texts of some reports, lists of documentation, lists of conferences, lists of activities going on, and travel forecasting models. We have more on urban models; however, through co-sponsoring this conference, we want to bring in the statewide models as well.

TMIP is a seven-track activity. It starts with Track A, an information dissemination process, which includes the website and a clearinghouse of information. It also has technical training and technical assistance for which TTI is responsible.

Track B has numerous reports on results of updating and improving existing travel forecasting models and strategies. This may be more important to you because those improvements tend to be of the four-step model type that Alan talked about this morning, more applicable for statewide planning.

Track C is the brand new models, such as TRANSIMS, the Transportation Analysis and Simulation System, the simulation modeling being developed by Los Alamos National Laboratories. I will give you a few more comments on that in a minute.

Track D is the data track. We have a huge report, about two inches thick, prepared by the Federal Highway Administration. It is a collection of data processing and collection procedures. There is other documentation available through Track E, which is land use. We have not gone very far with land use, but we have a major activity underway at this time. We did have a conference in 1995 on land use models. We are currently examining a potential major research effort in Eugene, Oregon for possible inclusion in TMIP.

And we have Track F, freight. Russ Capelle is really leading the freight work in Track F. He can tell you a lot more about it and more accurately than I.

Now TRANSIMS is getting ready for deployment. Your TRB Program will show that our first presentation will be on the results of applying those models. We are going to present a status report, but, more importantly there will be a report on the deployment of the models and how we are going to make TRANSIMS available to you within the next few years. We expect major completion of those models by mid-2000. There will be a major case study, testing all of the parts of the model, including the multi-modal aspects like walking, as well as rail transit and conventional highways, in Portland, Oregon.

I will be here for the next two days with all of you. If you have questions, comments or suggestions, I would be happy to talk to you
about them. Thank you.

Neil Pedersen

The Federal Highway Administration suggested this workshop on statewide forecasting to TRB and our committee, and we felt that it was very appropriate for us to undertake this project at this time. There were a number of states considering the development or improvement of statewide models, and several had been struggling with and learning lessons.

The first activity of the conference was to send out a survey to all 50 states asking what they are doing in the area of statewide travel forecasting. 37 states responded to the survey, and the results are in the envelope you were given this morning. It is interesting going through and reading what issues were identified through that survey.

Based upon the input we received, a number of specific issues that were identified are listed by topic areas in the buff-colored agenda in your envelope. That list of issues is what we are going to be working on over the course of the next two and a half days.

We decided that this is going to be a workshop and not a conference. It is not going to be just a series of talking heads up here lecturing on issues of statewide forecasting. We expect you to be working during the course of this conference, giving us input and advice, as well as sharing what is going on in your state.

We have the conference formatted so there will be a panel discussion this afternoon on policy issues. Then we will begin each half-day, Monday morning, Monday afternoon and Tuesday morning, with presentations by four different states on what they are doing in the area of improving statewide forecasting.

After each presentation session we will break up into four workshops, and discuss specific topic areas identified in the survey responses. During the workshop this afternoon the first three topical areas will be discussed by each of the four breakout groups. Out of those workshop sessions, we are looking for summary information for the conference proceedings. We want to know what the state of the practice is, information on major issues discussed, conclusions reached in workshop sessions, and research recommendations.

Tuesday morning we will ask you to specifically identify research needs and prepare preliminary problem statements for them.

Tuesday afternoon we will wrap up with a summary of what each of the workshops discussed and recommended. Between one and three o'clock there will be a summary presentation from each workshop. We hope recorders will volunteer from each workshop. All the reports will be put together in a set of proceedings of the workshops.

Before we begin discussing the seven topic areas assigned to the workshops, we felt it was important to discuss what questions the statewide forecasting process is being asked to answer.

That really has to come from top-level policy makers; administrative people within state departments of transportation, as well as legislators and other elected officials. We also thought it would be useful to get some perspective on policy questions from fairly high-level people within planning departments of state DOT's, and a representative of the Federal Highway Administration.

From the presentation that Alan Horowitz made, and from my own thoughts, I put together a list of questions and gave them to each of the panelists this morning. I have asked them to consider those questions in their presentations, and to help stimulate some discussion after each presentation. We have asked them to each take about 10-15 minutes to discuss the policy issues they are confronting in their states that the statewide forecasting process would address; policy questions that they themselves, their employers or their legislatures are developing. I am not going to lead you through all of these questions right now. I am distributing this to stimulate some thought on your part, as well as questions for the panelists in the discussion part of the presentation.

In the interest of time I am going to introduce all the panelists now, in the order in which they will make their presentations. If you have specific questions about an individual presentation we will take them at the end of the presentation. I would like to hold the general questions of the panel until after we have heard all the presentations.

Our first presentation will be by Ken Leonard, Director of Planning for the Wisconsin Department of Transportation.

The second presentation will be by Ysela Llort, State Transportation Planner for the Florida Department of Transportation. She has overall responsibility for planning and policy issues in Florida DOT.

The third presentation will be by Lou Lambert, Deputy Director of the Michigan Department of Transportation, responsible for Planning and Policy for the Michigan DOT.

The fourth presentation will be by Charlie Howard, Planning Director for the Washington Department of Transportation.

The fifth presentation will be by Alan Hendrix, already introduced to you when he delivered his welcome. Alan is Deputy Director of the California Department of Transportation and is responsible for planning.

To wrap up, Bob Gorman, Community Planner with the Federal Highway Administration, Intermodal and State Planning Division, will be our last presenter.

Speeches

Ken Leonard
Wisconsin Department of Transportation

I think this presentation addresses most of the questions that Neil asked. But I want to talk about some of the policy issues we have addressed using the statewide travel demand forecasting as a tool.

Specifically, I want to describe what travel demand forecasting we have done and some of the results; talk about the policy issues we have tried to address; and then discuss some of the key components of statewide travel demand forecasting for making policy decisions. Then we will mention what we think some of the future forecasting improvements might be, and how TRB can help.

First, why perform statewide travel demand forecasting? Probably the top reason is it helps us determine where to make investments. We do not know where the future travel is going to be, and it is hard to decide in what particular areas of your system investments should be made. It also helps to be able to say ‘no’ sometimes, because we all get requests such as: ‘If we had high speed rail here or light rail there, etc., it would reduce roadway traffic.’

Some kind of forecasting is necessary to analyze the travel conditions, and it helps to be diverse and make investments in modes other than highways. Then the information can be used by the decision makers--state legislators and local officials as well as the general public, who are usually pretty well informed about what's going on, and have some very good questions.

What are the policy issues we deal with? Generally, they are about what the total resource needs are, and we have got to know what the travel demand is going to be before we can know what those needs are. And we want to know the needs by each for the modes, and what the modal tradeoffs are. For instance, if you have rail service or high-speed rail, what is the demand going to be relative to the highway system? An example of that is inter-city highway improvements versus rail. A lot of those issues are examples of where to use travel demand forecasting; such as in urban areas when you add another way to handle capacity problems or you build a light rail system.

Travel demand forecasting will also help us make decisions about state subsidies. We are involved in subsidizing Amtrak between Chicago and Milwaukee. Before you make those kinds of decisions, you should look at what the future forecasts are, how much revenue you are going to get from this system, and what the long-term subsidy is going to be. Until you have started doing that, you do not really have the answers to those questions. But once you start forecasting, it is pretty hard to get out of proceeding with the project even if it is not a wise investment. We use statewide travel demand forecasting where we have to answer policy questions.

Let me talk about our multi-modal plan that we gave the name of TRANSLINKS-21, and tell you a little bit about the State Highway planning and about some of the rail studies that Alan and Neil referred to.

First, TRANSLINKS-21 was a multi-model statewide plan developed for year 2020 forecast. We developed modal shares and tradeoffs between modes. Two major elements were those of passenger and freight. In both cases there were consulting firms that, I think, did a pretty good job, and I will mention a little about the techniques they used.

We looked at passenger modes of course--auto, inter-city bus, rail, air passenger and passenger ferry. Regarding freight, we looked at motor carriers, freight rail, air cargo, etc., and I will tell you a little bit about each of those models.

The passenger model was an inter-city multi-modal travel demand model with modal shifts. It had a user preference component that was part of what gave us a policy sensitive model. We could ask the users under certain conditions what they would use. We were able to ask them, if it traveled from ‘here’ to ‘there’, it costs ‘this’ much, ‘these’ are the travel times and the frequency of service, would they use it? That went into part of the model.

The inter-city passenger forecast assumed a trend that we would do the same amount of highway improvements and repairs that we'd done in the past. The trend did not have high-speed rail, but it had inter-city bus and some conventional rail. The plan we put together included high-speed rail from Chicago to Milwaukee, Madison, and the Twin Cities. It also had feeder bus service to the high-speed rail line and, under certain conditions, to conventional rail.

In terms of modal shares, we found that, for the trend versus the plan, the auto share went from 99.4 percent to 98.3. Overall, from this review we concluded that, when you introduce service such as quality high-speed rail in the major corridors of your state, you are not going to get much impact on auto travel. We have not seen much of an overall reduction of inter-city auto travel in Wisconsin, though we did get significant reduction in some corridors. This graphic has actually been very useful in answering some of our policy questions, and we've done some more detailed studies.

On the freight side, we forecasted commodity by mode and then looked at the shifts between the three different modes. We also used a freight expert panel of eight to twelve representatives with someone from each mode. We had someone from the major shipper groups, and Don Schneider, the head of Schneider Trucks, was head of this committee.

We asked them to look at forecast trends and give some expert opinions about how those trends would change. What would happen in terms of an emerging intermodal partnership switching some of the travel from truck to rail? Their expert opinion on the share of freight shipments was that it would mostly be by truck, introducing things the expert panel was concerned about, changing that modal share a little bit. Again, not anything really significant; however, some of the corridors we looked at revealed a 50-60 percent decrease which, in some, focused on travel from Milwaukee to Chicago. Now we are looking into that in more detail.

Another example that I want to talk about is our state highway plan. The last time we did a highway plan was in the early 1980's. When we updated it, we forecasted auto travel up to the year 2020. We looked at tradeoffs between modes. We integrated what we put together for inter-city travel as part of TRANSLINK-21 and applied that to the highway trend. It assumes that we would have some improvement in high-speed rail, and then the highway plan would deal with the auto travel that is left.

In the forecast we were able to reflect the MPO land use plans in their metropolitan areas. This is important because most of these cities have a concentrated land use development plan. We do not feel we're making an unusual forecast for the highway sector.

From a policy perspective, we found that even when you add things for other modes, and you have concentrated land use development, there are still a number of areas that need more highway capacity. Obviously that is important information necessary for making policy decisions, and we need to be able to talk to the legislature, interest groups, and the public to answer those policy questions.

I am going to talk a little bit about three rail studies and plans. In the Milwaukee to Chicago high-speed rail study that was done, we were able to estimate the ridership, work up what the revenues would be from the ridership, and compare that to the costs. Using the user/rider preference survey, we were able to make changes based upon the users' preferences in terms of frequency, service, cost and travel time. We are doing something similar now for the Milwaukee to Twin Cities Corridor, called the Midwest Rail Initiative. It was a coalition, and it still exists. We needed a coalition of nine other midwestern states to submit an Amtrak plan to the FRA. We have been looking at the need for a regional system in the country, using Chicago as a hub by going to Detroit, St. Louis, and Milwaukee. Using some of the forecasts that we had done earlier, we forecast ridership and what the revenues would be. This shows us what the network of regional rail service would be. We have had a fair amount of attention at the federal level with this effort.

The last rail item I want to mention is a governor's task force on passenger rail. The governor is going to announce the appointment of a task force on passenger rail, and he is going to give them a four-point charge. He wants them to look at existing passenger rail plans and service. He wants them to review what exists in terms of state law and federal law, and then recommend changes to those laws if necessary. They are to identify what potential funding may be used at the state level, local level and in the private sector, and recommend rail passenger travel.

The interesting thing about this is that he wants an interim report by April. And we would be in a bind if we had not already been working on things like the travel demand forecasts. You never know what you may be asked to do or what kind of decision you may have to make.

Now I want to talk a little bit about observations. One is we think there are some basic components for statewide travel demand forecasting from a policy perspective, the kinds of things really needed. You must have good data. We did use the freight data information, and there is always a question about how exact that is, and if it is worth making that investment.

You also need good origin--destination information and the knowledge of the staff, the in-house staff, and the help of the consultants. We found help from the consultants has been good. You need multi-modal information because you are going to be asked to make tradeoffs between buses, rail and auto travel. You need employment and socioeconomic data. You need to have modeling that is fairly easy to update, and you need a model that is policy centered. You need to be able to do what-if analysis and say that, if the cost is so much and fare is so much, what the results would be.

There are also certain factors that are necessary to make policy decisions. The forecasting should be model based; it should be multi-modal; it should consider local and regional plans and try to do that in a state highway plan. It should involve the public and the private sector. Obviously, on the freight side the private sector's very important because they form the railroad and trucking loads. The forecasting should also consider land use because where the development occurs is what is going to affect the travel. The public, the various interest groups and so on are looking for that, and they want to know what land use tells them in the statewide travel demand.

It is important to mention some progress in forecasting improvements we should think about in the future. One is how to incorporate urban and regional plans at the local level and how to incorporate land use. We know that what we are forecasting already considers what MPO's are looking at for the local area. There need to be regular updates because the data changes, the policy issues change, government and their friends change. Another improvement would be to address certain externalities like the environmental impact on any kind of travel demand.

More interstate cooperation is needed, and probably more consideration to financial concerns for what you can model, how you can really address demand, and what kind of constraints there are. TRB can help by having workshops like this where we can share what we are doing and actually work on and develop new ideas. These days we are able to support the national data gathering that is going on, syntheses on current practices, research and new methodologies to promote technology sharing, and help develop some standard methods so there is some compatibility between states.

Ysela Llort
Florida Department of Transportation

I would like to address three main areas today. First I am going to tell you a little bit about Florida, Florida DOT, and our statewide model. Next, I would like to talk to you about some of the policy issues that are emerging in Florida. And finally, I would like to share with you some of my personal issues with travel forecasting model, and what I see as some opportunities to really make some enhancements.

Florida, with 14 million people, is the fourth largest state. We expect over 22 million visitors this year, a landmark for Florida.

We have 70 percent of the population living in coastal areas. You can imagine all the folks glutted along the edges, at the beaches. Our number one economic activity is international trade, which most people do not usually associate with Florida. Tourism is number two, very closely followed by agriculture.

We have over fourteen deep-water ports. The Port of Miami is the busiest cruise port in the world. We have a very active aviation industry in Florida, and the Miami International Airport has the highest level of freight activity in the world. In Florida, transportation activity is synonymous with economic prosperity because all our economic activities are highly dependent on good transportation.

We are a growth management state, which means we are very concerned about concurrency of land use and transportation and good coordination between the two. In listings of the nation’s fastest growing urban areas, we usually rank in the top ten. Miami is one of three Florida cities listed in Texas Transportation Institute’s index of congested cities. However, that does not seem to be attracting more money for transportation to Miami. We also have lots of government. We have 67 counties, 401 cities, and 25 MPO's, so a lot of coordination is needed.

We are the home of the leaders of the new Urbanist Movement, like Andreas Duany and some of the neo-traditionalists. We are concerned with shaping Florida into something different and better than what it is today.

Let me tell you about our fairly traditional statewide model. We use MPO numbers and MPO forecasts mostly, and some rural forecasting processes are also used to generate external trips for MPOs. We then put those numbers through a decision process; an expert system to really help us develop our highway plans. We use pretty highly developed highway plans, particularly for the Florida Intrastate highway system. We have a 2010 cost feasible plan, a 2020 plan and so on, paralleling the types of activities that occur in metropolitan areas.

One problem we have is that our statewide planning process does not really allow branching out beyond highways, into testing other modes. That is a concern we all share, particularly when you have the type of intermodal infrastructure that we have in Florida.

We have the typical struggle that I call the‘battle of the model-nauts.’ These occur in many areas where the results of model numbers and model outputs are disputed due to a major policy issue concerning investment decisions. We produce our modelers and our model results, the other party produces their modelers and model results, and we go through the process of proving which is best. But that does not occur as often as it used to.
However, the statewide model is not being used to its fullest capacity in decision processes prior to project development. It is being used mostly to forecast demand on the highway system rather than really addressing the bigger issue of whether or not the investment ought to be made; which is the key issue that policy makers are facing, not only in Florida, but almost everywhere.

We have had some interesting things happen lately Florida that, five years ago, I would not have believed. We have a chairman of the Senate Transportation Committee looking at transportation planning to see how

it can be improved. This does not usually happen in the legislature. But in Florida last year the Senate did an interim study to look at the transportation planning process. A large amount of the time was spent looking at the modeling process, not only in statewide, but in metropolitan models.

Senator Jim Hargrett held three statewide meetings about transportation modeling and planning. Many who attended those meetings were concerned that we were not considering all the inputs needed in the transportation delivery process. People in Florida know that if you do not get a process fixed, you are not going to be able to get the kind of outcome that you want. The Senator and the Senate Transportation Committee, after hearing the comments of many people, came up with a report illustrating the concerns.

The number one concern was that the models being used in the State of Florida are not doing a good job of integrating economic activities. They are doing a good job dealing with the home to work trip, but

not at integrating freight issues and other mainstream economic activity, ascertaining what kinds of transportation investment decisions would best suit those economic activities.

The second observation was that the transportation and land use were not very well coordinated. As a result of the Senate investigation, now there is a transportation and land use legislative committee looking at integration of the two processes, and I have the pleasure of co-chairing that group. That has been very interesting because, while everyone wants to have better integration, they all have a different interpretation of what integration means.

A feedback loop mechanism is needed between transportation and land use. If land use initiates transportation modeling processes, the output of travel demand forecasting needs to feed back into the land use process to be adjusted for consistency. Particularly because the transportation planning process requires that economic feasibility be considered, that same type of control needs to be applied to land use.

Another action that came out of Senator Hargrett's investigation was the establishment of a freight task group to insure that freight would receive the necessary consideration in the investment process. So we have a group looking at how to integrate freight, not only into the model process, but into the investment decision process as well, a concern shared with our 25 MPO's.

Another comment from the legislative committee on transportation and land use regards their concern that models and modelers are running the transportation decision process. This is a blue ribbon committee looking at a very technical process, compiling a very long list of top-level policy issues. At the top of it they were saying that policy needs to lead in this business of modeling, the models cannot determine the policies by default.

That last was a very crisp statement, and we are trying to figure out how to deal with it. That statement showed us that both sides of the debate had failed. The professionals had failed because we had been so keen on coming up with technical answers that we had not given the policy makers an opportunity to fully address issues and factor them in. I felt that it meant that the policy people had defaulted to looking at the technical process as the means to provide the answers.

Let me close by saying that I have a lot of concerns looking at where we are in Florida and where we are as a profession. Apart from the many technical issues that present themselves in modeling, whether it is

metropolitan or statewide, I think there are some side issues that need to be addressed.

The first is timeliness. We are always chasing ourselves with this whole business of modeling. We figure out how to model problems that were present ten years ago rather than figuring out how to model current or future issues. It takes us too long as an industry to come up with the technical methods to address the policy issues that are on the table. In Florida for instance, there are policy issues on how we forecast the effects of neo-traditional urban structure on transportation. How do we demonstrate whether it has some benefits over the traditional?

I see problems with marketing ourselves in transportation planning and in modeling specifically. When groups like this legislative committee say they 'will not worship' the Florida Standard Model, I think that shows a credibility gap. Perhaps we have become so entrenched in our technical processes that we are not looking for the decisions that need to be made.

Finally I think that, apart from the technical issues, we need to worry about how we are explaining information. How are we displaying the outputs of our work in modeling so we 'de-mystify' the profession and people can understand what we are doing?

We need to be a lot more efficient in how we handle modeling and make use of display technologies that are present now. We are doing this around the nation, but a lot of people are saying they have not seen much of it lately. With all the GIS and the visual aid technologies that we have now, we need to be able to rapidly deploy them in modeling and transportation planning, to engage people in the technical process.

I am concerned about processes that take us a long time to crank out the numbers, and about how we are displaying the information once we have those numbers. We are trying to answer legitimate questions that people have with tools that are cumbersome, take a long time, and do not display information effectively. Other than that, we are doing a hell of a job.

Lou Lambert
Michigan Department of Transportation

Neil invited me because he wanted an old demand estimator, someone who had been in it when it was new and had left to move into other areas of Planning. I guess he thought I might bring some appropriate perspective from that standpoint.

Our statewide model was first thought of in the 1960's when Michigan, in some early lunacy, decided it needed land use planning. So we got a major push in the early 1960's for a state land use and transportation plan. Michigan, being the strong property rights state it is, saw this effort go quickly down in flames.

But out of that came our statewide planning process. The model development was part of the original land use component and was very farsighted for its time. It was a 547-zone model, direct estimation, and a fairly simple process that served us very well. In the last four or five years we have extended that to a 2300+ zone model with four step process: the whole nine yards.

But there are some real issues I'll address today for those who are considering going into this. You need to

think about the relative importance of what is needed from a statewide model. Having just gone through this process recently, we might make a different decision today about what the design of our statewide model would look like.

We have a statewide model because of the unique nature of our state. We are a peninsula state—no one comes to Michigan by accident, you have to want to be there.

We are not on anybody's direct route, and it is pretty important that our transportation links hook up with the rest of the nation. So transportation has always been an important component of our economic well being. This has necessitated that we have a multi-modal approach for our modeling process. We are a bridge state, both for rail and for a lot of the truck traffic, as well as the fact that we need to connect to the major east-west routes. Our modeling process has always addressed how we relate to the rest of the country, and our statewide model has needed to provide the state with information about the traffic moving at our borders, as well as within Michigan.

Things have changed since I was in the business. When I first started demand modeling right out of grad school, we were looking for where we needed to pick up another half lane of traffic. If you needed another half lane of traffic, you had to widen the road in 20 years, and that was pretty much what we were asking for.

Today, we are expecting levels of sophistication that I am not sure our tools can deliver. Right now we are providing information to assist in for determining incentives/disincentives clauses for construction contracts or what the air quality will be in 2020 in major cities, etc.

We are being asked more and more to answer these sorts of questions and we only have the statewide and urban models to provide them. From that standpoint, the models have become critical decision-making tools. You use the best tools you have in your kit. You have a consistent tool and you try to make it work and defend the results. It is a process. It is defensible. It is reproducible. However, much of our activity seems to be driven by the model requirements, rather than by the needs of the business.

We have learned to generate information, but what does it mean? It's there, it’s often factual, it's very interesting, but it may not really address many of the issues we, as decision-makers, are being asked. For example, Michigan is about to announce a 5-year capital investment program. The number one question I have to address is: what is the impact of spending $7 billion in the next five years? How does it improve the condition of a system and the level of service provided to the people of Michigan? These are supposed to be system-level models, but they have not always kept pace with the questions being asked.

The model will give me some ideas about what it might look like out there, given a set of socioeconomic conditions or some spending alternatives, but it does not really help me programmatically. To develop delivery strategies, I need to be able to to look at various financial strategies and their possible impacts. This model needs to address outcomes, not outputs. So we are about halfway there.

We are able to show what might happen, but we are not able to say what the overall impact of that commitment is going to be. As I mentioned, we did expand our model significantly. Michigan has gone to a four-step process. And quite honestly, we did it because we were comfortable with it.

I came through the process. I am head of planning. Therefore I was an easy sell as I look back today. What is necessary is a tool that allows good impact assessment capabilities.   Not all states will necessarily need a statewide 20-year assignment model. You need to be able to make some observations and assess the impacts. To do that you need good networks, good travel times, matrices, and solid, unified databases, including ties to financial records.

Too frequently, when we want a quick answer to a question, we need to deal with how well the model is calibrated in a specific area. If the modeling process is to be effective, we need to do a better job of calibration.

Another issue that must be addressed is the actual use of the information that is generated by the models, especially traffic volume projections and travel time estimates. We need to find ways to use this information as a comparative total to actual information. This provides a relative platform for discussion, not an absolute. If we know what the present situation or conditions are, and we have some ideas about the tested alternatives, then we need to use that relationship, not the model results. It is a powerful descriptor when the various answers from the model are adjusted to the present situation baseline. I think that makes a lot more sense, and non-technical people understand it.

One thing I wanted to correct this morning is that we need to find ways to use it as a relative framework, a relative platform for discussion, not an absolute. If we know what the present situation is and we have some ideas among alternatives, then we need to use that relationship given some solid knowledge about existing conditions -- not what happens or what comes out of the model. But what the relationship is between the various answers from the model and the present situation. I think that makes a lot more sense, and people understand it.

An idea that others on the panel have not talked about is the need to operate our system – not just propose projects, get them built, and then do routine maintenance. We are being expected to manage our assets and asked more and more from site managers to operate the system – something we have never really done. In fact, until ISTEA, federal legislation never really put us in the position to be able to manage our assets, quite frankly. With the idea of capital preventive maintenance, the opportunity is now before us. We need to be able to use this very expensive investment in our high level system much more efficiently. I think statewide modeling has a long way to go in that area. In tying that to the idea of asset management, we talk about service and facilities together, how we build strategies and prioritize activities that work both with pavement condition, bridge condition, and expected levels of service. In terms of how we can spend our money, it will help a lot in improving our use of the resources we are given as stewards of the system. I think that is very important.

We need to start viewing transportation as a utility that we, in fact, are managing. We need to do the best job we can with the resources we are given in providing a network for our customer to drive on, recognizing that we have no control over the users. Electric companies for instance, basically manage delivery networks just as we have and now allow any power supplier to use their system.
One last comment on users of the tool. We used it very recently as an assessment tool more so than an assignment tool. By hanging information onto the model, you begin to assess the effectiveness of your program. We have gone to a franchising activity—a ‘decentralization’ in the department. We use the network model to identify and locate our facilities, to help move our people, and develop plans in those

areas for providing transportation services. We plan to use the tool to assist in coordinating work along corridor lines, to help determine what the proper size of the system should be compared to cities and counties. In the next two years we will use it to help us rewrite legislation that controls how transportation monies are allocated and are spent in Michigan. We also used it to develop our National Highway Network and establish criteria in identifying good projects in support of economic development.

Charles Howard
Washington State Department of Transportation

I am a bit more skeptical since Washington is in the process of figuring out if we need a statewide travel demand model. We do not really have such a model up and operating. I will give some background on Washington's planning process, about modeling at DOT and what we do right now, and some of the policy issues I see involved.

First, state law requires Washington’s planning process. That provision was originally enacted in 1977 when the state DOT was created. It languished for a while and was revived in 1993 after our state's Growth Management Act passed, as well as federal ISTEA legislation. Those two things led to a rethinking of our statewide planning process, and a state law was established requiring statewide transportation planning, in conjunction with our state's growth management.

Our state's Growth Management Act is a ‘bottom-up’ planning process meaning that the local governments were given broad authority to plan for their future with very little direction from the state. That basic structure differed from states like Oregon and Florida, which have state plans that drive local decisions. Ours pretty much relied on local governments to figure out their own futures.

This statewide planning process is, in the state law, called a multi-modal balanced statewide transportation plan. It includes two categories of facilities: state-owned facilities, which are the state highways; and state ferries and state-owned airports, which are traditionally planned at the state level. It includes a series of other transportation facilities and services that weren't traditionally state responsibilities—public transportation, inter-city passenger rail, freight rail, marine ports and navigation, aviation and non-motorized transportation. It gave the state planning responsibility for those modes that we do not own and operate; another interesting arrangement. We had to figure out our role and how we could partner with the owners and operators of those systems who actually make the investment decisions for those modes.

Our planning process is a partnership with our regions. Our Growth Management Act authorized creation of what are called ‘regional transportation planning organizations’. They coincide with existing MPO's, but also extend beyond MPO jurisdictions. There are rural regions now under this program. We have 14 of these regional transportation planning organizations in the state, going from the growth management approach of a bottom-up process, self-created by local governments who decide to affiliate with each other. San Juan County, which is an island, chose not to participate in the process. They felt they didn't belong to any particular region.

Our planning process is carried out as we've structured it. It is a partnership between the state level and those regions. We review the regional plan where we coordinate state level activities with the local governments' work under the growth management, and that's an important part of our planning process.

In 1998 the legislature belatedly put the top back on some of our growth management process by passing a bill that I have been working on for about six years called Transportation Facilities of Statewide Significance. The top part of the state's growth management clearly points out that the state has lead planning responsibility for certain types of transportation facilities. It's getting into that messy area of governance and wrestling back local government's planning authority for statewide significant transportation facilities. We are in the middle of figuring out what that means and how to implement it. It includes some siting responsibilities, meaning that, if an improvement is identified for one of these facilities in our state transportation plan, it becomes what is called under the Growth Management Act, an essential state public facility, and the local government may not preclude the siting of that facility. This implies that if something gets into our plan, it may not be precluded. That is an issue we are dealing with, which is going to lead to a lot of sticky negotiations. However, it is an important governance issue, which we feel is necessary in order to have a bottom-up planning process and still meet statewide travel needs. This brings another big area of responsibility to our statewide plan— considering modeling implications and the technical analysis tools that are needed to answer those questions.

Finally, we are in the middle of an update process to be completed by the year 2001. We backed up and are creating a statewide vision based on societal values. Three components of that are vital communities, vibrant economy and sustainable environment, all leading toward a livable future for Washington. That is our vision theme, putting transportation into context with support for societal values. We are incorporating this vision from all of our regions. It's going to be a joint vision statement from the regional process and the state process. We are then going to do the majority of our planning at the regional table. There will be some statewide issues identified, but most planning will be done in partnership with our Regional Transportation Planning Organizations.

We are viewing the regions as being the place to move forward toward multi-modal analysis. We are exploring a new type of corridor analysis that may involve some legislation to change the governance structure. When transit agencies, the state highway agency, and city streets and county roads all have separate governances, how do you bring them all together and plan for corridors? Who plans for what? We are trying to address this issue so we can make integrated investment decisions across all those modes, because we are wasting too much money and time worrying about this particular situation.

Our plan will end with a six-year implementation process. The 20-year plan is too abstract for most people. This will lead to ongoing, rolling six-year implementation plans to realize investment needs. We use the MPO models where they exist. But we have allowed technical expertise in modeling to disappear. The DOT doesn't pay enough to recruit good modelers. So one of the points in deciding whether we pursue modeling is our ability to obtain staff.

We had the beginning of a statewide model back in the 1970's and 1980's, though it was largely just a network we used. That model was mostly used to come up with the mileage chart in our statewide map. We let that model lapse, and now we cannot add any more communities to that chart because we do not know the distance between them.

On November 3rd, citizens voted for a $2.4 billion bill for highway improvements in the State of Washington. This gives a detailed presentation of our thinking on our statewide modeling, putting the importance of technical analysis tools and modeling into perspective. Think about that in terms of how important this demand modeling will be in the future. Statewide demand modeling can help us make some

of the informed policy decisions that need to be made. Our planning process is really about

decision making, and we need to think about what tools can be used to help answer questions and reach decisions.

Some of the policy questions facing us are very similar to those that others have mentioned—intermodal tradeoffs. How do we make rational investment decisions between modes and programs, especially related to inner city travel? We have had the same issues with our inter-city passenger rail, and the expansion of our airport has been a controversial issue. Is there some other approach that could obviate the need for future expansions? How do we make those investment tradeoff decisions when we are not yet equipped with the needed tools?

Freight mobility has been another very big issue in Washington, and we do not have the tools needed to determine the impact of freight movement and the need for freight facilities. Because of the Endangered Species Act, we are facing a draw down of the Columbia River. A very big shipping channel, The Columbia River was actually designated as a transportation facility of statewide significance by the legislature. How do we analyze the impacts of a draw down of the river, which would basically get rid of all barge traffic? How then, does grain move out of the eastern part of the state? We need some tools to analyze that.

This linkage with regional modeling is significant because it's not only a technical issue; it's also a policy issue. Every single decision in the modeling process is a policy decision. For example, population and employment allocations—how many have experienced population and employment allocation processes that were not political? Or how many have actually seen MPO models that set mode splits for policy? The question on those linkages between the statewide model and the regional model is who will be the decision-maker on those policy decisions that drive this technical process?

We have a statewide performance budgeting law, and we are moving quickly toward performance measures in our system to measure the outcome of transportation investments. What can a statewide model do to support the process of looking at the system and seeing how it's performed, then coming up with performance measures for our legislature to help us determine the cost benefit of various investment options, both prospectively as well as retrospectively?

The last point I want to make is on land use, and what the impacts of the state transportation system on land uses are. Conversely, I think what is more important is what the impacts of land uses on statewide mobility are. We run into a problem here because a lot of the neo-traditional strategies we are pursuing under the state's Growth Management Act really deal with intrazonal issues. So the real micro scale type of analysis that helps pedestrians and promotes pedestrian travel really does not get captured in any of this analysis. We are looking at strategies to link our transportation investments at the state level to good land use practices at the local level. So the question is what those good practices are, how we analyze them, and how we demonstrate that one local government is doing the right thing and another is doing the wrong thing.

And how do we model state facilities in concurrency? Under the Growth Management Act, we have a concurrency system that requires adequate public facilities at the time of growth. How do we measure whether or not a state transportation facility is meeting that concurrency level?

Those are some of the policy issues we are facing. We remain healthfully skeptical of whether we need this tool in our toolbox.   Each of our modes has come up with its own forecasting methodology, we just do not have them all working together.

Allan Hendrix

The history of our development as a transportation planning organization pretty much parallels Washington's. I will tell you about where we are now and where we are headed in terms of our internal visioning process. We have been going through internal visioning for a number of years. First we looked at the purpose of the California Department of Transportation, which is to enhance the quality of life and promote the economic vitality of California. We are viewing transportation in those terms.

As a transportation planner, I tell my folks our mission is to support decision making. We are past thinking that we at the Department of Transportation make decisions; we know we do not.

Transportation investments are very decentralized in California. We passed a new law under which 75 percent of the money available for capacity improvements goes directly to the counties' programs. They get the money to spend practically any way they want. 25 percent of the money goes to state programs, and there are restraints on what the state can do with its 25 percent. So, if we want something done in a particular urban area, we have to convince somebody else to do it, making them the decision maker.

My thesis on land use is this: if indeed you can control land use and manage growth through withholding of transportation investments, then California should not have grown over the last 20 years. In California our system capacity has not grown at anything like the rate of population growth in the last 20 years, as we have not invested in many new facilities in the last 20 years. We have built new lane miles on the existing system to address existing congestion. I do not think that withholding transportation investment works as a growth control strategy. I do not think any model or any conventional wisdom that says to the contrary is right. I think there is a problem with that approach.

I think we should have four things in modeling—both statewide and regional. The first thing is the information has got to be totally accessible.   Legislators must be able to get hold of the data, to understand the data, and to believe the conclusions that come from the data. We are making a big investment in GIS because we think it’s a tool that will let us do that.

Second, the ideal model has to be dynamic simulation modeling: modal, intermodal and cross-modal analysis. ‘Dynamic’ in terms of how fast can you turn it around. People want to be able to see what happens if, ‘I do this, this and this’, and they want to know within five minutes. You need that real time turn around. Simulation is a way of showing the results so that they are obvious to everyone and it simulates behavior of people as they confront changing situations. And modal, intermodal and cross-modal means it deals across the board with all the modes.

If I were taking a program to our state transportation commission, I would like to have a videotape that would show, in ten minutes, what happens with my investment package over ten years. Then they could see what happens when different improvements cut in and how people respond to them as it happens in the model. Such a critical thing and, for now, we can only do it on a very small scale.

The next thing, and it's been mentioned before, is we need to have consistency between different agencies' models. We have 43 transportation planning regions in California. Some are MPO’s and some are smaller. There are regional transportation planning agencies—in Washington and in California—at the county level. They all do modeling of one sort or another. We have transit agencies, land use planning agencies, air quality agencies and all kinds of other agencies that do transportation modeling. But if you try to put any two agencies' products together, they do not fit. There has to be agreement in the community, not just the transportation community, but the community that deals with transportation in the models. There has to be agreement on the data that goes in, the way the data are manipulated and the results that come out.

There is a project six miles from here that happens to go, not only to across county line, but also between metropolitan planning organizations. All they could agree on was a number for how many cars are going across that border. It's not model output; it's just a number. You cannot work that way. We are trying to complete a project that is very controversial with information like that. We have published statewide travel forecasting guidelines to try to establish some minimums. I would never want to do anything more than guidelines because people have got to come to the conclusions themselves.

The other thing is the ‘econometric model.’ Until two years ago I was not getting any questions at all about investments. Their attitude was, ‘we do not want to know needs because that will cause us to have to increase taxes. We do not want a long-range plan because the money is going to run out anyway. We are not going to do anything four years from now.’ We took down our planning organization by 60 percent—maybe more than that—up until about two years ago.

When projects were proposed in the program, it was because they had a history behind them. Then, in the last programming cycle that resulted in programming actions earlier this year, I was getting requests like: ‘Tell me five projects we can do that will have a dramatic impact on goods movement’ and ‘If we spent all the money we have on one project, what should it be?’ Those are the kinds of questions I was getting. My answer is I do not know, nobody else knows, and I do not think I will ever be able to tell you.

We have a couple of problems. The most significant is that we are a huge state. I think we are too big to model. I think we are too big to have a comprehensive database. I do not think the technology is there. The hardware and the software are not there to manipulate the kind of data I am talking about, and I am very concerned about that. I see this problem even at the regional level. I see it affecting on our internal management systems where we spend a lot of money; we have a lot of programs, but no useful results. I am concerned about modeling being in the same boat.

Finally, the last point I will make is that the real nature of the transportation business is changing. It's been mentioned a couple of times. We are going to operations rather than capital investment, and the models have to deal with operations.

It takes me back to the dynamic real time simulation model. It can tell you what happens when you make changes in the system, when an event occurs, and so on. It's a statewide issue as much as an issue on a highway segment, in a corridor or in a region, because you have a lot of statewide travel.

We have thousands of vehicles a day that go up I-5, over ‘the Grapevine’, and we have to be able to manage and operate that. What happens when the pass shuts down because of snow? What happens when

the earthquake takes out a structure? Those are strategic as much as tactical issues, and the models have to be able to address all of the issues.

Bob Gorman
Federal Highway Administration

I have a couple of observations on what we have been talking about. First, I would say that there has been a little development of statewide models over the last 20 or 30 years, but not much, and there is a lot to be learned. We are at the very early stages of the development of a statewide travel forecasting process. There are a lot of problems, and I am sure as you get deeper into it, you are going to find a lot more. I hope this conference is an opportunity for people to learn and to share experiences with others in the same area of development. A couple of years from now, as many of you currently developing models get further along, you might also get together to find out what has and has not worked.

There are a lot of people working at various aspects, and I think it's a great idea that we brought all those people together: those working on the data that would go into the models; those working on the statewide models; and some that are working on the urban models. I think this is a great opportunity for people to learn what is being done with the data, what some of the problems are with the existing data and, by meeting each other, we can work together and solve some of these problems in the future.
Another observation I have deals with the problem of cost in collecting original data. There are a lot of national data sets out there, and a lot of work has already gone on to begin to merge those various data sets so that we can get greater use out of them. I think there is considerably more work that needs to be done in that area. People also need to become more comfortable with using someone else's data. Not everyone needs to go out and collect original data.

10 or 15 years ago, I went to a TRB session, and there was a fellow from Israel called Yankov Zahavi. One of the most interesting things I have ever heard at TRB was his observation that, if you cannot transfer data from place to place or, if travel behavior is not comparable from place to place, you cannot expect it to be comparable over 10 or 20 years in the future. That is something we need to remember when we are working with data.

What are some of the uses for the models? We are seeing a much greater interest on high priority corridors, multi-state corridors, and multi-state transportation plans. There has been a great deal of interest in the effect of NAFTA. During the debates on the impact of NAFTA a lot of statements were made with very little data to back them up.

Another thing mentioned today is the comparability and the consistency among forecasts. I know a couple of the states are working on models. One of the purposes is to obtain data from regional planning organizations that would provide some degree of confidence to help make decisions between one region and another. In states developing a bottom-up approach in transportation planning, how do you work with the corridors that not only transcend different regions of the state, but also might be interstate as well? We need to come up with some ways of looking at those types of corridors.

The distinction between urban and rural has been blurred over the last 20 or 30 years, and it's going to become even blurrier in the future. We have a problem with urban models going off to a particular point, and then we have a totally different approach beyond that. In the Atlanta region the metropolitan area

probably encompasses eight to twelve different counties. Some of those counties are a part of the urban planning process and some are not. Some of them are not the recipients of growth because growth management policies are in place in the area.

We are beginning to see that in northern Virginia where some of the counties are imposing growth management policies, which may have an unintended effect, causing us to sort of leapfrog development further on. So the possibility of a statewide model is beginning to impact how things might bear out in the future.

Another observation is in the area of sustainable transportation. Currently, this is more an urban problem. People are looking for different forms of development, but we do not have a very good idea of the impact those development forms are going to have on the transportation system.

Finally, I have a couple of recommendations. Earlier in my career, I did a lot of work in travel forecasting, and I have recently gotten back into the process. One of the things I learned was there is a point of diminishing returns. Working in an area, you reach a certain point, and you realize there are still a lot of problems with your model. You spend a tremendous amount of additional effort, time and money, and the answers do not get much better. You need to recognize that point of diminishing returns to avoid wasting resources.

My recommendation is to avoid developing models that do everything. If you try to come up with something that does everything, you are probably going to end up with something that is never really used for anything."

Papers Presented at the Conference on Statewide Travel Demand Forecasting

A Contrast of Statewide Models for Small, Medium, and Large States

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Travel demand modeling at a statewide level typically follows established procedures that are the same as for those applied in urban models. The major difference is in the level of detail and the characteristics of the model component attributes. Small states can be treated as a large urban area model. Statewide models for medium size states can be developed by combining urban or regional models and in-filling the rural areas. Larger states can also take advantage of MPO models as a source of data. The models can be built by supplementing the urban information with new data collected in the rural areas. In the larger states, rural areas tend to cover a much larger geography than the urban areas.

To establish a framework for the relative characteristics of models developed for different size states, this paper compares the characteristics of statewide models developed for three states considered to be small, medium, and large. They are Vermont, Missouri, and Texas, respectively.

DEMOGRAPHIC COMPARISONS

Vermont

Located in Northern New England, Vermont is characterized by rolling and mountainous terrain. Covering an area of 9,249 square miles and with a 1990 population of approximately 652,758, the state has an average population density of 63 persons per square mile. Vermont has 2,452 miles (93 percent) of roads classified as rural and 176 miles (7 percent) classified as urban.

Missouri

Missouri is A mid-west state characterized by a level to rolling terrain. The state is 68,945 square miles in area and, in 1990, had an approximate population of 5,117,000. The average population density for the state is 74 persons per square mile. The state has 30,650 miles (95 percent) of road classified as rural and 1,733 miles (5 percent) classified as urban.

Texas

The largest of the contiguous United States, Texas is located in the south central section of the country. Texas is 261,914 square miles in area and has a generally level terrain. In 1990, the approximate population was 16,986,510. The average population density for the state is 69 persons per square mile. Texas has 68,093 miles (88 percent) of its roads classified as rural and 10,434 miles (12 percent) as urban.

These are very broad statistics which describe each state’s demographic and transportation system

characteristics. Clearly, the concentration of activity centers has a significant impact on travel patterns and the way in which each state's travel demand model is structured. Table 1 presents additional data that characterizes the attributes that are typically considered in model development. The percentages presented in Table 1 are calculated with Texas as the basis of comparison.

MODEL APPLICATIONS

Each of the three states being compared has a different reason for developing a statewide model. The use to which the models will be applied dictates the basic character and configuration of its structure.

Vermont

The Vermont Agency of Transportation (VAOT) implemented a planning initiative whereby the state's 12 Regional Planning Commissions (RPC) would have an early input into the improvements to the state's transportation system and the development of a statewide Transportation Improvement Program (TIP). The intent was to provide the RPCs with tools they could use to plan and evaluate transportation improvement alternatives in their respective regions. The basic tool was a statewide travel demand model, structured so that each region could use the model to test alternatives for transportation systems and land use configurations. Recommendations developed through this approach by each RPC are then passed upward to VAOT for evaluation and prioritization on a statewide level.

An RPC can modify land use or transportation infrastructure in its own region. Because of the compact size of the state, the RPC can run the entire statewide model and not be concerned with estimating travel at the externals defined by the cordon of the RPC study area. The RPCs can make individual changes to their copy of the model for evaluation purposes, but cannot change the base model maintained by VAOT.

Missouri

The Missouri Department of Transportation (MoDOT) determined a need for a statewide travel demand model to support transportation planning efforts. Basic requirements of the model are that:

- it has the capabilities to estimate current and forecast future travel under a variety of conditions and assumptions; and

- it provides assistance for evaluating statewide corridor priorities.

A two-way data exchange with the existing ArcInfo and Oracle databases is also an important feature of the demand model for sharing existing and forecast travel data. The objective is to establish a process that can adequately address mandated policy and overall system-level analysis for planning and programming.

The travel demand model development was envisioned as a two-phase process. The first phase would provide traffic data for a number of corridor transportation improvements to be used in a needs study of the I-70 corridor, from Kansas City to St. Louis. The corridor model would also serve as a

demonstration of the capabilities and validity of a statewide model to be developed in the second phase.

At the conclusion of the first phase, MoDOT will evaluate the travel demand model and make recommendations for improvements, if any, prior to moving to the second phase.

The planned approach was to build a statewide model with a greater traffic analysis zone and network level of detail in the I-70 corridor and a broader based zone and network configuration in the rest of the state. This would reduce the problems associated with locating and forecasting traffic at external stations. Subsequent to the completion of the I-70 corridor analysis, the model in the rest of the state would be upgraded to provide the capability to conduct analyses in other corridors in the state. Because of the automated processes used to develop the corridor model, the detailed information required for the remainder of the state was carried along in the database, thereby expediting the completion of the statewide model.

Texas

The Texas Department of Transportation (TxDOT) currently builds and maintains travel demand models for individual urban areas in the state. These traditional three-step models use a custom trip generation model (TRIPCAL5), a custom trip distribution model (ATOM2), and a capacity restraint assignment. The models provide TxDOT with a mathematical tool, with quantifiable accuracy, that can be used to forecast travel demand based on household and employment characteristics. TxDOT has a need to expand the coverage of its travel demand modeling process to include consideration of different passenger and freight modes and to quantify the interaction between modes. This capability is to be provided through the Texas Statewide Analysis Model (SAM).

Included in the project is a component in which data to identify the impacts of the North American Free Trade Agreement (NAFTA) traffic on the Texas Highway Trunk System are developed and evaluated. Part of the justification for developing the SAM is a legislative requirement for TxDOT to analyze the increase in commercial traffic on Texas highways due to NAFTA. The legislation also directed TxDOT to identify the highways that need to be designated for construction, expansion, and maintenance as a result of NAFTA.

MODEL STRUCTURE

Each of the states has a different model structure because of the intended applications. The Texas and Missouri models were under development at the time of this writing, and some of the model components might change in the final version.

Vermont

The state is comprised of 12 Regional Planning Commissions with four MPOs. One MPO has a working model. The VAOT statewide model traffic analysis zones are based on Block Group census geography. The model has 622 internal and 98 external zones.

The roadway network was taken from the Vermont Geographic Information System (VGIS) and includes Functional Classifications of collector and higher.

Trip generation cross-classification data were developed from a mail out/mail back household survey of household characteristics and travel.

Trip distribution was by gravity model and mode choice was determined by the household data. Travel time factors were developed from survey trip length information.

Roadside intercept O&D surveys were conducted at 25 cordon locations, which represent 95 percent of the traffic crossing the state line.

Of the 12 RPCs, four have bus service. Only intercity bus trips were considered. Trip assignment was by the equilibrium technique.

One RPC had a fully operational model. The zone structure and accompanying demographic data were aggregated to a level consistent with the rest of the state and integrated with the statewide zone system.

Trip purposes are HBW, HBS, HBO, NHB, and Truck. Based on roadside survey data, trucks were estimated to be approximately 19 percent of the NHB purpose.

The travel demand software used in the model is TRANPLAN. Documentation and training workshops for users was an important component of the model process.

Missouri

The state has six Metropolitan Planning Organizations (MPO) that currently run and maintain urban models. The MoDOT model incorporates a zone structure of Block Groups and Block Numbering Areas (BNA) for the rural areas, and aggregations of existing Traffic Analysis Zones in the urban areas. Current plans call for the MoDOT model to have 1100-1500 internal and 120-150 external zones. The structure for the Missouri statewide model is illustrated in Figure 1.

The highway system is based on the state's ArcInfo GIS system which features Oracle databases that contain most of the required attribute data. The model network includes minor collectors and higher in the rural areas and collectors and higher in the urban areas.

The model network was constructed by building MoDOT district level models from the ArcInfo/Oracle system. Then the district models are combined into a statewide model structure. There are 10 MoDOT districts which, in combination, cover all 115 counties.

Because of the large number of lines in the ArcInfo database, most traditional software packages cannot accommodate the line work. To overcome this problem, a custom network editing program was used to edit the ArcInfo line work, including local roads. Table 2 presents a comparison of GIS line work and the final model link counts for urban and rural areas in one MoDOT District. This interactive editor allows the network editing to consider the inclusion of local roads in the model structure where needed

for network continuity. Thus, in addition to collector and higher classified roads, local roads can also be included in the model. The network editor also attaches zones to the highway network and establishes one zone connector for each zone. Additional zone connectors are added later in the editing process. The availability of this network editor/GIS interface allows model networks to be developed quickly. In addition, because each district is initially developed as a separate model, network editing to the district models can be done concurrently rather than having one large network and model with access restricted to one user at a time. Subsequent to the editing process, the 10 district networks are combined into a statewide network.

Trip generation cross-classification rates are based on a small-sample survey of 400 rural households statewide. Approximately 1000 households were contacted to recruit and obtain 400 usable surveys.

Data were obtained from roadside intercept O-D surveys conducted by MoDOT within the most recent five year period (1992-1996). This information will be used in the base model calibration and validation. The majority of the interview stations were conducted at internal locations throughout the state.

Travel time factors for the distribution process will employ a combination of MPO data and results of the household survey.

Mode share will be determined by a combination of household survey data and information available from the MPOs. Only intercity transit travel will be modeled.

Trip purposes are HBW, HBO, and NHB. Trucks will also be treated as a purpose.

TRANPLAN was selected by MoDOT for the statewide model. Several training workshops are schedules to provide MoDOT staff with detailed exposure to the model and hands-on opportunities to apply them. The development of statewide modeling theory and operations manuals are integral components of the model development and application process.

Texas

The most complex of the three models being compared, Texas will be subdivided into1700-1900 internal and 250-300 external TAZs based on Census Designated Place (CDP) geography. Texas has 26 MPOs, 24 of which hacve. The passenger and freight models will be built on a platform that will be extensible, flexible, and will accommodate new modes without major restructuring. The SAM is planned as a multimodal and intermodal model with two major components, passenger and freight. The passenger component will model highway and rail systems while the freight component will model highway, rail, air, and water systems. The two model components will be integrated through common demographic and transportation systems databases. Figure 2 illustrates the model structure for the SAM.

The initial highway network description is represented by the Texas Highway Trunk System, which is basically the same as the National Highway System (NHS).

TxDOT has a customized trip generation program, TRIPCAL5, and a custom trip distribution model, ATOM2, that will be interfaced with their software of choice, TransCAD.

The passenger model and the freight model will differ in operation, but both will be tied to an integrated data base. Commercially available freight data bases and limited roadside truck intercept O&D surveys will be the basis for the freight model development, particularly for the NAFTA impact study.

Because of the short time-frame in which the NAFTA study had to be completed, a network was constructed from a GIS database and a truck trip table was developed using a trip matrix estimator.

Table 3 presents a summary of the model characteristics of the three statewide models.

STATEWIDE MODEL TECHNICAL CHARACTERISTICS

Because most modeling efforts over the past 30 years have focused on urban models, it is useful to look at the key differences between urban and statewide models that were encountered in the development of these three statewide models:

Model Applications

Statewide models are typically used to supplement the urban models by providing travel information and forecasts in the rural areas. By having travel forecasts at a statewide level planning, policy, and priority-setting activities can be more logically established.

Traffic Analysis Zones

The size and number of TAZs in a statewide model are dictated by the geographical area to be modeled. Urban areas in statewide model are typically represented by larger and fewer TAZs than would be found in an urban model.

Networks

The level of network detail in a statewide model is coarser due to the larger geographic area represented. The lowest level of functional classification is generally major arterial or minor arterial, depending upon the state. Smaller states tend to use a lower limit of the functional classification because of the need to have a detailed network that can adequately support the TAZ system and provide a reasonable level of connectivity. A key issue with building statewide networks, particularly those that are GIS based, is that some commercial travel demand software systems cannot accommodate the number of lines required to process and build a network. This requires building the network outside the model, linking the GIS line work into roadway segments that are readable within the limits of the software. Table 2 presents a comparison of the number of lines in a Missouri District GIS database and the resulting number of links in the network model built from the GIS.

Friction Factors

Friction factors, or travel time factors, which express an impedance to travel due to certain conditions, are different in a statewide model trip distribution compared to an urban or regional model. Key differences are found in trip length and trip length distributions. They are more pronounced in larger states and the friction factors are more difficult to calibrate. The urban model travel time factors might be useful as a starting point in some cases.

Trip Generation

Urban trip generation rates are likely to be represented by one set of cross-classification rates for trip productions and one set of regression equations for productions and attractions. A statewide model might have different rates for urban and rural areas.

Intrazonal Trips

The intercity and local travel issues reflect the geographic differences. In larger TAZ's, intrazonal trips are likely to be a higher
percentage of total travel in a statewide model than for an urban model.

Mode Split

Mode split is not usually an issue in statewide models. Public transportation is typically limited to intercity travel by bus, and sometime by rail.

External Travel

External travel is likely to be less difficult to estimate in a statewide model because of the traffic and O-D data typically collected at the state boundaries. However, where a statewide model has a large city bordering a large city in an adjacent state, such as Kansas City, MO and Kansas City, KS, cross-border traffic is more difficult to identify. In states that have a statewide model, the urban models can take advantage of the statewide model to better estimate the external travel at the urban area model cordons.

Trip Assignment

There can be a significant difference in trip assignment techniques between urban and statewide models, and even between statewide models for states of different sizes. Larger states might tend toward an all-or-nothing assignment for broader, corridor-level assignment needs. Smaller states that have analysis applications closely related to urban studies might require a type of equilibrium assignment for greater accuracy and reliability.

Computer Run Time

Because of the larger statewide systems, computer processing times might be slightly higher than urban models. With the capabilities of current software and ever-increasing computing power, this is becoming a non-issue. The exception might be the time it takes to use GIS line work to develop a model network. However, the conversion process is a one-time process and once the model network is created, process time is not excessive.

Calibration and Validation

Calibration and validation in a larger statewide model will be very similar, while in a smaller state, they could be two distinct and separate process.

CONCLUSIONS

There are a number of differences in the character and application of small, medium, and large statewide models. The greatest differences can be seen in the level of detail in the TAZ and network components of the models. The intended application of the models also has a significant influence on their basic structure. The uses of the models discussed here include development of state transportation improvement programs, the development of data for analysis of interstate mainline and interchange operations, and the establishment of an integrated multimodal and intermodal source of information for policy evaluations.

There was a significant reliance, in each of the statewide model developments, upon the use of GIS databases for the development of the model networks. The models also relied upon limited data collection efforts to supplement and validate data available from MPOs and commercial data sources. In Vermont and Missouri, statewide household O-D surveys were conducted. In Texas, roadside truck intercept surveys were conducted.

Due to the recent interest in statewide model development, what are considered to be state-of-the-art practices change with every new model being developed. Data sources and techniques are being refined to respond to, and accommodate the needs of, this latest phase of travel demand modeling.

TABLE 1 State Characteristics

Characteristic	Vermont	% Texas	Missouri	%Texas	Texas
Land Area, sq. miles	9,249	3.5%	68945	26.3%	261914
Land Area Rank in the U.S.	43rd		18th		2nd
Demographic					
Population	652,758	3.8%	5,117,000	30.1%	16,986,510
Households	271,214	3.9%	1,961,206	28.0%	7,008,999
Average HH Size	2.41	99.3%	2.61	107.7%	2.42
Average HH Income	$36,261	110.2%	$31,870	96.8%	$32,914
Total Employment	379,000	3.5%	3,244,000	29.8%	10,888,000
Roadways[1] - Rural Miles	280	12.7%	809	36.7%	2,204
Interstate	310	4.6%	3,052	45.2%	6,751
Other Principal Arterial	709	7.5%	3,397	36.1%	9,416
Major Collector	1,142	3.3%	17,938	51.2%	35,019
Minor Collector	10	0.1%	5,454	37.3%	14,636
Local	1	1.5%	0	0.0%	67
Total	**2,452**	**3.6%**	**30,650**	**45.0%**	**68,093**
Percent Rural Miles	93.3%		94.6%		86.7%
Roadways [1] - Urban Miles					
Interstate	40	3.9%	369	35.8%	1,030
Other Freeway & Expressway	14	1.3%	279	25.8%	1,083
Other Principal Arterial	56	1.7%	710	21.1%	3,372
Minor Arterial	61	3.2%	304	16.0%	1,897
Collector	5	0.2%	64	2.1%	3,047
Local	0	0.0%	7	140.0%	5
Total	**176**	**1.7%**	**1,733**	**16.6%**	**10,434**
Percent Urban Miles	6.7%		5.4%		13.3%

All Roadway Mileage - Total	**2,628**	**3.3%**	**32,383**	**41.2%**	**78,527**
Total Interest Trips (millions)	4.77	2.49%	15.78	82.5%	19.12

Figure 1 - Missouri Statewide Model Structure

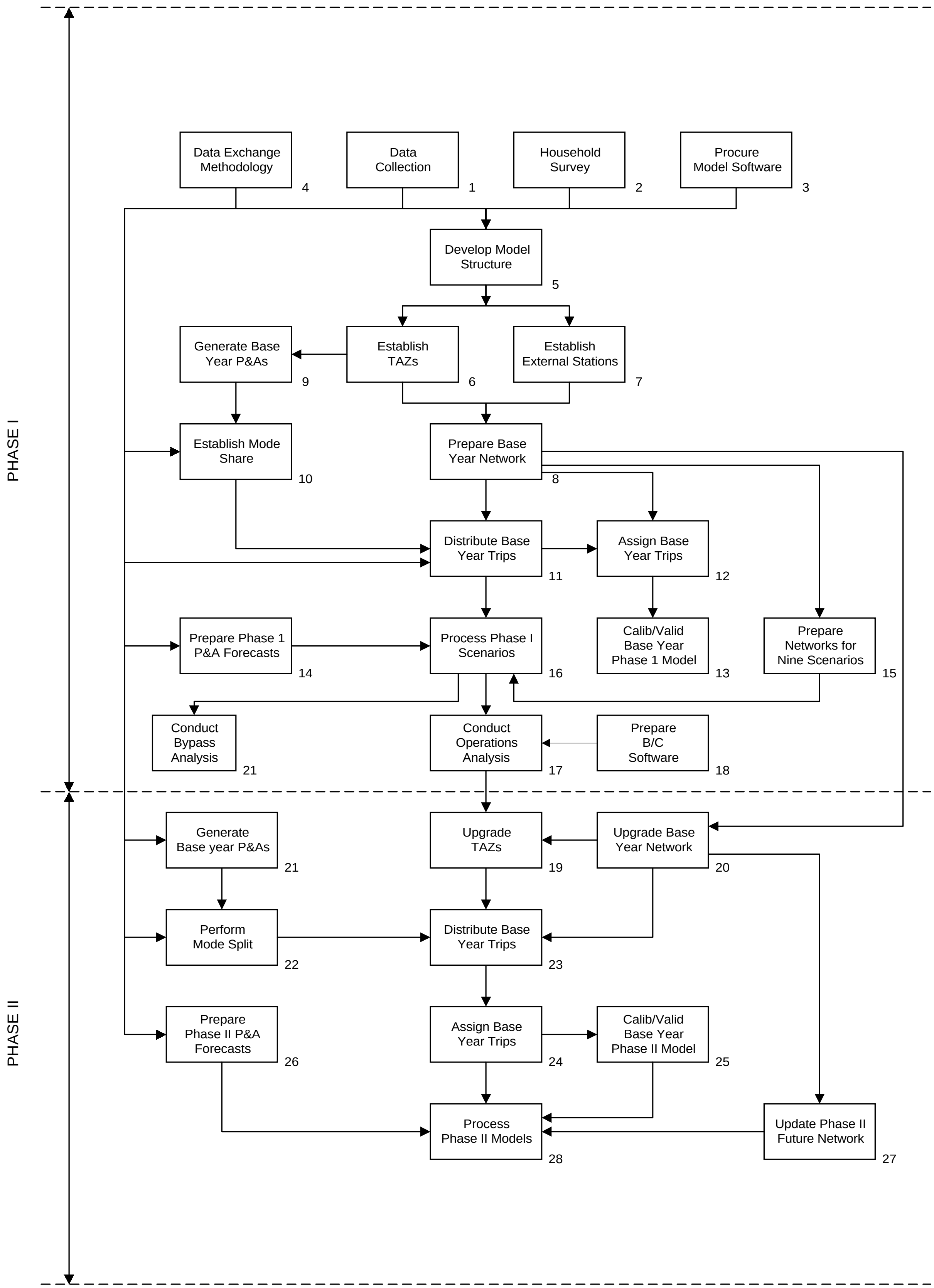

TABLE 2 Comparison of GIS Line Work and Model Links

	Missouri - District 6							
	Urban				Rural			
	GIS		Model		GIS		Model	
Functional Classification	**No. Of Lines**	**Miles**	**No. Of Links**	**Miles**	**No. Of Lines**	**Miles**	**No. Of Links**	**Miles**
Local	59,665	1,680	0	0	35,386	1,625	0	0
Interstate	1,779	105	0	0	399	34	0	0
Freeway	333	24	0	0	11	1	0	0
Expressway	0	0	0	0	0	0	0	0
Principal Arterial	4,619	129	0	0	921	45	0	0
Other Arterial	0	0	0	0	0	0	0	0
Minor Arterial	3,842	101	0	0	614	312	0	0
Collector	6,409	192	0	0	464	11	0	0
Major Collector	240	10	0	0	3,431	208	0	0
Minor Collector	6	1	0	0	1,077	71	0	0
Totals	**76,893**	**2,242**	**0**	**0**	**42,303**	**2,307**	**0**	**0**

Table 3 Statewide Model Characteristics

Characteristic	**Vermont**	**Missouri**	**Texas**
Internal TAZs	622	1100 - 1500	1700 - 1900
External TAZs	98	120 - 150	250 - 300
Avg. Square Miles per Internal TAZ	14.9	8.4 - 6.2	154.1 - 137.8
Avg. Population per Internal TAZ	905	4651 - 3411	9992 - 8940
No. of MPOs	4	6	26
Trip Purposes	6	4	
Trip Generation	Cross-Class	Cross-Class	Cross-Class[1]
Trip Distribution	GM	GM	GM[2]
Mode Split	Intercity Bus	Intercity Bus	Rail[3]
Trip Assignment	Equilibrium	Equilibrium	Equilibrium
Data Sources	Surveys Census	Surveys Census	Surveys Commercial Census

1. TxDOT has a custom trip generation program, TRIPCAL5.
2. TxDOT has a custom trip distribution program, ATOM2.
3. The TxDOT model passenger mode split is by auto and rail. The freight is by truck, rail, air, and water.

The Evolution of a Statewide Model for New Jersey

Talvin E. Davis
New Jersey Department of Transportation

INTRODUCTION

The state of New Jersey has twenty one counties, and is located between two major cities, Philadelphia and New York City. There are three Metropolitan Planning Organizations (MPOs) in the state: the North Jersey Transportation Planning Agency (NJTPA), the Delaware Valley Regional Planning Commission (DVRPC), and the South Jersey Transportation Planning Organization (SJTPO). The NJTPA region consists of the 13 northern New Jersey counties, and is a bridge crossing away from New York City. It is heavily influenced by the City. The DVPRC region consists of four New Jersey counties and five Pennsylvania counties including the City of Philadelphia. The SJTPO region covers the remaining four counties and includes Atlantic City. This region includes most of the New Jersey shore/beach area, casinos and summer recreational markets.

The three uniquely different MPO regions are represented by three unique transportation demand models. There are three transportation demand models corresponding to each of the MPOs. These models were originally developed to be used for regional transportation planning by the New Jersey Department of Transportation (NJDOT) and the MPOs. Later, with the passing of the 1990 Clean Air Act and ISTEA, the expectations and uses for these models changed significantly. They would now be used for macro scale and micro scale types of analyses. New uses included support of the Transportation Improvement Programs (TIP), State Implementation Plans (SIP), Plan Conformity, TIP/SIP Conformity, air quality budgets, and others items. These additional demands on the models would result in greater scrutiny of the models' results and assumptions.

THE NORTH JERSEY REGIONAL TRANSPORTATION MODEL (NJRTM)

The NJRTM was developed using the TRANPLAN transportation planning software package. The NJRTM includes the 13 North Jersey counties and contains over 1450 census tract based zones. New York City, New York State and Eastern Pennsylvania are external stations in the model and are not included as part of the zonal system. This could be considered as a weakness, but in the development of the model there were software limitations on the maximum number of zones that could be modeled. Consequently, the decision was made to stop the model at the Hudson River and the Delaware River. The NJRTM includes the traditional four step model process of:

1. trip generation
2. trip distribution
3. mode choice
4. highway & transit assignments

Because of the close proximity to New York City, this region has a significant share of transit trips. The transit trips that remain in this 13 county region are estimated by this model, however, transit trips between New York City and Jersey are estimated by a New Jersey Transit-Hudson River Waterfront

model and imported into the NJRTM. The NJ Transit model was developed by NJ Transit for their planning and operation. Their model uses MINUTP and has a more complex mode choice model and more network details in the urban areas and CBDs. It also included Manhattan, which is why the New York trips are imported into the NJRTM.

The NJRTM was initiated in 1986, and calibrated based on travel characteristics and patterns from the 1986/87 Home Interview Survey (HIS), and the 1980 census. It has four trip purposes, HBWork, HBShop, HBOther, and NHB. The trips were stratified this way based on the results from the HIS. This model was enhanced during the mid 1990s to include the 1990 census results, time-of-day analysis, accessibility function and feedback process. These enhancements allows the model to meet the requirements identified in the Best Practice Guidelines.

THE DVRPC MODEL

The DVRPC model is a four step model of four New Jersey counties, Mercer, Burlington, Camden, and Gloucester, along with five Pennsylvania counties. After years of running this model in UTPS, it now operates in the TRANPLAN. The zonal system for this model is based on census tracts including the City of Philadelphia and surrounding counties. There are 1395 internal zones, with over 350 New Jersey zones. The Delaware River crossing trips between Pennsylvania and Jersey are internal trips in the model. The DVRPC model has three trip purposes, HBWork, HBNWork, and NHB. It also includes six area types, CBD, Fringe CBD, Urban, Suburban, Rural and Open Rural.

The early foundation of this model is based on the 1960 travel survey data. This model has been updated based on the 1987 HIS and the 1990 CTPP Journey-to-Work data. Additional O-D data and transit ridership data was also utilized. Because transit trips into and around the City of Philadelphia are an important component of this model, additional network was required and in the CBD the zone system was disaggregated to the tract level. A study to evaluate this model was recently completed, and identified some enhancements that could be made to the various models.

THE SJTPO MODEL

The primary counties included in this model are Atlantic, Cape May, Cumberland, and Salem. These four counties makeup the SJTPO Region. Salem and Gloucester are not in the region but are included in the model as secondary counties. This was done to better analyze South Jersey issues. The components of this model are trip tables and an assignment tool. The trip table is based on trip generation and distribution from an 1980s model and extensive roadside surveys which were conducted in 1989. The model simulates a summer Friday condition with five trip purposes; work, casino work, casino visit, beach visit, other. Most of the congestion problems in this MPO are seasonal related (mainly summer months) and this model has been effective for more than ten years. Transit usage is not significant in this region, and until recently there existed no real need to use the model for transit planning. However, this is a rapidly changing area and the model is no longer acceptable in developing future transportation demand forecast.

THE STATEWIDE MODEL

During the early 1990s as New Jersey made plans to complete the Interstate system it became apparent that a tool was needed to analyze projects that crossed the above model boundaries, and state boundaries. A tool was necessary to evaluate the impact of a project in one region on another region. To accomplish this would require building a statewide model, including the 21 counties and the three regional models. It was also decided that the area surrounding New Jersey should be included in the new statewide model. Instead of building a new model to accomplish the objectives, it was decided to try and combine the five existing regional models that cover the state and areas of interest:

1. North Jersey Regional Transportation Model
2. South Jersey Regional Transportation Model
3. Delaware Valley Regional Planning Commission Model
4. Port Authority of NY/NJ Interstate Network Model
5. New Castle County Model from Delaware DOT

The benefits of this approach was that a new costly four step model would not have to be developed. This would save time and money. This approach would also take advantage of the work already invested into the existing models.

An important component in the development of this new statewide model was the need and ability to analyze truck and goods movement within and through New Jersey. None of the existing models had the ability to separately evaluate trucks and goods movement, therefore development of a truck model as part of this statewide model was deemed necessary for this effort.

The above models are considered regional detail models, with sufficient detail and accuracy for incorporation into the new statewide model, and required no additional enhancements. It was decided that this new model would be formed through the merger of these five networks and trip tables. The zonal system and network was collapsed from 4023 zones and 71,502 links, to 2813 zones and 44,000 links. The New Jersey zones from the three New Jersey models remained unchanged at the census tract level, but several of the Pennsylvania and Delaware zones were aggregated.

The NJRTM has the largest portion of New Jersey zones of the three models. Therefore, it was decided that the NJRTM would be the foundation of the statewide model. The software package and the network format from the NJRTM was used. The other models networks were converted for consistency with the NJRTM. The networks were expanded to include some additional features, such as the coding of truck routes and nontruck routes, the coding of a separate toll structure for autos and trucks. Truck restriction for large trucks and no trucks were placed on the network. These changes were easily accomplished using dBASE IV and a spreadsheet software package. The external zones/cordons from the five models were connected to create a single network for the statewide model.

The auto trip tables from the five models would be combined to form one auto trip table for the statewide model. This was accomplished using a special FORTRAN technique called Trip Table Weaving. The first step in this process was to make the time of day, peak periods and daily trip tables consistent for the different models. The internal-internal trips from each model were incorporated into

the statewide model unchanged. However, the Trip Table Weaving technique would weave the internal-external, external-internal, and external-external trips for two adjoining models. The external trip from one model would be distributed to the connecting zone based on that model's distribution of those trips. The final step in the process was to validate the final trip table and balance the external trips between the two adjoining models.

The truck trip tables were developed using a standard gravity model. It was based on commodity flows for the region. This commodity flow data was compiled to produce a county-to-county commodity trip table. This table was then converted to trucks based on truck inventory data and census data. The local delivery type truck trips were not included in the commodity data and had to estimated base on zonal employment and household data. It was also necessary to locate special truck generators. Examples of special truck generators are rail yards, ports, airports, landfills, truck terminals and warehouses. This detail produced a complete truck trip table capable of estimating regional and local truck traffic on network by truck size. Four truck classes were developed from these trip tables:

1. light trucks
2. medium trucks
3. heavy trucks
4. 102-inch (which are greater than the standard 96-inch width)

The first project to be analyzed using the new statewide model was the I-287 completion project. The limits of this project crossed all three MPO regions and the regions surrounding New Jersey. The impacts were primarily heavy trucks traveling long haul and through New Jersey. The model estimated the number of autos and trucks that would be diverted from the New Jersey Turnpike to I-287 to avoid tolls and New York City congestion. The results were later validated with traffic counts and truck O/D surveys at several locations.

This network merging and Trip Table Weaving techniques provided a cost effective method to create a statewide model. It utilized the best models presently available for the region. To build this model from the beginning would be costly and time consuming. This model has allowed the NJDOT and other outside agencies to evaluate significant projects that cross MPO boundaries, which otherwise could not be accomplished with any of the existing three MPO models.

NEXT STEPS AND ENHANCEMENTS

As these regional transportation models continue to evolve, additional demands and expectations are placed on them. Previously these model were only required to predict motorized trips, but now transportation model developers are predicting non-motorized trips, and from the non-motorized trips, predicting bicycle and pedestrian usage. These regional models continue to be vital in air quality, but are now also being utilized in the Congestion Management Systems. They are used to test various transportation improvement strategies such as HOV lanes, congestion pricing, arterial signal systems and other intelligent transportation systems. Advances in personal computers have allowed many of these changes to occur; networks are expanding, zonal system are becoming more detailed, there are more feedback loops, and more iterations. To meet these demands New Jersey DOT, the MPOs and other transportation agencies must work together to maximize staff and resources. The agencies must

continue to enhance the models and explore new ideas to ensure that the models remain up to date and capable of meeting the present and future demands.

In the North Jersey/New York Region, the New York Metropolitan Transportation Council (NYMTC), the MPO for the New York region, is developing a new transportation model for its region with many of the state-of-the-art practices. This region includes the North Jersey counties. The NYMTC model will become the third model developed for the North Jersey counties. Originally it was thought that this model could eliminate the need for the other two models, NJRTM and NJ Transit model. In the early stages of the NYMTC study it became apparent that the NJRTM and the NJ Transit model met certain needs that the NYMTC model could not meet. Since the NYMTC model would take years to complete, significant financial investments have gone into enhancing the other two models. However, as part of the NYMTC model development, an extensive HIS would be conducted to obtain data on trip generation, trip chaining, non-motorized trips and other essential items. New Jersey participated in this HIS to get additional survey samples for New Jersey counties, and this information would be the basis for the next revalidation of the NJRTM.

All three model will eventually be used to model regionally significant projects. Although they will be used by three different agencies with different missions, it will be important that each produces reasonable and consistent results for similar projects. To accomplish this similarity , each of the model should have similar networks and zonal systems. They will be based on the same HIS, and produce similar generation rates and equations. A important issue to be resolved will be the demographics and the selection of a land use model to ensure consistency. These issues are being discussed between the MPOs and various state agencies, because they impact air quality, emission budgets, statewide planning, and corridor planning. Both the NJTPA and the NYMTC are evaluating the various land use models.

Presently, the DVRPC model is being enhanced to include many of the state-of-the-art practices. Each of the components of this four step process will undergo a series of enhancements. Generation will be revised based on a HIS which is scheduled to begin in 1999. It will simulate non-motorized trips, bicycle and pedestrian travel. The mode choice model will become a nested logit modal split model and the transit and highway assignments will run for the peak and off peak periods separately. Another important addition to this model will be the incremental feedback procedure through the entire model process. This is a new feature in the TRANPLAN package. The DVRPC has received a grant to evaluate several of the land use packages for incorporation into this model.

A new four step model with mode choice and other state of the art practices is being validated for the SJTPO region. This new model will replace the old model. The first task in the development of this model was a beach survey at four different locations to understand the trip characteristics for beach travelers. With this data, a recreational trip generation model was developed, it includes 16 trip purposes (hbcasino access, nhbcasino visit, casino bus, hbevent, hbbeach access, hbbeach, hbboardwalk, hbshop, hbdine, hbo, nhbevent, nhbbeach, nhbboardwalk, nhbshop, nhbdine, and nhbo). A non-recreational trip generation model was also developed. It includes nine trip purposes(hbw, hbschool, hbshop, hbo, nhbw, nhbat-work, nhbo, heavy truck and commercial). This detail was provided to test various alternatives for Atlantic City and the many Jersey beaches. The SJTPO model zones are census tracts except for Atlantic City where a casino can be a single zone. Another important component of this model is the tabulation of Life Cycle into the production model. Life cycle is comprised of the following categories:

1. No retired people, no children age 18 or younger
2. No retired people, with children 18 or under
3. Retired people

The theory here is that the presence of children increases household trip making and the presence of retired people should reduce trip making. Life cycle was tested in other states and imported into this model. The high percentage of retirement communities on the Jersey shore, make this a valued enhancement.

Some of the techniques developed in the other models will be incorporated into the SJTPO model. The coverage of this model will be expanded by weaving trip tables and networks with DVRPC model. Other new items include land use accessibility, feedback and the temporal model. To improve the mode share model NJ Transit invested time and money into the mode choice process.

A unique aspect of this model is that it will be calibrated for an August Friday. But based on data collected for this study, factors were developed to adjust trip tables for any day of the week and any month of the year. This is an important component to this model. It allows the model to test the various strategies on the different days and the different seasonal characteristics.

The enhancements that will be performed on the NJRTM, DVRPC, and SJTPO models will be imported into the statewide model using the existing network merging and trip table weaving techniques. This will result in an improved statewide model. This work effort is not in the existing plans, but it will be a project in the future.

Over the last ten years, these models have undergone a series of enhancements costing millions of dollars. If the Transims traffic-simulation project is ever implemented in New Jersey it will cost millions more. In order to maintain these state-of-the-art models, and satisfy existing and future demands, New Jersey anticipates allocating significant resources and continuing this process for many years.

Evolution of Statewide Modeling in Florida: the Teamwork Approach

Robert G. McCullough
Florida Department of Transportation

SYNOPSIS

While animation, pictures and anecdotes (to spice up an otherwise dry flavor) bolstered my presentation, the following is a simple and concise synopsis of the salient points.

The key to the success of the Florida Statewide Model's evolution has been the recognition that most trips within the state are under local influence. That is, only a small percentage of the person and freight trips exceed 50 miles and even a smaller percentage venture past 200 miles. While many of the gravity modeling methodologies are often criticized when used with statewide models, these same methodologies have actually been the backbone of the Florida Statewide Model evolution. Early recognition of the importance of local transportation infrastructure on statewide transportation systems allowed Florida to disaggregate the statewide modeling process to include the broad array of urban, county, regional and special application models that constitute the Florida Statewide Modeling System.

WHERE IS THE NATIONAL MODEL?

My air trip from the eastern reaches of the continent, Florida, to the western boundary, California, pointed out a glaring reality: it is difficult to imagine that statewide models serve as the only means to represent a transportation system of national travel and international trade routes to analyze the efficient movement of people, freight and raw resources. With the absence of a national model, each state is challenged to forecast the national influences at their borders.

FLORIDA STATEWIDE MODEL APPLICATIONS

Since my presentation involved a statewide model for Florida, I asked the audience to travel with me and review the broad array of transportation infrastructures supported by the Florida Statewide Modeling System.

The next dozen slides gave the audience a feeling for Florida's geography and model applications: rural Interstate highways, Turnpike, Turnpike Revenue Corridors, High-Speed Rail, truck and container ships, trips to the moon (injected for a little humor), trucks on the highway, trucks to train, the Tri-rail commuter system on the east coast, Metro Rail, and the People Mover in Miami. Urban Interstates were contrasted with the rural environments of Alligator Alley through the Everglades (alligator shown for rural humor). The Overseas Highway completed our trip to the southernmost part of the state, the Florida Keys. At the Florida Keys, we started our story of how the Statewide Model evolved.

PARTNERING TOOLS (KEY WEST) SLIDE

Two chairs on the beach symbolize the basic requirement for partnering: two or more must join together to have a partnership. Also shown on the slide are grains of sand on the beach, which individually are small particles of silica but when collectively joined together form a beautiful beach. The beach slide

exemplifies how partnering is the basic support system for the statewide modeling process—all levels of government working together as a single team.

EVOLUTION OF THE STATEWIDE MODELING PROCESS

The next six slides showed the evolution of Florida, a high growth state, transitioning from 15 urbanized areas in the 1980s to 25 urbanized areas in 1990 and the expectation to add an additional seven urbanized areas with the 2000 Census. Paralleling this demographic evolution, more urban models were developed and were joined by county models. County models were joined by regional models; regional models supported corridor models and revenue models were used to provide alternative financing for transportation infrastructures. Collectively, these form the Florida Statewide Modeling process.

EVOLUTION OF THE TEAM (STATEWIDE MODEL TASK FORCE)

Over the last two decades Florida has built a very active modeling community supported by the Statewide Model Task Force and strong user groups at the local level.

The lead-in slide to the evolution of the team uses an illustration of triangles to show how the majority of trips, person and freight, are influenced by local factors. Similarly an evolution from a centralized Florida Department of Transportation to a decentralized Department recognized the need to move the decision-making process to the eight transportation districts in Florida and their local governments (city, county & MPO).

Slides 32 and 33 demonstrate how a seamless bond between the policy side of the team is related to the technical side of the team. This union provides feedback to both parties and builds a sense of trust and recognition for the importance of each other's role.

The next half dozen slides (34-41) demonstrate the basis for the formulation of the Statewide Model Task Force, which maintains stewardship over all modeling activities, and is headed up by three chairmen. The tri-chairs, one chosen from the MPOs, one from the Districts, and one from regional agencies gives leadership roles to district, MPO, and regional interests. Additionally, the tri-chair structure ensures that there is never a tie vote from the leadership and policy direction is never dominated by one interest group.

Team recognition is accomplished by giving key members a vote, resulting in a large voting body of the Model Task Force. Model Task Force voting members consist of representatives from 25 MPOs, eight district, four user groups, and one representative each from the Federal Highway Administration, a transit agency, the Department of Environmental Protection and the Department of Community Affairs. To ensure decentralization is carried out in good faith, the Central Office acts as a non-voting facilitator and support unit. The Model Task Force also enjoys the participation of a majority of consultants operating in Florida and many national forms dealing with transportation modeling. The diversity of the group forms a rich resource for creating technical sub-committees.

Strong technical sub-committees allow this enormous voting team to function very efficiently. The entire state operates from a universal menu for modeling applications. New ideas are assigned by the tri-chairs

to sub-committees for evaluation, testing, and providing recommendations for the Model Task Force to vote on. This evaluation by peers provides oversight and flexibility--necessary for healthy growth.

Slides 38-40 show the composition of the modeling subcommittees and its membership. Efforts to foster communications and the sharing of a broad spectrum of transportation modeling information include a rigorous training program offering workshops given at the local level throughout the year (slide 50). We often comment that the most important workshop we teach is basic modeling concepts. The basic modeling course is kept lively and primarily attended by people just entering the modeling community or those wishing to have a refresher course. Recognizing that most of the attendees at our basic course are actually transitioning through career ladders, we often joke that they go on to lesser missions such as MPO Director, Transportation Director or someone you might later recognize as your boss. However, after attending the basic workshop, they have more of an understanding of the complexities involved with modeling.

Newsletter publications have provided a valuable means for technical information sharing. These newsletters also provide recognition to the many modelers working together in Florida developing new techniques and applications. Slides 44-49 display the type of information shared through the *Florida Transportation Modeling* newsletter, a Central Office publication in support of the Statewide Model Task Force, and through newsletters by each of the four user groups.

FUTURE EVOLUTION

Future evolution of the Statewide Modeling process will continue to recognize that local policy and transportation infrastructure directly affects more than 95% of the person trips and 80% of the freight trips that are less than 50 miles in length. While these trips are individually local, they collectively have statewide impacts. The Satatewide Model will continue to combine these local trips with regional and statewide trips to represent the synergistic effects of the Florida Statewide Modeling process.

As discussed by Ysela yesterday, the Statewide Model Task Force was recognized by the Chairman of the Florida Senate Transportation Committee and asked to make recommendations to help ensure development factors and freight modeling are fundamental in the future development of all transportation models in the State of Florida. This interaction between policy makers and modeling practitioners will help Florida to continue to have a strong modeling community and a strong modeling process.

Florida is at a crossroads and has an opportunity to set into motion the evolution required to carry us into the twenty-first century. The statewide modeling process has the necessary policy and management direction to improve freight modeling, intermodal connectivity, economic development factors, international trade routes, non-highway transportation systems, and more.

The Statewide Modal Task Force provides the oversight and guidance to develop 25 MPO, six regional, seven county, and six revenue models, all using model structures that allow the interchange of data and all operating interactively with each other. The once thought to be impossible task of modeling three urban areas within the same model has been completed on both the east and west coasts of Florida. Imagine technical folks from three different MPOs all working cooperatively together on the same

model.The challenge for the future is to have the ability to model all of Florida's MPO models at the same time.

Florida has requested resources to support the integration of all models into one mega-model. The concept of how this model will operate is much the same as GIS with multi-levels of data, each having different information about the same data theme, (i.e., bridges, roads, and utilities for the Florida themes). The model likewise would consist of statewide, regional, county, and MPO levels all stacked and each supporting the other. As you need more detail, you could "bore" down to the appropriate level, while not having to run the more detailed level in parts of Florida outside your area of concern.

Recent computer technological improvements available to the Florida modeling community would support this ambitious evolution process. GIS interfaces are being completed to provide for visual communication of modeling results. This evolution would attempt to follow the guidelines of the federal Travel Model Improvement Program (TMIP) at the national level, thus providing the infrastructure to support TMIP's full implementation in future years.

The most important evolution will be the preservation of the existing partnership of federal, state, county, city, and MPO agencies which is the lifeline of the Statewide Model Task Force and the Florida Statewide Modeling process.

The New Hampshire Statewide Travel Model System

Subramanian Sharma and Robert Lyford, New Hampshire Department of Transportation,
Thomas Rossi, Cambridge Systematics

INTRODUCTION

The New Hampshire Department of Transportation (NHDOT) began an important statewide study to carry the Department's transportation planning into the 21st century. The overall goal of the Statewide Planning Study is to "provide recommendations for developing a coordinated transportation system that will facilitate the movement of persons and goods in a safe, cost effective, efficient, and environmentally conscious manner." Recommendations from this study were to be directed to all transportation modes in the State of New Hampshire, including highways, public transportation, and freight movement. The study began in the year 1994 and is in its final stages now. The Department and its consultant team, with a multi-dimensional public participation program incorporated the concerns and ideas of the citizens of New Hampshire into the planning process.

NHDOT's consultant team was led by Cambridge Systematics, Inc., and included Holden Engineering & Surveying, Inc. and Wallace, Floyd, Associates, Inc. The study was closely coordinated with the Regional Planning Commissions, who were represented on the Advisory Committee and participated in the data collection and analysis.

This study reflected the emerging direction of transportation planning. It also reflected the Department's desire to lead in this direction, as NHDOT strives to meet the goals of transportation-related legislation, such as the Federal Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, and the Clean Air Act Amendments of 1990. Among other things these laws call for increasing the availability of transportation options to reduce the reliance on single-occupant vehicles, and for greater public participation in transportation planning and decision making.

The Department recognized that the success of the Statewide Planning Study, and the ability to meet the goals of the legislation, depended on public involvement and commitment to the transportation planning and decision-making process. NHDOT also recognized that better study decisions can be made through an open public participatory process. With this in mind, a comprehensive public participation program was developed to accompany the Statewide Planning Study. Elements include: a Legislative Advisory Committee, Technical Steering Committee, periodic newsletters, public workshops, and a Travel Demand Management brochure and video.

Other study objectives included: developing methodologies to assess the impacts of transportation projects; coordinating local and regional travel demand planning and management; helping to implement recommendations of the Department's Transportation in the 21st Century January 1993 report; and demonstrating on specific corridors (I-93 and Route 16) the analytical tools developed through this study.

The New Hampshire Statewide Travel Demand Model System (NHSTMS) was developed as part of this study. The model will help predict travel behavior (i.e., how people travel- by car, bus, etc.) and travel demand (i.e., how many people want to travel on a certain road or by a certain mode). The model is

based on statewide data collected on highway, bus, rail and airport systems; and land use, social and economic characteristics. Household travel, roadside motorist, and transit rider surveys were conducted as part of the data collection effort. The Department and its consultants plan to use the model to identify potential new or improved transportation services and strategies, designed to improve overall transportation services, reduce congestion and improve air quality.

The remainder of this paper describes the NHSTMS and how it works. The next section describes the objectives of the model system. This is followed by a summary of the model structure. Section four discusses the data requirements of the NHSTMS. Section five describes the zone system and networks in the NHSTMS. Section six provides a detailed discussion of the trip table creation, mode choice, and assignment processes, and Section seven describes the database and GIS features of the model system.

OBJECTIVES OF THE STATEWIDE MODEL SYSTEM

The Statewide Model System was developed to address the needs of the Department in the following areas:

Project/subarea analysis
The model will be used as a tool to analyze the impacts of major highway projects such as new corridors, widening of existing alignments etc.

Project alternative analysis
The model has the capability to look at impacts of policy decisions such as increases in tolls, transit fare increase etc.

Air Quality analysis
The model is designed to generate, for peak and off-peak periods of a summer average weekday, VMT estimates which can be used as input to air quality analyses.

Inputs to regional models
The statewide model is expected to provide the external cordon line volumes for other regional models (such as the models developed by the Metropolitan Planning Commission).

Management Systems
The model will serve as a tool to develop Congestion Management, Public Transportation, and Intermodal Management system.

Statewide Planning Study analysis
The model will be used to identify potential new or improved transportation services (such as bus, rail) and strategies, designed to improve overall transportation services and reduce reliance on single occupant vehicles, reduce congestion, and improve air quality.

MODEL STRUCTURE

Description of Model Structure

The NHSTMS is a tour-based model system consisting of many submodels, or components. The model system structure[1] is illustrated in Figure 1. The model system is intended to model travel by auto and transit modes for peak and off-peak periods of a summer weekday.[a] The base year of the model is 1990 with analysis capabilities for all forecast years ranging from 1997 to 2020 although years beyond 2020 could be analyzed using extrapolation of socioeconomic forecasts.

The NHSTMS is implemented as a series of multinomial logit models estimated using data primarily from a household travel and activity survey conducted for the Statewide Planning Study. This survey is similar to many recent efforts in U.S. metropolitan areas. Because of the low incidence of transit trips in New Hampshire, the estimation of the mode choice models required additional data. This information comes from a stated preference survey that was conducted for a subset of households from the original activity-travel survey and onboard surveys of transit riders.

The model system components are summarized in Table 1. All of the model components listed in this table are multinomial logit models except the time of day model, which consists of sets of factors for each trip purpose which convert daily trips to a.m. peak, midday, p.m. peak, and off-peak trips. The multinomial logit model is a means of determining the probabilities for a set of discrete choice alternatives given a set of individual and alternative specific attributes. For example, the choice of mode given the characteristics of individuals (e.g., income, auto ownership) and of auto and transit use (travel times, costs, etc.) could be modeled using a logit model.

Because existing modeling software is geared toward four-step trip-based models, components 1 through 6 in Table 1 are implemented using programs written specifically for the NHSTMS. The outputs of the secondary destination choice model are converted to traditional origin-destination trip tables, and the EMME/2 software[2] is used to apply the mode choice and time of day models. Auto vehicle trips are assigned to the highway network using traditional equilibrium assignment methods, and transit trips are also assigned using standard methods. The model outputs are therefore similar to those for a traditional four-step trip-based process.

The basic modeling process in the NHSTMS can be summarized as follows:

1. Develop the necessary data (networks and socioeconomic data);
2. Prepare and run the trip table creation process :
    1. Vehicle availability (auto ownership) modeling;
    b. Tour generation;
    3. Primary destination choice;
    d. Auto/non-auto tour modeling;
    5. Tour type; and

[a] Summer is defined roughly as the period form June through September. This definition is intended to include not only the large number of recreational trips, but also school trips.

f. Secondary destination choice.
3. Constraint of home-based work attractions
4. Mode choice
5. Transit assignment
6. Time of day
7. Truck trip modeling
8. Constraint of external station trips
9. Highway assignment

The assumptions associated with the NHSTMS are summarized in Table 2. Details of individual model components are provided on the remaining sections of this report.

TOUR BASED MODELING APPROACH

With few exceptions, urban area and statewide travel model systems in the United States use the traditional four-step modeling process. The inability of the four-step process to perform certain necessary transportation analyses and recent advances in both research and computing capability has prompted a reexamination of the four-step modeling paradigm. One of the most significant problems with the four-step process is the treatment of individual trips as independent decisions where the effects of other activity decisions are not considered (even the mode choice for a preceding trip to the origin). During the development of the plan for the NHSTMS, New Hampshire officials expressed concern about modeling trip chaining behavior.

To address this concern, a *tour-based*, or trip chaining, modeling approach was developed as an alternative to the four-step process. Tour-based models have already been implemented in urban areas both in the United States and other countries and do not require data beyond what is needed to develop a four-step travel model system.[3] Although tour-based model systems are relatively new to the U.S., models have been around in some European countries, such as Sweden and the Netherlands, for several years. Prior to the development of the NHSTMS, a tour-based model system was implemented in the Boise, Idaho urban area. This means that as of 1998, the NHSTMS is one of only two tour-based model systems being used in the U.S. (Portland, Oregon, is currently implementing a new activity/tour-based model system.)

Another innovative approach used in the NHSTMS is the use of *sample enumeration* to create data inputs for the trip table creation submodels. Unlike the common practice of using zonal averages for variables such as household size, the NHSTMS computes the number of households in each zone which fall into categories specified by the cross-classification of household size, number of workers, income level, and dwelling type. The models are then applied separately to the households in each stratum in each zone. In the recent past, sample enumeration could not be considered in the context of large regional or statewide model systems because of the computational cost. However, modern microcomputers can perform this analysis in a reasonable amount of time.

The major advantage of the sample enumeration approach is that aggregation error resulting from the use of zonal averages is greatly reduced. For example, say that transit use in a particular area is predominantly among low-income households. If a model using zonal averages were used, transit use

would occur mainly in zones with low average incomes; however, there may be no such zones. The sample enumeration method would show transit use among low-income households (with access to transit) in any zone in which they exist.

DATA USED IN MODEL DEVELOPMENT

A variety of data sources were used in the development of the NHSTMS. These include the following:

- Surveys:
  - Household activity and travel;
  - Transit onboard;
  - Vehicle intercept; and
  - Stated preference.

- Highway Network Data:
  - NHDOT GDS-based highway inventory;
  - U.S. Census TIGER files;
  - Field collection of highway data; and
  - Other data provided by NHDOT (e.g., speed limits).

- Transit Operation Data:
  - Schedules; and
  - Fare structures.

- Socioeconomic Data:
  - U.S. Census (households by municipality, tract, and block group by income level, number of persons, number of workers, and number of vehicles available);
  - New Hampshire Department of Employment Security figures on employment by category for each municipality;
  - U.S. Census Public Use Microdata Sample (PUMS) for New Hampshire;
  - Dun & Bradstreet employment database for New Hampshire; and
  - New Hampshire Office of Planning Population and household forecasts by community, and employment forecasts by county.

- Geographic Boundary Information:
  - U.S. Census TIGER files.

These data sources are described below.

Survey Data

New Hampshire Activities and Travel Survey

The primary data source for the estimation of the travel behavior models was the New Hampshire Activities and Travel Survey, which was conducted for the statewide planning study by the firm of

Market Opinion Research. A total of 2,844 households in New Hampshire provided data on the activities and travel undertaken by household members over a 24-hour period. Households were recruited for the survey by phone, were sent a diary form for travel and activity data, and were called back to retrieve the diary data. The survey was conducted between August 1994 and June 1995.

For the model estimation process, a total of four files were created from the survey data:

Household– For each household, the number of persons, number of workers, number of children, number of vehicles, location (address and various categorizations such as regional planning area, urban/rural, etc.), number of tours by purpose.

Person– For each person, the age, sex, driver's license status, worker/student status. There were over 7,000 persons in the survey.

Tour– For each tour beginning and ending at home made by each person, the location and purpose of the primary destination, number and location of stops, time tour began and ended, whether an auto was brought on the tour. Level of service information between the home and the primary destination for highway and transit, including in-vehicle and out-of-vehicle time and cost was obtained from the highway and transit networks and attached to each record. There were about 10,000 tours in the survey.

Trip– For each trip (tour segment), the origin and destination of the trip, mode(s) used, time trip began and ended, trip purpose. Level of service information between the home and the primary destination for highway and transit, including in-vehicle and out-of-vehicle time and cost was obtained from the highway and transit networks and attached to each record.

Transit On Board Surveys

A series of transit on board surveys was conducted in summer/fall 1994 to supplement the household survey data on transit trips. Surveys were conducted of riders of bus service from New Hampshire on C&J, Concord Trailways, Coach, and Vermont Transit. Riders were handed survey forms on the buses or at the stops which were mailed back for tabulation. This provided a trip file similar to the household survey trip file. This file was used to supplement the trip file from the household survey, which, not surprisingly, had relatively few transit trips.

Data were also obtained from a 1994 survey of riders on the Massachusetts Bay Transportation Authority (MBTA) commuter rail service. A total of 210 of the records from this survey represented trips by New Hampshire residents boarding on the Fitchburg, Lowell, Haverhill, and Ipswich lines. These records were important because there were only a handful of actual commuter rail riders in the household survey. They were added to the trip file from the transit onboard survey.

Vehicle Intercept Surveys

A series of vehicle intercept surveys was conducted in summer 1994 by Holden Engineering to obtain data on external trips. In this context, external trips refer to trips made by New Hampshire residents to locations outside the state and trips made by non-New Hampshire residents to or through New

Hampshire. Drivers were surveyed at 24 locations at or near major New Hampshire border crossings using one of three methods:

- Drivers were stopped and asked the questions at the survey sites. Responses were tabulated on hand held computers.
- Drivers were handed survey forms and asked to mail them back.
- License plates were recorded and matched against records from motor vehicle departments in New Hampshire and Massachusetts (this procedure was used only at sites on the Massachusetts border).

This survey provided a trip file similar to the household survey trip file. This file was used to model trips by non-New Hampshire residents.

Stated Preference Surveys

A stated preference survey is conducted to obtain information about behavior which is rare or nonexistent and therefore cannot be easily obtained from travel behavior surveys. A stated preference survey was conducted by Market Opinion Research on a subset of the respondents to the Activities and Travel Survey. Respondents were asked to make hypothetical choices given the availability of new transit service, increased auto costs, or other potential changes to the transportation system. This resulted in another supplemental trip file which contained a richer sampling of transit choices.

Highway Network Data

The main source for information about the highway system in New Hampshire was the database maintained by NHDOT using the Graphics Design System (GDS). The GDS database contained information on all roads in New Hampshire, including the following characteristics that were important for the development of the NHSTMS highway network:

- Physical locations of roads, intersections, and interchanges;
- Roadway types;
- Segment lengths;
- Number of lanes; and
- Surface type (paved/unpaved).

For roadways in the NHSTMS network located outside New Hampshire, the TIGER files available from the U.S. Census Bureau were used. These files provided the necessary geographic information to determine the physical locations of roads, intersections, and interchanges.

The GDS and TIGER databases did not provide all information necessary for model development. It was necessary to supplement this information with field data checks. The major data item lacking from

these sources was speed data. For New Hampshire roadways, speed limit data were obtained directly from NHDOT.

Transit Operation Data

The NHSTMS has a transit network which is used for developing travel time and cost information for the mode choice and transit assignment processes. This network focuses on longer intercity routes such as the intercity service provided by C&J, Concord Trailways, Coach, and Vermont Transit, and commuter rail service provided by the MBTA. The following data on these transit services were required for model development and/or application:

- Fare structures;
- Headways/frequencies;
- Travel times; and
- Ridership

This information was obtained directly from transit operators or from published information (e.g., schedules).

Socioeconomic Data

The NHSTMS requires a significant amount of socioeconomic data for both model development and model application. Tables 3 and 4 summarize the data requirements for model development and model application respectively.

Base Year Socioeconomic Data

The base year of the NHSTMS was chosen to be 1990 to coincide with the most recent U.S. Census. Zone boundaries were chosen to be consistent with census geography, and so it was a relatively simple task to estimate the population and number of households by type (see Table 3) for each zone. This process was facilitated by the use of the TIGER files since the zone boundary layer of the NHSTMS GIS could be overlaid with the census data in the TIGER files. The population and household estimates for each zone were reviewed by the appropriate regional planning commission and NHDOT before they were finalized.

Employment estimates by employment type for each zone for 1990 were developed from estimates for each municipality obtained from the New Hampshire Department of Employment Security. For cities and towns which consist of more than one zone, the Dun & Bradstreet data file was used to allocate the employment among the various zones comprising the municipalities. The regional planning commissions reviewed these figures and provided revisions. These revisions were numerous due to the relatively imprecise nature of the original estimates, particularly in communities where allocation of Department of Employment Security figures was required.

Socioeconomic Forecasts

There are two “base” forecast years for the NHSTMS: 2005 and 2020. Zonal forecasts of the model variables shown in Table 4 were made for these two years. Forecasts for any intermediate year are made

by straight line interpolation between 1990 and 2005, or 2005 and 2020.

The New Hampshire Office of Planning has developed population and household forecasts at the municipality level. For the many New Hampshire communities which correspond to exactly one NHSTMS zone, the Office of Planning forecasts are therefore the zonal forecasts. For communities which consist of more than one NHSTMS zone, the forecast for the city or town was maintained, and the growth in population or households from 1990 allocated to zones proportionally based on the 1990 population/number of households. The resulting initial forecast estimates were reviewed by NHDOT and the regional planning commissions, who provided valuable insight into the expected locations of future development. This resulted in more reasonable allocations of growth within a community in many cases.

Employment forecasts were available only at the county level. It was therefore necessary to allocate the expected growth among all zones within each county among all zones in the county. The review by NHDOT and the regional planning commissions was even more critical since the allocations were made over much larger areas (counties rather than cities and towns).

It should be noted that although socioeconomic forecasts have been provided (or can be interpolated) for all forecast years through 2020, alternate growth forecasts for a particular alternative can also be analyzed by replacing the standard forecasts for the affected zones with the desired replacements.

Disaggregate Household Forecasts

As discussed earlier, the NHSTMS model system is applied using sample enumeration. This means that rather than using zonal averages for each model variable, the model is applied to each individual household based on its characteristics. Actually, since households are defined in terms of a four-dimensional cross-classification, the models are applied to each category of households within a zone, and the resulting tours and trips multiplied by the number of households falling into each category.

For the base year, the census data provide most of the necessary categorization of households for each zone. For forecast years, the household forecasts provide one-dimensional classifications of households by each category (income level, number of persons, number of workers, and single family vs. multi-family). The full cross-classification of the household forecasts is achieved through the use of iterative proportional fitting (IPF). In this process, which is equivalent to the Fratar process used in other components of the model system, the base year classification is adjusted iteratively until the marginal totals match the targets. The IPF process is implemented using Excel spreadsheet macros.

Geographic Boundary Information

Because the final model system was to reside ina geographic information system (GIS), it was necessary to obtain detailed information on geographic boundaries which could be used for zone boundary definition. The major source for this information was the TIGER file, which contained boundary information on all census geography, including municipal, tract, and block group boundaries.

ZONES AND NETWORKS

Traffic Analysis Zones

The NHSTMS uses the traditional approach of aggregating trip end locations to traffic analysis zones. It is reasonable to use a relatively small number of zones since the statewide model system does not focus on short local trips.

The model area is the area which includes the origins and destinations of most trips which are made wholly or partially in New Hampshire. This area includes the entire state of New Hampshire and locations in neighboring states which represent destinations for significant numbers of New Hampshire residents, or whose residents make significant numbers of trips to New Hampshire. The areas outside New Hampshire which are included in the model area are described below.

In general, internal zones were defined to be consistent with municipal boundaries, census tracts and/or block groups, and zone boundaries for the models maintained by Regional Planning Commissions (RPCs) in New Hampshire. Each city and town is represented by 1 to 21 zones.

Because of the large number of trips between New Hampshire and the Boston area, it was necessary to include in the NHSTMS external zones in Massachusetts extending south to Boston. This also allowed the inclusion in the transit network of nearly all intercity bus routes which serve New Hampshire.

External stations were used to represent the "other ends" for trips to and from the internal and external zones which lay outside the model area. External stations also represented the origins and destinations of through trips (trips which used roadways in the NHSTMS network but had neither an origin nor a destination in the model area).

Transportation Networks

The transportation networks are the basis for all modeling analyses. The networks represent the specific highway and transit route assumptions for the scenario being analyzed and are used for estimation of level of service variables (travel times and costs) and for highway and transit assignments.

The highway and transit networks consist of a series of links, representing roadway and rail line segments, and nodes, representing the points where links intersect. Links connecting the zone centroids to the network are also included in the networks.

The transit routes which are identified as part of the NHSTMS are the major intercity or long-distance routes in the model area. The NHSTMS transit modeling capabilities focus on these longer distance transit routes because local transit cannot be adequately modeled by the relatively coarse zone structure of the statewide model system and because there is relatively little local transit travel to model in New Hampshire. Local transit is more appropriately handled in urban area model systems.

TRIP TABLE CREATION, MODE CHOICE, AND ASSIGNMENT

This section describes the process used to create person trip tables by trip purpose and mode in the NHSTMS and to assign vehicle and transit person trips. These processes use zonal data– such as socioeconomic data– and highway and transit network data to estimate the tour making patterns in New Hampshire and, from that, the number of trips by purpose between each pair of zones. These person trip tables are used as inputs into the mode choice and time of day models.

The required inputs for the trip table creation process are the zonal socioeconomic data, the number of households in each zone in each category of the four-dimensional classification (household size, number of workers, income level, and dwelling type), and the travel impedances by highway and transit. Table 5 displays the required impedance components.

The trip table creation process creates as outputs 12 trip tables containing person trips. These trip tables are used as inputs into the mode choice and subsequent submodels. These are listed below:

Trips made by New Hampshire residents:

- Home-based work trips in auto tours;
- Home-based work trips in non-auto tours;
- Home-based school trips in auto tours;
- Home-based school trips in non-auto tours;
- Home-based other trips in auto tours;
- Home-based other trips in non-auto tours;
- Non-home based trips in auto tours;
- Non-home-based trips in non-auto tours; and
- Work subtour trips in auto tours

Trips made by non-New Hampshire residents:

- Home-based work trips;
- Home-based school trips; and
- Home-based other trips.

Vehicle Availability

The vehicle availability submodel essentially adds a fifth dimension—the number of autos per household—to the four dimensional categorization of households. Like the vehicle availability models which are part of many urban area model systems, this submodel is a multinomial logit model which is based on household characteristics such as income, household size, number of workers, as well as

locational characteristics of the household. This submodel was estimated using the PUMS dataset for New Hampshire.

Tour Generation

Tour generation models constitute the second step in the trip table creation process. The tour generation model relates the number of tours generated by a household to that household's socioeconomic and geographic characteristics. These models, one for each tour purpose, are somewhat analogous to the first step of the traditional four step modeling process, trip generation. Tour generation models were developed for the following tour purposes: Work, School, Other, Shopping, Recreation, and Chauffeuring.

For trip generation, the norm in trip-based models involves the development of production and attraction models linking the total zonal trips or trips per household to the household and zonal socioeconomic characteristics. Tour generation models look at travel as "tours" that combine a number of linked trips. For example, a person traveling from home to work may actually stop on the way to drop off someone and/or do personal errands.

In the NHSTMS, a tour is thus defined as a sequence of trips/activities that start at home and end at home. The analysis of trip chaining divides trip generation into two parts: estimation of the number of tours, and prediction of the tour type, that is the number and purposes of stops in each tour. Assume a single person household making one tour a day, starting at home, going to work, and then shopping before ending the day at home. The first part of the trip generation involves predicting that the household makes one tour, and the next step involves predicting that the tour has two intermediate stops, one at work and the other for shopping, in that order. The modeling of intermediate stops is discussed later.

Destination Choice

Destination choice models predict the probability of choice of all likely destination zones for a tour. All zones in the study area make up the choice alternatives. The destination choice model system includes primary destination choice, described here, and secondary destination choice submodels, described later.

The primary destination choice models were developed using data from the household Activities and Travel survey, which provides information on travel patterns of households within the state of New Hampshire. Due to the non-availability of similar data for households outside New Hampshire, models developed for internal zones are appropriately applied for travel from external zones.

The zone of primary activity on a tour is termed as the primary destination. The purpose of the primary activity/trip on a tour is the purpose of the tour itself. For example, in a work tour, the highest decision in the hierarchy of destination choices is the work destination. Based on the primary destination, the other stops along the tour are determined. Primary destination choice models were developed for the following tour purposes: Work, School, Other, Shopping, Recreation, and Chauffeuring. All submodels are developed as multinomial logit models in which the traveler chooses a zone among all potential

choices in the model area as the actual destination.

Mode Choice - Stage 1

Since the stated preference and onboard surveys had to be trip-based, a two-stage mode choice model is used. First, the tours are classified as “auto,” in which the traveler brings an auto from the home, or “non-auto.” Then, a trip-based model is used for each type of tour. For each type of tour, constraints govern the choice set of modes. Trips on auto tours must ensure that the automobile is available for each trip on the tour; the mode for each trip must be “drive alone,” “two-person carpool,” or “three or more person carpool” unless the origin is revisited in the tour (i.e., a subtour exists). Trips on non-auto tours do not have the auto driver modes available but do have transit and non-motorized modes available.

Besides the effect on trip level mode choice, there is also reason to believe that a personal vehicle provides for an increased flexibility in movement and could result in different travel behavior than when a vehicle is not available. This aspect of auto tours is dealt with in greater detail in the tour type models. The level of transit usage on a tour is also largely dependent upon whether auto is the primary mode or not.

The choice of whether to bring an auto on a tour depends upon its availability for usage and the ease of travel to the primary destination by transit as compared to auto. For this reason, these models cannot be applied until after the primary destination models. Also, because of the fact that the availability of an auto influences the travel pattern, these models should immediately follow the application of the primary destination models. Accessibility of the primary destination from home is measured by a composite variable that combines the level of service of auto and transit.

Tour Type

Tour type models determine the number of stops on a tour and whether a tour has a subtour associated with it. Based on observations made from the household activity survey data used for model estimation, and due to the complexity associated with determining destinations in tours with multiple stops, the maximum number of stops on a tour is limited to three (primary, secondary, and tertiary destinations), excluding the subtour stops. Subtours or midday tours, modeled only for work tours, are made during the day and have the beginning and ending as the work location.

One of the most important factors in determining the tour type is the availability of a vehicle on a tour. The ease of travel and the flexibility associated with the availability of an auto (hereafter referred to as auto tours) prompts an increase in the amount of travel. Therefore, auto tours exhibit a different travel pattern from non-auto tours and hence should be treated separately. Since the non-availability of an auto inhibits free movement, it could be safely assumed that travelers not using auto for their primary activity know a priori that their primary destination is the only stop on the tour. Therefore, non-auto tours are restricted to be one-stop tours without any midday tours from work. Separate tour type models are developed for each of the six purposes.

Secondary Destination Choice

Secondary destination choice models, including tertiary and subtour destination choice models, predict the starting and ending locations of study area trips. In simple terms, these models help determine the locations of the second, third, and midday stops for tours respectively. The secondary destination choice models are developed using data from the household Activities and Travel survey, which provides information on travel patterns of households within the state of New Hampshire.

The outputs of the secondary destination choice models are traditional person trip tables. At this point, it is possible to perform the remaining functions of the NHSTMS using the matrix manipulation and assignment capabilities of EMME/2.

Mode Choice - Stage 2

The second stage mode choice models are applied to the daily person trip tables which are outputs of the trip table development process. The mode choice models are multinomial logit models applied using EMME/2 macros. Models were estimated for eight tour type/trip purpose combinations as described below. The models were estimated from a combined data set containing data from household activity/travel, transit onboard, and stated preference surveys.

The main data set used for model estimation is a combination of:

- The trip file from the household Activities and Travel Survey;
- The trip file from the stated preference survey;
- The trip file from the transit onboard survey; and
- The records for New Hampshire residents from the MBTA survey of commuter rail riders.

Vehicle trip tables are required as inputs to the highway assignment process so that volumes can be estimated on highways. Vehicle trip tables consist of the following components:

- Auto trips;
- Auto access to transit trips; and
- Truck trips.

Auto person trip tables are the outputs of the mode choice modeling process. For each trip purpose, person trip tables are output for auto with one, two, or three or more occupants. For one and two person autos, the conversion from person to vehicle trips is straightforward. The single occupant vehicle and person trip tables are the same. The two-person auto trip tables are divided by two to obtain vehicle trips. For the three or more person trips, vehicle occupancy averages were determined from the household survey data by trip purpose.

Time of Day

The NHSTMS assigns vehicle trips for four time periods, which comprise an average summer weekday.

These periods are defined as follows:

AM Peak– 6:00 a.m. to 9:00 a.m.;
Midday– 9:00 a.m. to 3:00 p.m.;

PM Peak– 3:00 p.m. to 6:00 p.m.; and

Off-Peak – 6:00 p.m. to 6:00 a.m.

The trip tables that are outputs of the trip table development and mode choice process represent average daily travel. The daily trip tables by purpose are divided into trip tables for each time period by purpose through a set of factors. These factors were developed from the household survey data and adjusted to reflect traffic counts by time of day.

Truck Trips

Truck trips are estimated separately from the tour-based modeling process. Truck travel is estimated using the following process:

1. For internal (New Hampshire) zones, daily truck trip ends are estimated based on employment by category and households, based on information from the FHWA *Quick Response Freight Manual*[4]
2. For external zones and stations, daily truck trip ends are estimated as five percent of the total estimated vehicle trips.
3. Trip distribution is performed using a gravity model. The friction factors are given by a formula based on the Quick Response Freight Manual. For external stations, as recommended in the Quick Response Freight Manual, distance is added to represent the distance traveled outside the model area.
4. Time of day factors, based on the Quick Response Freight Manual, are applied to the daily truck trip table resulting from step 3.
5. The resulting truck trip tables for each period are added to the vehicle trip tables which are the outputs of the time of day submodel.

Transit Assignment

In the transit assignment process, the daily bus and rail trips are loaded onto the transit network. This process consists of the determination of transit paths between origins and destinations and the assignment of the trips from the mode choice model onto these routes. It should be noted that this process differs from the transit assignment process in a typical urban area model since the transit trips being modeled are longer intercity trips rather than short local trips. The major differences for the statewide transit assignment process are as follow:

- Distances are long, usually at least 10 miles and often much more, between stations. This means that the exact paths routes take between stations are unimportant as long as the travel times between the stations are accurate. It also means that buses may often achieve speeds as high as auto speeds over long sections of routes.

- Fares are nearly always distance-based although fare structures vary significantly throughout the model area.
- Auto access portions of park-and-ride or trips may be fairly long.

In the transit network development process, the network is defined in terms of both the links available to bus, rail, and access modes (auto, walk, and subway) and the specific routes operated in the model area. The first step in transit assignment is to determine the paths – the ordered sets of links along the network – over which the routes operate.

The next step is to determine the paths connecting the stops. This is done, using EMME/2 and custom programs written for this process, by determining the shortest paths between stops in a manner similar to that used during network skims. The result is a set of paths which include all nodes and links between the origins and destinations.

The transit assignment process is simply an all-or-nothing assignment procedure using the paths developed from the skeletal route files. However, it should be noted that only the portions of trips that are actually on board transit vehicles are assigned. The auto access portion of trips are separated from the transit trip tables using matrix convolution capabilities of using EMME/2 and custom programs written for this process. The auto access trips are then added to the auto vehicle trip tables prior to auto assignment.

Highway Assignment

The highway assignment process consists of assigning the vehicle trip table for each of the four time periods (a.m., p.m., midday, and off-peak) to its respective highway network. The vehicle trip tables consist of:

- Auto trips by New Hampshire residents;
- Auto trips in New Hampshire by residents of other states;
- Truck trips which travel within, to, from, or through New Hampshire; and
- The auto access portions of transit trips.

The four trip tables are assigned to the networks using traditional equilibrium assignment techniques within EMME/2. Because of the relatively uncongested nature of the majority of the highway network in New Hampshire, the base year assignments converge in two to three iterations.

DATABASE/GIS APPROACH

One of the unique aspects of the NHSTMS is that all network link and node data are stored in a series of databases. This is done to facilitate management of model data for various scenarios and data display using the GIS capabilities which are part of the NHSTMS.

All link and node records which are part of any scenario run using the NHSTMS are stored in a "master database." This database contains coordinates for all nodes as well as the relevant information for each

link, including length, link type codes, number of lanes, counted volume data, and speed. For each scenario, a separate database indicates which nodes and links from the master database are to be used. The user accesses and edits the databases through a Windows menu system, which also enables the user to create and manage scenarios, perform screenline analysis, and generate network data input files in EMME/2 format.

The use of a database manager to store network data allows easy transition of the model input and output data to a GIS. The GIS programs which are part of the NHSTMS, programmed in Arc/Info, allows a number of user capabilities including querying, color and bandwidth coding, and comparison of scenarios.

CONCLUSION

The NHSTMS is expected to be an important and flexible analysis tool in New Hampshire for years to come. It has many unique features including database/GIS capabilities, a tour-based model structure, and an underlying set of disaggregately estimated models. It is a state-of-the-art tool that will provide planners in New Hampshire the capability to perform a wide variety of analyses.

REFERENCES

1. Cambridge Systematics, Inc. *New Hampshire Statewide Travel Model System: Model Documentation Report*, 1998.

2. INTRO Consultants. *EMME/2 User's Manual*, *Version 7.0*, 1995.

3. Rossi, Thomas F. and Yoram Shiftan. *Tour Based Travel Demand Modeling in the U.S.* Paper presented at the 8th IFAC/IFIP/IFORS Symposium on Transportation Systems '97, Chania, Greece, June 1998.

4. Cambridge Systematics, Inc., Comsis Corporation, and University of Wisconsin, Milwaukee. *Quick Response Freight Manual.* Prepared for the Federal Highway Administration, 1996.

Figure 1 Tour-Based Travel Model System

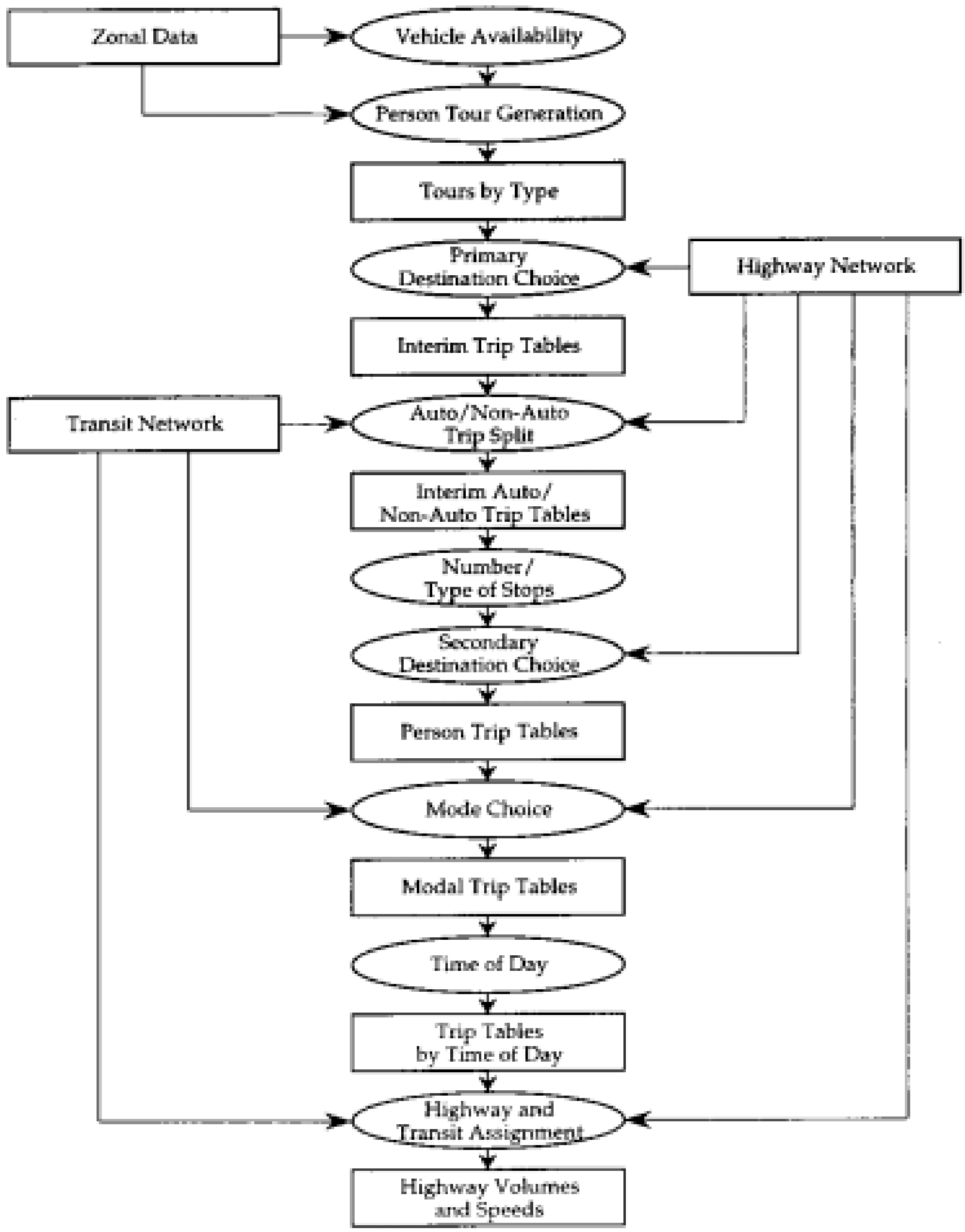

TABLE 1 New Hampshire Statewide Travel Model System Components

Component	Basis
1. Vehicle availability (auto ownership)	Household
2. Tour generation (number of tours by purpose)	Household
3. Primary destination choice of tour	Tour
4. Tour level mode choice (auto vs. non-auto tour)	Tour
5. Tour type (number and type of stops)	Tour
6. Secondary destination choice	Trip
7. Trip level mode choice	Trip
8. Time of day	Trip

TABLE 2
New Hampshire Statewide Travel Model System Assumptions

Model Feature	Assumption	Data Source
Base Year	1990	Households: U.S. Census Employment: NH Department of Employment Security
Forecast Years	Capable of analyzing any year through 2020, perhaps beyond if willing to extrapolate socioeconomic data. Socioeconomic forecasts exist for 2005 and 2020, other years available via interpolation	State Planning Office municipal/ county totals, disaggregated to zones and reviewed by RPCs
Base Modeling Period	Summer weekday	N/A
Times of Day	Three-hour a.m. and p.m. peak periods, midday and nighttime periods. Daily travel estimates can be reported.	Factors derived from survey data
Unit of Travel	Person-tours through trip distribution, person trips for mode choice and time of day	Household travel, stated preference, vehicle intercept (external), and transit onboard surveys
Zone System	Consistent with: existing RPC model zone boundaries, municipal boundaries, census geography	Census boundaries, RPC models

TABLE 2
New Hampshire Statewide Travel Model System Assumptions

Transportation Network	Multimodal – highway, bus, rail	NHDOT GDS, transit route information from operators and schedules
Tour Purposes	Work, school, shop, recreational, other, pick-up/drop-off	Household travel survey
Trip Purposes(mode choice/time of day)	Home-based work, home-based school, home-based other, non-home-based for each tour type (auto/non-auto), also subtours	Household travel, stated preference, and transit onboard surveys
Modes Included	Vary by purpose, but generally include: SOV, HOV2, HOV3+, bus, rail, non-motorized	Household travel, stated preference, and transit onboard surveys

Table 3 Socioeconomic Data Requirements for Model Development

All data items required at zone level

Employment by type	**Total population**
Number of households by:	Whether zone has a:
Vehicle availability level	Airport
Income level	Beach
Number of persons	College
Number of workers	Park
Single family vs. multi-family dwelling	Other recreational area
Land area	

Table 4 Socioeconomic Data Requirements for Model Application

All data items required at zone level

Employment by type	**Total population**
Number of households cross-classified in four dimensions:	Whether zone has a:
Income level	Airport
Number of persons	Beach
Number of workers	College
Single family vs. multi-family dwelling	Park
Land area	Other recreational area

Table 5 Impedance Measures Required by the Trip Table Creation Process
Auto distance
Auto costs
Rail out-of-vehicle time
Rail fares (work)
Rail in-vehicle time
Rail fares (non-work)
Bus out-of-vehicle time
Bus fares (work)
Bus in-vehicle time
Bus fares (non-work)
Auto travel times

Statewide Travel Demand Forecasting Process in California

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HISTORY OF TRAVEL DEMAND FORECASTING IN CALIFORNIA

The travel demand forecasting and analysis function in California initially was developed in response to the demonstrated need for additional and improved transportation facilities during the Interstate Highway construction era of the 1950's. Response to this need first required more extensive planning for the safe and efficient movement of people and goods. Over several decades travel forecasting evolved from non-existent to extremely sophisticated as it stands today.

Transportation planning and travel forecasting expanded to meet the information needs of decision-makers in each of several distinct transportation periods. Prior to the 1920's, interregional and intercity travel was primarily by rail or wagon. Highways were generally a local concern only, and local coordination and standards for transportation were established. During this period, there was no reason for travel demand estimation, as the explosive growth of California had not yet commenced.

From the 1920's through the 1940's, travel demand was estimated by “Rule of Thumb” for each facility being considered. This was the road network period when the Federal Aid Primary system was initiated and when facility design and other criteria developed. Simply put, newly constructed highway facilities virtually always exceeded demand when a project was completed. In most cases, many years may have past before the facility became inadequate. Sometimes even decades past before demand exceeded capacity and expansion or a new facility was required to meet the needs of the traveling public.

The first real demand for system analysis came in the mid-1940's, as small towns began to be bypassed, and has continued to the present. In that decade, both population and automobile ownership increased at such a rapid rate that the demand for intercity and urban area mobility could no longer be ignored. The Federal-aid Act of 1944 first provided Federal funds for the construction of urban area highways and advocated urban transportation planning. Almost 20 years later, the Federal-aid Act of 1962 required transportation planning for all urban areas of more than 50,000 population and formalized the Urban Transportation Planning Process which includes the 3-C Process for planning, e.g., cooperative, comprehensive, and continuing.

This new process provided the framework within which all levels of government (local, regional, State, and Federal) began conducting transportation planning. That framework included inventories, data and model analysis, forecasts, transportation system analysis, plan development, plan evaluation, plan selection, and plan implementation, followed by continuing reevaluation. This new process was a significant departure from the simplistic rule-of-thumb methods that provided for an estimate of the future based upon past experience (trend line, for example). Rule-of-thumb methods were limited to the point at which the estimate was made on the existing or proposed network only. Urban travel demand forecasting provided for an analysis of the entire system based upon alternative networks and service (supply side) and alternative estimates of socioeconomic data such as housing, population, income, employment, etc. (demand side). This process gave answers to the following questions for each of the alternatives:

- What is the magnitude of the system?
- Where are the activities located?
- How many trips will be generated?
- Where will the trips go?
- By which mode?
- By which route?

As the need for system analysis and travel demand forecasting matured through the 1960's, the next decade of the 1970's became the "environmental" era when the demand for environmental impact assessment was brought to the forefront and travel demand forecasting became fully entrenched in the transportation planning process. Caltrans' Office of Travel Forecasting & Analysis (OTF&A), as it exists in the Caltrans organization today, has undergone an organizational and functional metamorphosis over the years. Backing up to the 1950's and 1960's, the Transportation Analysis Branch within the California Division of Highways, provided modeling and forecasting services on a statewide basis to all regions in the State. The unit ran models on mainframe data processing machines to provide travel forecasts to the Caltrans district offices and their associated regional planning agencies. In the early 1970's, however, when Caltrans was created as a multi-modal department, the Division of Transportation Planning was legislatively mandated and OTF&A was created.

While OTF&A continued to provide considerable travel forecasting services to the districts and regions, the "locals" began their quest for independence and expressed desires to do their own modeling and travel forecasting. Currently, most all RTPAs and MPOs do their own technical travel demand analysis. This capability developed with the introduction of the desktop PC and workstations to replace mainframe UNIX-based EDP equipment that only the largest organizations previously could afford. The Office of Travel Forecasting & Analysis focuses on regional support, research, and vehicular emissions forecasting for air quality analysis. Through its regional support function, OTF&A provides technical services, updated software, and training (when requested) to modeling staff in the Caltrans districts, the RTPAs, and to some smaller local jurisdictions that do their own modeling, yet need technical assistance to become self-sufficient.

In its research function, OTF&A investigates and develops new techniques in modeling activities, particularly those related to operational improvements to facilities. Examples of Caltrans' ongoing research activities include investigation into intelligent transportation systems, driving cycle protocol development associated with air quality analysis, and data collection techniques using instrumented vehicles and relatively new state-of-the-practice research activities include investigation into intelligent transportation systems, driving cycle protocol development associated with air quality analysis, and data collection techniques using instrumented vehicles and relatively new state-of-the-practice equipment such as GPS.

MODELING SOFTWARE AND SYSTEMS USED IN CALIFORNIA

A variety of travel demand forecasting processes and software have been used in California since the 1960's. The old "Division of Highways" developed its own proprietary software of analytical modeling programs, known as the TRN and FWY systems. The TRN system handled all the data reduction of

origin-destination data collected through massive home interview survey efforts conducted throughout

the State. The FWY system was a mainframe system that addressed all phases of modeling including trip generation, distribution, assignment, and mode-split.

Over time, as work stations and personal computers became more and more powerful, other travel demand modeling systems were developed and evolved externally such as TRANPLAN, MINUTP, EMME2, and TP+/VIPER, just to name a few. The Caltrans modelers have utilized these more user-friendly systems and have adopted many of them as viable replacements to our TRN and FWY systems and the Federal UTPS mainframe system. Thus, the Caltrans systems and other mainframe systems have gone by the wayside as too expensive to maintain, particularly when most of the regions are doing their own modeling (using simpler systems and more powerful PCs). Many advantages are found in federal government systems or vendor systems that better meet the regional agencies' specific needs and data processing equipment.

While this paper primarily addresses systems used by the California Department of Transportation, several of our regional partners are very sophisticated in their development, use, and adaptation of various models. A prime example is the efforts that have been developed at the Metropolitan Transportation Commission in the San Francisco Bay Area. MTC completed work in 1997 on a new model system, known as BAYCAST, through the aggregate validation of all trip distribution models.

BAYCAST was designed as an advanced state-of-the-practice trip-based travel forecasting system that differed from the typical 'four-step' model. This modeling system includes the standard four steps of generation, distribution, mode choice, and assignment, as well as three extra main models: workers in household, auto ownership choice, and time-of-day choice models. BAYCAST, as a model system, is intended for application with different network planning packages including, but not limited to MINUTP, TRANPLAN, and EMME/2. To date, this model system has been used for updating both the Regional Transportation Plan and for updating county congestion agency model systems.

CALIFORNIA STATEWIDE TRAVEL MODEL

In addition to the modeling systems used by Caltrans and the regions for regional travel forecasting, several years ago OTF&A developed a Statewide Travel Model that specifically focuses on long, interregional/intrastate travel. The Statewide Travel Model is primarily intended to provide a baseline for statewide aggregated data rather than detailed regional forecasts. The Statewide Travel Model operates similarly to a standard regional travel demand model using the same variables but on a statewide basis. Trip generation, distribution, and assignment is run on a 1400 zone network, although this zone system and network was recently expanded to some 2500 zones in order to increase the accuracy of the model outputs.

MOTOR VEHICLE STOCK, TRAVEL AND FUEL FORECAST MODEL

Also, Caltrans has developed the Motor Vehicle Stock, Travel and Fuel Forecast (MVSTAFF) model that uses a macroeconomic approach to modeling statewide motor vehicle holdings, VMT, and total fuel consumption. Econometric equations are used to forecast total vehicle stock, total diesel fuel

consumption, and total VMT based on variables such as population, income, vehicle ownership, and the fuel cost per mile. Total on-road fuel consumption is estimated by dividing total VMT by an estimate of on-road fleet fuel economy. Total gasoline consumption is obtained as the difference between total fuel consumption and diesel fuel consumption.

The MVSTAFF forecasts are used for both short- and long-range statewide transportation planning, travel forecasting, and projections of revenues from excise taxes on fuel. This model is used to forecast travel on a total statewide basis rather than aggregate the regional modeling efforts into a statewide composite. Some interesting facts about California and its travel history and future resulting from MVSTAFF outputs follow:

- The decade of the 1950's experienced a 71% increase in VMT which was driven primarily by a 49% increase in population and helped along with moderate increases in per capita total personal income and vehicle ownership.

- The 1960's saw a 64% increase in VMT although population grew at about half the rate that it did in the 1950's. The driving force in this decade would appear to be the growth in per capita income and vehicle ownership, the highest in 40 years.

- The 1970's produced the smallest percentage increase in VMT (38%) in the previous 40 years as a result of the lowest percentage increase in population, a slower growing economy, and sharply rising fuel prices in the last half of the decade.

- In the 1980's, VMT grew by 62% while per capita income and vehicle ownership grew by only 12% and 7%, respectively. Most of the growth in VMT in the 1980's can, therefore, be attributed to strong population gains (26%) and the precipitous drop in the real fuel cost per mile of travel (57%), resulting from a 45% drop in the real price of fuel and a 39% increase in the on-road fleet fuel economy.

- In the 1990's, VMT has grown, but at a greatly reduced rate of 22% as population growth slows down to 16% and personal income shows small growth (9%).

- In the 2000's and 2010's, VMT is forecasted to grow moderately (27% and 22%, respectively) as population growth rates increase only slightly (18% and 16%) over the 1990's and personal income increases moderately (15% and 12%). Fuel cost per mile will have a small increase of only 2% in the 20-year period from 2000-2020.

Three years ago the Institute of Transportation Studies at University of California at Davis completed an in-depth analysis of Caltrans' MVSTAFF Model to evaluate the estimates generated by the model and to provide Caltrans with suggestions for enhancements to the methodology used, if necessary. The assessment clearly demonstrated that MVSTAFF is a viable tool in meeting its programmatic objectives and is consistent with models, used by other organizations, that are based on widely different methodologies and purposes. While some specific modeling and process improvement recommendations were made, the overall conclusion was that this model has analytical integrity and

produces reasonable and consistent results compared to other models being used throughout the country.

GUIDELINES FOR MODELING IN CALIFORNIA

In the early 1990's, in association with consultants and the FHWA, OTF&A developed a set of *Travel Forecasting Guidelines*, documented in a publication provided to the travel forecasting community upon request. This publication presents what reasonable and consistent methods should be used in preparation of regional travel forecasts developed to yield mobile source emission inventories. The *Guidelines* document addresses this purpose in three major areas: 1) An overview of state-of-the-practice in transportation modeling (as of 1992); 2) A description of the linkage with mobile source emission inventories, including methods for addressing transportation control measures in the modeling process; and 3) A discussion of future research and model improvement needs, some of which have already occurred or at least have been addressed by the modeling community. Other reasons for development of these modeling guidelines follow.

Several years ago, it was proposed that travel demand forecasting models be used for estimating emissions, traffic operational analyses, and congestion management planning. This proposal came as a result of passage of the California Clean air Act of 1988, the Federal Clean Air Act Amendments of 1990, and the Congestion Management Program of 1990. Each of these uses had different requirements for the accuracy and usefulness of the model outputs and the validity of the input assumptions and data. These new uses for existing travel demand forecasting models prompted Caltrans to initiate a set of travel demand forecasting guidelines.

The State and Federal legislative requirements for modeling, particularly California’s Congestion Management Program, resulted in a proliferation of regional or countywide models. While regional modeling used to be practiced by only a few metropolitan planning organizations in the State, the CMP legislation led to the development of a countywide model by virtually every county in the State that contained an urban area. Many of the regional or countywide models in the state were reasonably sophisticated and constituted good modeling practice, but some MPOs or CMP agencies were using procedures that had not been updated since the 1960's or 1970's.

Alternatively, some agencies were using default values provided with the analytical software packages that were being utilized. As a result, there was considerable variation in the level of sophistication and the level of accuracy of regional models within the State. The effort to develop statewide guidelines was designed to raise the overall level of the quality of modeling within the State and to provide some consistency in the way that modeling is practiced in California.

The primary purpose for regional modeling of travel when it began in the late 1950's was to determine the need or requirements for major highway investments. This determination was most often made on the basis of projected volumes on particular roadway links. From that estimate, the number of lanes of additional capacity needed or the need for new roadway facilities was determined. When used for this purpose, rough approximations of forecast volumes (particularly in rural areas) were sufficient to

determine when existing facility improvements or development of new facilities were needed. In and around urban areas, the detailed outputs of sophisticated zonal forecast and freeway system models were necessary and usage of these early models increased.

With an emerging regulatory and legislative environment some ten years ago, however, significantly greater accuracy and sensitivity became necessary. An emphasis on meeting air quality standards within the State became a primary focus in developing guidelines to improve the forecasting of travel activity data as an input to emissions estimation as part of an overall conformity analysis for regional transportation plans and transportation improvement programs.

A secondary concern to be addressed in the *Guidelines* emerged regarding the accuracy of models in conjunction with how they would be used: 1) To produce inputs for level of service calculations as required by the Congestion Management Program; 2) To evaluate transportation control measures as required by the Federal and State Clean Air Acts; and 3) To evaluate alternative modes such as transit or other high occupancy vehicle modes, including carpooling and vanpooling. Within each of these areas, there was concern about inconsistencies and inaccuracies in the model systems and how they represented travel behavior.

Greater accuracy in modeling was desired as a means of more efficiently planning for transportation facilities or facility management programs. Also, greater consistency was desired to facilitate comparisons of forecasts between regions or between agencies within the same region in a process of prioritizing state project funds. For these purposes, there was the desire to establish more consistent methodologies for travel forecasting and for more consistent use of assumptions within the models. The guidelines as they were developed and published were an attempt to specify a <u>minimum</u> acceptable standard. Caltrans encouraged that this standard would apply to all agencies throughout the State. It also was suggested that a more advanced level of acceptable practice would be expected from the four larger, more sophisticated agencies in the State that do their own transportation modeling (Los Angeles-SCAG, Bay Area-MTC, Sacramento-SACOG, and San Diego-SanDAG).

The Caltrans *Travel Forecasting Guidelines* consists of two chapters that provide guidance on travel demand modeling (Input Data & Assumptions and Travel Demand Models), one chapter on the requirements that emission inventories places on travel demand modeling (Emission Inventory Needs), and one chapter on further research that will promote improved travel demand modeling for air quality analysis (Research & Recommendations). Copies of this document are available from the Office of Travel Forecasting & Analysis in the Transportation System Information Program at Caltrans.

DATA COLLECTION IN CALIFORNIA

Another area that Caltrans has undertaken very aggressively over the years is data collection through travel surveys, conducted in a variety of ways. Using temporary local staff hired by Caltrans, the Department conducted massive home interview origin-destination surveys in the 1960's and 1970's. From 1963 to 1972, Caltrans conducted 12 separate home interview surveys up and down the State. With a 20% sampling rate, some 3,100 households were interviewed in Eureka and over 33,00 households were interviewed in Los Angeles (a 1% sampling rate). Over 140,000 household were interviewed in that ten-year period, an accomplishment that today is not only fiscally unfeasible but also

logistically impossible.

From 1976 to 1980, Caltrans covered the State again with another, yet much smaller, Statewide Travel Survey update. The last Statewide Travel Survey was conducted in 1991, by a consultant, and data were collected from some 15,000 households throughout the State, with a minimum of 500 samples in any one region. With such small samples (compared to 20-30 years ago), the survey was primarily used to update trip generation rates. As the new millennium approaches, efforts are underway to acquire funding for a Year 2000 Statewide Travel Survey to once again update the statewide database.

Current activities are underway in California for a data collection effort that includes a Truck Travel Survey. It is anticipated that trucks will be surveyed for origin-destination information at major border crossings, weigh stations, and at major interregional screenlines. This survey that will establish a new database for interregional truck travel in California and will be the basis for development of a truck travel model which is sorely needed in the State.

THE FUTURE OF MODELING IN CALIFORNIA

Now that virtually all of the regional transportation planning agencies in California are doing their own travel forecasts and not relying on Caltrans to do the modeling for them, the focus of the Department has changed. Caltrans has always been research-oriented in reference to modeling systems. The Department is now specifically focusing on models related to operational improvements and intelligent transportation systems as well as an integration of GIS into travel demand modeling systems.

A few years ago a travel demand and simulation modeling contract was executed by Caltrans to improve methods for forecasting mode shift, route diversion, and mobile source emissions that result from the implementation of high occupancy vehicle (HOV) lanes and other freeway operations strategies. The primary goal of that project was to develop an analytical tool that would improve upon the sensitivity and accuracy of then currently available transportation modeling software used for predicting impacts of HOV facilities. These impacts included changes in operational characteristics such as speed and congestion, emissions, and fuel consumption. The analytical tool that was developed was a model framework that integrated a regional planning model with a freeway simulation model (FREQ) and an emissions model (the Direct Travel Impact Model, DTIM). The resultant CALINK software produced a direct linkage between freeway simulation software and transportation planning software packages. The current emphasis on traffic simulation modeling systems is directed toward such models as CORSIM, FRESIM, NETSIM, INTEGRATION, FREQ11, FREQ12 (in development), and PARAMICS. A training project was just recently completed with the University of California at Berkeley where 28 Caltrans staff members were provided with in-depth technical training in the use of these analytical tools. Additional training courses are being developed for attendance by more Caltrans modelers and traffic engineers as well as for regional agency staff. Expanding to this type of modeling is an attempt by Caltrans to keep up both with the state-of-the-practice and the state-of-the-art in the technical areas related to travel demand modeling and travel forecasting.

The Rhode Island Statewide Travel Demand Forecasting Model

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INTRODUCTION

Purpose

The Rhode Island Statewide Travel Demand Forecasting Model (henceforth referred to as the RI State Model) was prepared by Louis Berger & Associates (LBA) under contract to the Rhode Island Department of Transportation. The RI State Model facilitates the State of Rhode Island's compliance with air quality and congestion management requirements set forth by the 1990 Clean Air Act Amendments (CAAA) and the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991. The initial use of the RI State Model was to evaluate Rhode Island's Transportation Improvement Program (TIP) to determine project conformity to requirements of the CAAA. Later the model was used in different studies such as corridor planning, traffic management, strategic planning, high occupancy vehicle (HOV) studies, testing of travel demand management (TDM)/transportation system management (TSM) strategies, project level modeling, testing landuse scenarios and other congestion management system (CMS) strategies.

Features

The RI State Model was developed using TransCAD, a Geographic Information System (GIS) software package for planning, management, operation, and analysis of transportation systems and facilities. TransCAD is capable of directly reading many data files (e.g., STF 3A, PL94-171, and TIGER/Line files), thus allowing the street database, area database, and much of the 1990 socioeconomic data to be imported directly from these sources.

The RI State Model is a multi-modal model with highway, transit, and high-occupancy vehicle (HOV) components. It consists of nearly 1000 traffic analysis zones, thus allowing statewide as well as subarea transportation projects to be modeled. To facilitate long-range transportation planning, the RI State Model contains data for five years: 1990, 1996, 1999/2000, 2010, and 2020. Information for all five years is contained in one database allowing for powerful and convenient data analysis and management. Socioeconomic data, roadway attributes, and the network itself can be modified to evaluate land use and roadway alternatives. Peak hours and off-peak hours can be modeled.

In addition to projecting travel demand, the RI State Model produces projections, stratified by functional classification, of vehicle-miles traveled (VMT), and vehicle-hours traveled (VHT). This data can be used with *Mobile 5.0A*, a mobile source inventory model for emissions analysis.

Software for the Model--TransCAD

Preceding development of the RI State Model, several software packages were assessed as possible platforms for development of the RI State Model. Each of these software was examined relative to a common set of evaluation criteria. The evaluation process led to selection of TransCAD as the software

for developing the RISM. TransCAD also provides ready compatibility with the Rhode Island Department of Administration, Division of Planning (RIDOA/P) data sources and analyses because of their use and application of TransCAD's geographic informational system (GIS) functions.

TransCAD's Geographic Information System (GIS) capabilities were more attractive and suitable to the needs of this project than many any other complex transportation modeling capabilities. TransCAD helps transportation professionals store, display, manage, and analyze transportation data. Information on transportation networks, freight flows, routes, schedules, traffic analysis zones, and transportation system performance can be stored, displayed, and analyzed at any spatial scale with ease.

Trip Generation

Four trip generation models were tested for the RI State Model. Three basic criteria were used to evaluate the alternative trip generation models:

1. accuracy in representing existing activity,
2. predictive power, and
3. relative ease in forecasting the required input variables.
4. The final trip generation model used the following socioeconomic variables in the enactions: population, employment and auto registration.

Calibration

Calibration was performed in two stages: in the first stage, cordon line and cut line calibration was performed in accordance with *Calibration and Adjustment of System Planning Models,* Federal Highway Administration, December 1990. In the second stage, detailed link volumes were calibrated with the SPME procedure in TransCAD. The guidelines provided in the FHWA report "Calibration and Adjustment of System Planning Models" was used to measure model effectiveness.

Forecasting

Future year forecasts were based on a simple Fratar process. Since the Fratar process is based on factoring, growth factors from 1990 to 1996, 1999/2000, 2010, and 2020 had to be defined for each zone. For the internal zones in the study area, the growth factors were based on changes in auto registrations and employment at the zonal level. The external station growth factors were based on historic traffic growth. The future year socioeconomic data were then used with the trip generation equations to obtain zonal growth factors for each forecast year. The Fratar model in TransCAD was then applied to the base year 1990 calibrated trip table to arrive at forecast year trip tables. Also, the design engineers often preferred the growth factors for each TAZ to future year volumes obtained from detailed traffic assignments. Hence, a matrix of growth factors for different forecast years for each town was created.

Applications of the Model

The RISM was applied in several projects in a regional as well as statewide level to test and

demonstrate its potential uses. Some of the projects and the type of application in which the model was used are given below:

- Air Quality Analysis--Conformity Analysis
- East Providence Case Study--Corridor Planning
- Washington Bridge Case Study--Traffic Management
- Combination of Projects--Strategic Planning
- Moshassuck Case Study--Test Land Use Scenarios
- Route 10 Upgrade Project--HOV Modeling
- Apponaug Circulator Project--Project Level Modeling

Coordination with Rhode Island Agencies

Throughout the course of the contract, LBA coordinated extensively with the Rhode Island Department of Transportation (RIDOT), the Division of Intermodal Planning, and the Rhode Island Department of Administration, the Division of Planning (RIDOA/P). Extensive coordination meetings provided both agencies with the opportunity to review the model in its developmental stages. Accordingly, as work by LBA progressed, revisions were made to the RI State Model to address the needs of both agencies.

Model Documentation

LBA also prepared an extensive documentation of the RI State Model. The document provides detailed documentation of the model; its development; data used in model preparation; the sources of that data; any assumptions used in model preparation; and the results of alternative tests conducted during model development. Appropriate chapters also include a discussion of the relevant TransCAD procedures used and clarifications and/or corrections to the step-by-step process for those procedures provided in the TransCAD users' manual and/or in supplements provided by Caliper Corporation entitled *TransCAD Reference Manual, Version 2.0*.

MODEL DESCRIPTION

Modeled Area

The Rhode Island Statewide Travel Demand Forecasting Model (RI State Model) includes the entire state of Rhode Island (including New Shoreham) as well as municipalities which border Rhode Island in Massachusetts and Connecticut. There are a total of 62 municipalities in the RI State Model. Table 1 shows the list of municipalities included in the RI State Model.

Municipalities in Massachusetts and Connecticut adjacent to Rhode Island were included in the RI State Model for three main reasons:

- to capture work trips into Rhode Island from these municipalities,

- to capture all trips between the municipalities on either side of the Rhode Island state lines, and in an attempt to limit the number of external cordon stations.

Roadway Network

In Rhode Island, the RI State Model includes all roads that are part of the Federal-Aid System. This portion on the roadway network of the RI State Model was created using the Rhode Island Geographic Information System (RIGIS) database did not contain interchange configurations. Therefore, interchange configurations for all interstates, freeways, and expressways were coded based on information provided by the Rhode Island Department of Transportation (RIDOT) and based on street maps of Rhode Island. Roadway attributes, i.e. speed, capacity, direction, and number of lanes, were assigned to roadways based on functional classification. Supplementary functional classification information for additional links was obtained from *State of Rhode Island Federal-Aid Systems*, prepared by the Rhode Island Department of Transportation in June 1985.

The roadway network for municipalities in Massachusetts and Connecticut was constructed based on U.S. Census TIGER/Line data. The coverage in Massachusetts and Connecticut consists of all roads classified as state highways and higher. Roadway attributes, i.e. speed, capacity, direction, and number of lanes, were assigned based on functional classification.

Zone Structure

Traffic analysis zones (TAZs) in Massachusetts and Connecticut coincide with 1990 U.S. Census tracts. TAZs in Rhode Island coincide with 1990 U.S. Census block groups. This zone structure was selected for the following reasons:

- the ease of importing data from the 1990 U.S. Census data products (e.g., STF 3A, CTPP, etc.) at this detailed level,
- the ability of the hardware and software of present-day micro-computers to analyze a large amount of data both accurately and efficiently,
- to improve the accuracy of VMT estimates by creating small TAZs, and
- to minimize the need to further sub-divide TAZs for sub-area or project-level modeling, there-by allowing greater consistency with the RI State Model.

The internal TAZ structure follows 1990 block group geography in Rhode Island and 1990 census tract geography in Massachusetts and Connecticut. There are a total of 971 TAZs in the RI State Model: 892 are located in Rhode Island, 61 are located in Massachusetts and 18 are located in Connecticut.

External stations, demarcated by a triangle, were created for all major roadways serving trips into and out of the RI State Model study area. Roadways classified as State Highways or higher were chosen as external stations. A total of 36 external stations were identified. Table 2 lists the attributes stored in the TAZ layer of the database.

SOFTWARE EVALUATION

Preceding development of the Rhode Island Statewide Travel Demand Forecasting Model (RI State Model), several software packages were assessed as possible platforms for development of the RI State Model. This review was conducted for the following modeling packages:

- TRANPLAN
- MINUTP
- QRSII for Windows
- TransCAD

Each of these models was examined relative to a common set of evaluation criteria. These criteria included:

- ease of use of the model and transferability to Rhode Island Department of Transportation (RIDOT) with minimal training,
- the inclusion within the model configuration of multiple travel mode analyses,
- the relative ease with which existing data and databases can be accepted by each of the models,
- the comprehensiveness and clarity of the model's documentation relative to its application to a range of simulation conditions, and
- the inclusion in the model of input and output display functions and capabilities.

After detailed review and assessment of the above software, it was recommended to RIDOT by LBA that the RI State Model utilize the TransCAD software package. The additional considerations leading to this recommendation included:

- TransCAD has the necessary capabilities to simulate the state-wide network and has the flexibility to incorporate additional computational model elements that can function on the existing networks and databases.
- TransCAD provides accessibility to a significant array of databases including TIGER/Line and other U.S. Census data files.
- TransCAD provides ready compatibility with the Rhode Island Department of Administration, Division of Planning (RIDOA/P) data sources and analyses because of their use and application of TransCAD's geographic informational system (GIS) functions.

TransCAD is a Geographic Information System (GIS) that helps transportation professionals store, display, manage, and analyze transportation data. Information on transportation networks, freight flows, routes, schedules, traffic analysis zones, and transportation system performance can be stored, displayed, and analyzed at any spatial scale. TransCAD provides:

- Broad end-user access to transportation and related geographic data;
- A full-featured GIS with extended data models to support transportation planning and travel demand modeling;

- Tools for presenting and visualizing transportation data; and
- A powerful applications development capability.

SOCIOECONOMIC DATABASE

Much of the 1990 socioeconomic data needed for the trip generation equations was obtained from the 1990 Census of Population and Housing conducted by the Bureau of the Census, U.S. Department of Commerce. The following is a list of the 1990 U.S. Census data products from which 1990 socioeconomic data was extracted for use in the Rhode Island Statewide Travel Demand Forecasting Model (RI State Model):

The following socioeconomic variables from the TAZ layer area database were used in the modeling process: population, vehicle registration, retail employment, and non-retail employment. In addition, other socioeconomic variables such as total households, dwelling units, auto availability, and autos per household were also included in the TAZ layer for analysis, future reference, and to test various trip generation models. Data for these additional variables were included in this database for the year 1990 only. All other socioeconomic variables were included in this database for the base year 1990, and the four forecast years: 1996, 1999/2000, 2010, and 2020. These socioeconomic variables were used in the trip generation equations.

HIGHWAY NETWORK DATABASE

The network database was created using the database provided by RIGIS (Rhode Island Geographic Information System). The RIGIS database was digitized in ARCINFO using USGS maps, RIDOT county maps, and 1988 aerial photographs. This database was imported into TransCAD using the ARCXLATE utility. The following node and link attributes were available from this database:

NODE LAYER------ID, Longitude and Latitude

LINK LAYER------ID, Length, Road Class, Functional Class, Road Name, Route Number, Town, MCD and County

TRAFFIC VOLUMES

Several data sources were used to compile the traffic volumes in the network database. These include:
- Data from permanent count stations;
- Data from 1990 Traffic Flow Map from RIDOT; and
- Data from special count stations throughout Rhode Island.

CORDON TRIP TABLE

Calibration and Adjustment of System Planning Models, published by the Federal Highway Administration in December 1990, provides a means of identifying the approximate percentages of all external trips that are external-external trips based upon the urban area population.

The external-external trip table was estimated using a gravity model. The distribution was based upon the relative volumes at the external stations. The relative separation, distance, and friction factors between the stations were not considered.

TRIP GENERATION

Four trip production models were tested for the RI State Model. Three basic criteria were used to evaluate the alternative trip generation models:

1. accuracy in representing existing activity,
2. predictive power, and
3. relative ease in forecasting the required input variables.

It is essential that the trip generation models accurately reflect existing zonal activity. Factors influencing trip generation include vehicle ownership, population, household size, income, and employment. Verifying which factors had indeed the greatest influence on transportation activity in Rhode Island was the first step in validating the trip generation equations. By using the journey-to-work data at the block group level for modifying trip rates and calibrating coefficients, validation is already embedded for HBW trips. However, no other data sources were available for evaluating other trip purposes, therefore, model calibration was relied upon for final validation.

The ability of the trip generation models to accurately forecast trips into the future was also considered. Historic growth in trip ends was compared against historic traffic volume growth to determine how well the models reflect transportation activity over time. Traffic counts obtained from the Rhode Island Highway Performance Monitoring Station (HPMS) traffic volume count database were used for this purpose.

Selected Trip Generation Model

The final analysis allow the following conclusions: a) the NCHRP trip generation rates need to be adjusted to account for the recent travel demand characteristics, b) the use of auto registrations as one of the independent variables appears to be appropriate as they are not only correlated to the historic traffic growth trends, but also are relatively easy in terms of data collection. Consequently, auto registration was used as one of the independent variables in the final trip generation model. The other variable included in the final trip generation model is population. Use of a trip generation model to estimate person trips using only auto registration was deemed inappropriate and potentially inaccurate. A final trip generation model using population, employment and auto registration was implemented in the RI State Model. The trip production and attraction equations used in this model are shown below:

Trip Productions =
4.02*(Auto Registrations)
+ 0.91*(Population)

HBW Attractions =

1.7*(Total Employment)

HBNW Attractions =
10.0*(Retail Employment)
+ 0.5*(Non-Retail Employment)
+ 0.39*(Population)

NHB Attractions =
2.0*(Retail Employment)
+ 2.5*(Non-Retail Employment)
+ 0.20*(Zonal Population)

In order to model external-internal trips, cordon trip productions and attractions must also be defined. The cordon productions were defined as the total volume count at the external station for each of the 36 external zones. The cordon attractions were computed using the following equation developed by the Michigan Department of Transportation Travel Demand Analysis Section:

Cordon Trip Attractions =
67 + 2.28*(Retail Employment)
+ 0.5*(Non-Retail Employment)
+ 0.08*(Population)

TRIP DISTRIBUTION

The traditional Gravity Model was used to distribute trips among traffic analysis zones.

$$T_{ij} = P_i \frac{A_j F_{ij} K_{ij}}{\sum A_j F_{ij} K_{ij}}$$

Mathematically, the gravity model is formulated as follows:
where:

T_{ij} = number of trips produced in zone I and attracted to zone j

P_i = number of trips produced by zone I

A_j = number of trips attracted to zone j

F_{ij} = travel-time factor

K_{ij} = specific zone-to-zone adjustment factor

In order to apply the gravity model, the travel times between each zone and the friction factors for each trip purpose are required in addition to the trip generation results. Travel Time Matrix was developed by computing the travel times between each TAZ pair. Computation of travel times are typically based on the shortest path method using free flow speed, distance between zones and terminal times at the zones as input.

Friction Factors by Trip Purpose

Due to the lack of availability of trip length data, the friction factors were initially developed based on data from NCHRP Report # 187. These friction factors are currently available within TransCAD. However, during model calibration, these initial friction factors were fine-tuned . One method of fine tuning home based work trips is to use the work distribution data from the Census Transportation Planning Package (CTPP). However, it was deemed important to maintain the relationship between the four trip types for the RI State Model. Therefore, rather than skew only the home based work trips based on the CTPP data, the CTPP trip distribution data was not used. All four trip types were adjusted in the same manner.

MODE CHOICE MODEL

Mode Choice Analysis

The mode choice model for an area is developed to determine the number of trips using different modes of travel (auto, transit etc.). The ultimate goal of this analysis in our study area was to determine the percent split of travel between transit and auto. As mentioned earlier transit service in the state of Rhode Island is provided by Rhode Island Public Transportation Authority (RIPTA) serving most of the state. The methodology used in the analysis was developed by the U.S. Department of Transportation, and it is discussed in the following sections.

The mode choice model utilizes transit and auto disutilities to calculate the percent split between the two modes. The transit disutility is formulated as shown in the following equation:

Disutility
= (access time) (walk weight)
+ (wait headway) (wait weight)
+ (wait penalty)
+ (riding time)
+ (transfer penalty)
+ (transfer headway)
(transfer weight)
+ (egress time) (walk weight)
+ (fare/value of time)

TRAFFIC ASSIGNMENT

User Equilibrium Assignment

User equilibrium on a transportation network occurs when no trips can be made by an alternative path without increasing the total travel time of all trips in the network. The assignment process consists of an iterative series of all-or-nothing traffic assignments with an adjustment of travel times reflecting delays encountered in the associated iteration. The traffic volumes from each assignment after the first iteration are combined with the volumes from the previous iteration in such a way as to minimize the travel impedance (travel time) of each trip and thus reducing the number of iterations to find the equilibrium volumes. Equilibrium assignment is multi-path because the final link volumes are a linear combination of the all-or-nothing volumes from each iteration.

The travel time adjustment based on link volumes (in order to reflect congestion delays) is performed

$$T_n = T_{n-1}\left[1.0 + \alpha\left(\frac{AssignedVolume}{PracticalCapacity}\right)^{\beta}\right]$$

using the widely used Bureau of Public Roads capacity restraint formula:
where n is the current iteration. The values alpha and beta represent a speed-flow relationship

appropriate for the facility type. For the RI State Model, standard alpha and beta values of 0.47 and 4 were used.

MODEL CALIBRATION

Calibration was performed in two stages: in the first stage, cordon line and cut line calibration was performed in accordance with *Calibration and Adjustment of System Planning Models,* Federal Highway Administration, December 1990. In the second stage, detailed link volumes were calibrated with the SPME procedure in TransCAD. Detailed discussion of the two stages are provided below:

First-Stage Calibration

In the first stage of calibration, cordon lines surrounding the study area and cut lines across critical links were established. Calibration at this stage involved running and adjusting the model until total simulated traffic flows across each of these lines matched ground counts. Although this sort of calibration can involve adjusting trip generation and distribution and other model elements, the focus here was on adjusting network speeds and capacities in order to improve the routing of assigned volumes through the network. Attributes of both roadway links and zone connector links were revised during this process.

Second-Stage Calibration

In the second stage of calibration, the Single Path Matrix Estimation (SPME) procedure in TransCAD was used to better match individual link volumes.

Model Calibration Guidelines

The FHWA report "Calibration and Adjustment of System Planning Models" provides guidelines to measure model effectiveness. These guidelines fall under the following broad categories:

- Areawide VMT
- VMT by functional class
- Distribution of VMT by functional class
- VMT per person
- Link volumes by volume groups
- Correlation coefficient
- Screenlines
- Cutlines
- Individual link volumes

The guidelines provided in the FHWA report were used to assess the model effectiveness during the calibration process.

MODEL VALIDATION AND CONCLUSION

Based on the results presented in the preceding sections, it can be concluded that the 1990 base year highway model has attained reasonable consistency with several observed statistics such as VMTs, screenline and cutline volumes, and volumes at permanent count stations. While every effort was made to adequately model flows throughout the study area, there will still be pockets where the modeled volumes could be improved to better reflect counts. Considering the size of the model, these are better handled through project level analysis. These improvements were made during the case studies phase on an as needed basis. In addition, as a validation process, 1994 VMTs were developed by interpolating between the 1990 VMTs and the 1996 forecast VMTs and compared to the 1994 HPMS based VMTs. This comparison is shown in Table 3.

TRAVEL DEMAND FORECASTS

Future year forecasts were based on a simple Fratar process. Since the Fratar process is based on factoring, growth factors from 1990 to 1996, 1999/2000, 2010, and 2020 had to be defined for each zone. For the internal zones in the study area, the growth factors were based on changes in auto registrations and employment at the zonal level. The external station growth factors were based on historic traffic growth. The future year socioeconomic data were then used with the trip generation equations to obtain zonal growth factors for each forecast year. The Fratar model in TransCAD was then

applied to the base year 1990 calibrated trip table to arrive at forecast year trip tables. Also, the design engineers often preferred the growth factors for each TAZ to future year volumes obtained from detailed traffic assignments. Hence, a matrix of growth factors for different forecast years for each town was created.

CASE STUDIES

The Rhode Island Statewide Travel Demand Forecasting Model (RI State Model) was used in several case studies to demonstrate its use and applications. These case studies are listed below:

The Air Quality Conformity Analysis

This case study evaluated projects on Rhode Island's Transportation Improvement Plan (TIP) for conformity with the 1990 Clean Air Act Amendments (CAAA) and the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991. This case study examined the entire State of Rhode Island.

Metacolm Avenue

This case study examined the effects of this project on the county.

East Providence

This case study used the RI State Model to evaluate the effects within a municipality due to proposed roadway improvements. The two projects under consideration were Waterfront Drive and the Henderson Bridge Connector.

Washington Bridge

The RI State Model was used to test the effect of lane restrictions on an interstate highway and the resulting traffic diversion during peak periods of travel.

Moshassuck Valley Industrial Highway

This case study evaluated the effect that completion of an industrial highway and the resulting land use changes would have on traffic volumes and travel patterns in the immediate area.

Combination of Projects

This project evaluated combination of several projects on a statewide level for strategic planning and policy making purposes.

Route 10 Upgrade Project

The RI State Model was used to model alternatives involving HOV lanes on Route 10.

Apponaug Circulator Project

This case study involved the using the RI State Model for project level analysis. A small subarea was extracted from the statewide model to build a new model for the Apponaug Circulator study area.

FUTURE ENHANCEMENTS

The Rhode Island Statewide Travel Demand Forecasting Model(RISM) has been calibrated successfully as per the RIDOT's requirement for ISTEA and Clean Air Act Amendment of 1990. However, we anticipate that some of the features and aspects of the model should be refined and enhanced to meet the growing demand for more detailed air quality analysis and evaluation of congestion, operational improvements and economic feasibility for various highway and non-highway projects. Also, the assumptions made due to unavailability of data while developing the RISM could also be tested and confirmed with the proposed enhancements to the model for truck trip table estimation, mode choice/HOV model development, peak hour models etc. The following are some of the proposed refinements and enhancements for the RISM:

Integration with HPMS

Integration of the RISM with HPMS would allow a continuous update of traffic volumes and speeds on the highway network. This has the dual advantage of calibration of the model with respect to traffic volumes as well as with speed, which would be good for air quality analysis.

Peak Hour Models

The peak hour models in the RISM need to be fully calibrated to link and turning movement volumes. The current peak hour models in the RISM could only be used for studies which involve comparison of various alternative project options.

Truck Trip Table/Freight Modeling

Additional enhancement to the RISM could be done by using the existing RISM database for freight modeling. This could be especially useful for tracking and analyzing the flow of different commodities by mode, generate a statewide truck trip table as well as forecasting future truck traffic. The truck movement estimation would be extremely useful in developing truck routes and restriction, pavement management systems, air quality analysis and other planning processes.

Integration with Different Management Systems

Enhancement to the RISM could be made by integrating it with different management systems used by the state. A GIS based model such as RISM is particularly suitable for storing and retrieving data spatially and can be a valuable asset for several management systems like Safety, Pavement and Congestion Management Systems.

Transit/HOVModel

The mode choice model in the RI state model was calibrated on the basis of statewide average share of autos and transit rather than calibrating it by individual link or roadway segment. Hence, a more detailed calibration of the mode choice model would be necessary before it is used for any serious application. There is a need for differentiating person trips from auto and transit trips for calibration as well as evaluation of different transit projects. To facilitate HOV lane modeling, it is also necessary to estimate the drive alone, two plus and three plus vehicle occupancy trips. Even though the RISM database consists of RIPTA, Rail and Water network, the mode choice model considers only the personal automobile and RIPTA mode. Hence, other non-highway modes of transportation such as Rail and Water could also be easily incorporated into a more comprehensive multi-mode choice model. A calibrated multi-modal RISM would allow simulation of different non-highway projects and its effect on all modes of transportation in the state.

MODEL DOCUMENTATION

LBA also prepared an extensive documentation of the RI State Model. The document provides detailed documentation of the model; its development; data used in model preparation; the sources of that data; any assumptions used in model preparation; and the results of alternative tests conducted during model development. Appropriate chapters also include a discussion of the relevant TransCAD procedures used and clarifications and/or corrections to the step-by-step process for those procedures provided in the TransCAD users' manual and/or in supplements provided by Caliper Corporation entitled *TransCAD Reference Manual, Version 2.0.*

Table 1 Municipalities Included in the RI State Model

Rhode Island				
Barrington	Jamestown	Cranston	North Smithfield	Exeter
Bristol	Little Compton	Cumberland	Pawtucket	Narragansett
Warren	Middletown	East Providence	Providence	New Shoreham
Coventry	Newport	Foster	Scituate	North Kingstown
East Greenwich	Portsmouth	Glocester	Smithfield	Richmond
Warwick	Tiverton	Johnston	Woonsocket	South Kingstown
West Greenwich	Burrillville	Lincoln	Charlestown	Westerly
West Warwick	Central Falls	North Providence	Exeter	
Massachusetts				
Webster	Blackstone	Wrentham	Attleboro	Swansea
Douglas	Bellingham	Plainville	Seekonk	Somerset
Uxbridge	Franklin	North Attleboro	Rehoboth	Fall River
Millville	Westport			
Connecticut				
Thompson	Killingly	Voluntown	Stonington	North Stonington
Putnam	Sterling	Plainfield		

Table 2 TAZ Layer Attributes

Field No.	Name	Description	Field No.	Name	Description
1	ID	Zone ID	26	CAP_ACTUAL	Actual zonal captivity (transit)
2	Area	Zone area	27	PROD-CTPP	CTPP productions
3	Name	Municipality name	28	VREG-10	2010 Auto registrations
4	TAZ Label	Zone label number	29	POP-10	2010 Population
5	NTYPE	Node type (C=Centroid, E=External)	30	RET-10	2010 Retail employment
6	HH-90	1990 Households	31	NRET-10	2010 Non-retail employment
7	DU-90	1990 Dwelling units	32	PROD-10	2010 Total productions
8	AUTOS-90	1990 Census vehicle availability	33-40	2010	2010 Trip generation results
9	VREG-90	1990 Auto registrations	41	1990 TRIPS	1990 Total trips
10	POP-90	1990 Population	42	2010 TRIPS	2010 Total trips
11	AUTO/HH	1990 Autos per household	43	FACTOR-10	Growth factor from 1990 to 2010
12	RET-90	1990 Retail employment	44-56	1996	1996 Data, trip generation results
13	NRET-90	1990 Non-retail employment	57	1996 TRIPS	1996 Total trips
14	NODE_ID	Node ID for data transfer to node layer	58	FACTOR-96	Growth factor from 1990 to 1996
15	HBWP-90	1990 Home-based work productions	59-71	1999/2000	1999/2000 Data, trip generation results
16	HBWA-90	1990 Home-based work attractions	72	1999 TRIPS	1999 Total trips
17	HBNWP-90	1990 Home-based non-work productions	73	FACTOR-99	Growth factor from 1990 to 1999
18	HBNWA-	1990 Home-based non-	74-	2020	2020 Data, trip

	90	work attractions	86		generation results
19	HBOP-90	1990 Home-based other productions	87	2020 TRIPS	2020 Total trips
20	HBOA-90	1990 Home-based other attractions	88	FACTOR-20	Growth factor from 1990 to 2020
21	NHBP-90	1990 Non-home based productions	89	2010 MTRIPS	2010 Total trips - Moshassuck case
22	NHBA-90	1990 Non-home based attractions	90	GROWTH-M10	Growth factor from 1990 to 2010 - Moshassuck case
23	PROD_DU	Production disutility (transit)			
24	ATTR_DU	Attraction disutility (transit)			
25	CAP_MODEL	Adjusted zonal captivity (transit)			

Table 3 1994 VMTs by Functional Classes

Func. Class	1994 Model VMTs	Rep. 1994 VMTs	% Diff.	Description
0	1,506,070	2,346,000	-35.80	Centroid Connectors
1	492,020	788,000	-37.56	Interstate Highways - rural
2	585,514	538,000	8.83	Principal Arterial - rural
6	364,660	403000	-9.51	Minor Arterial - rural
7	367,755	463,000	-20.57	Major Collector - rural
8	188,458	158000	19.27	Minor Collector - rural
11	4,260,590	4,155,000	2.54	Interstate Highways - urban
12	2,206,610	1,839,000	19.98	Other Freeways and Expressways - urban
14	5,243,050	5,663,000	-7.41	Principal Arterial - urban
16	2,674,410	1,881,000	42.18	Minor Arterial - urban
17	1,695,250	1,200,000	41.27	Collector - urban
TOTAL	19,584,400	19,434,000	0.77	Statewide

Michigan's Statewide Travel Demand Model

Richard Nellett, Garth Banninga, Cory Johnson, Lyle Witherspoon and Lawrence Whiteside, Michigan Department of Transportation

ABSTRACT

Michigan's Statewide Travel Demand Model

The Travel Demand and Intermodal Services Section (TDIS) of Michigan's Department of Transportation (MDOT), is responsible for the development, maintenance and application of the Statewide Travel Demand Model. Michigan's Statewide and Urban Travel Demand Models are intended to provide the analytical framework for assessing transportation system performance and deficiency analysis, long range plan development, systems level project analysis, as well as to provide the spatial analytical framework for many of the management systems.

The Statewide Travel Demand Model resides on the TransCAD 3.1 GIS / Travel Demand Model platform. TransCAD, a licensed product of the Caliper Corporation, is a Geographic Information System (GIS) with travel demand analysis capabilities.

This paper and presentation will outline the organizational and modeling processes within the State of Michigan. The statewide model includes 2307 instate zones and 85 outstate zones, a line data base with more than 13,000 highway links, and 8,000 nodes. The model is person trip based and has capabilities to forecast travel for all motorized ground transportation. Additional features include a truck model which estimates flows by commodity group and a local transit sketch planning model.

BACKGROUND

Paper Objectives

The purpose of this paper is to outline the institutional and historical context for Travel Demand Modeling in Michigan, to identify the source of the data used in model development, to illustrate the Statewide Model's Structure, and to discuss its relationship to the urban models and the Department's Management Systems.

Institutional Context

MDOT's Bureau of Transportation Planning (BTP) has 198 employees and is responsible for data monitoring, travel demand modeling, planning and programming, early preliminary engineering, environmental assessments and policy development. TDIS, a section of BTP, employs 24 full time people and is responsible for travel demand modeling and intermodal services. Of these 24 employees, 11 are in the Intermodal Services Unit, 7 are in the Urban Travel Analysis Unit, and 5 are in the Statewide Model Unit. The remaining 2 section staff are administrative.

The department is going through a transition period relative to organizational structure. Decentralization, early retirements, staff replacement, downsizing and out-sourcing are significant issues impacting the

modeling process.

MDOT's Strategic Leadership Team has aggressively embraced the open systems concept and has engaged in extensive public and private partnerships to implement nine Transportation Management Systems (TMS). These systems include the original six ISTEA mandated systems; Bridge, Pavement, Congestion, Public Transportation, Intermodal, and Safety. Three additional systems, Construction, Real Estate and Maintenance will also be developed. MDOT’s Management System is a single TMS with nine components. The TMS system is characterized by shared data, a common referencing system with a consistent user interface and decision support tools.

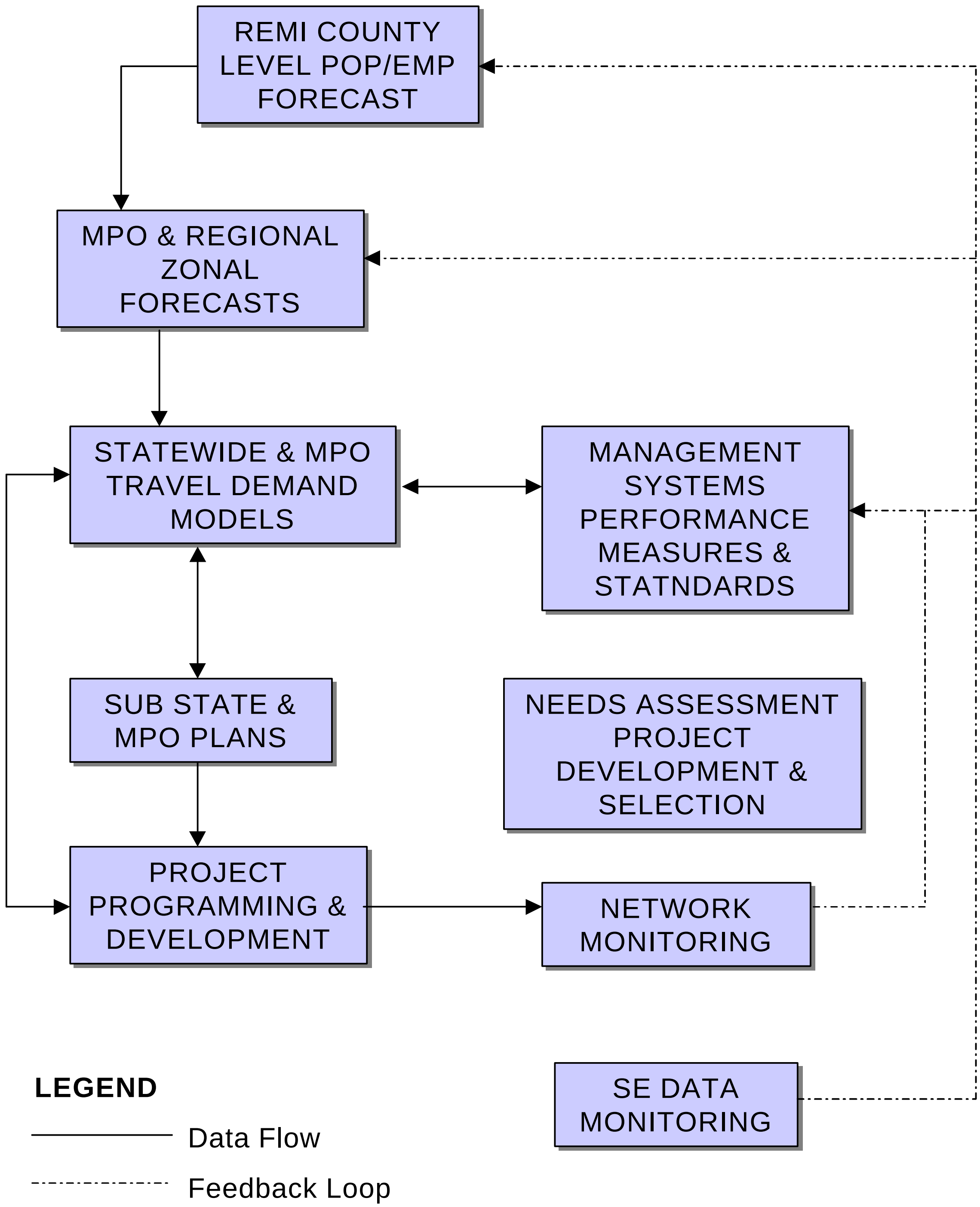
History

Travel demand forecasting has a long history at MDOT. MDOT began using travel demand forecasting tools in the sixties when they developed a Statewide Travel Demand Model with 547 zones along with a number of urban models. The statewide model had a direct demand structure that estimated motor vehicle trips based on the population within a zone and the proximity and population of adjacent zones. K factors and VMT per capita adjustments were used to arrive at a reasonable estimate of total travel and ensure proper zone to zone interchange. The original models were maintained on a Burroughs mainframe computer and, with the exception of the Detroit MPO, were maintained by MDOT. Several major weaknesses of the first statewide model included the inability to estimate the impact of changes in employment on trip making and a lack of sensitivity to changes in the population profile. Further the model was highly deterministic, relying on historical trends in VMT growth.

During the 1970's the Statewide 547 Zone Rural Travel Demand Model was upgraded to provide modal analysis capabilities and was used to develop rural subarea, regional and corridor planning studies in the eighties. The fifteen urban area models were reconfigured in the 1970's to use the National Cooperative Highway Research Program (NCHRP) 187 trip generation rates, and were converted to the TranPLAN format in the early nineties. The Statewide Travel Demand Model was re-engineered through a consultant contract in 1994, into a 2392 zone, PC based, multi-modal model that uses the GIS and modeling capability of the TransCAD software. The primary issues that directed that effort were:

- No major new data collection effort
- Should be integrated with urban models
- Include all ground based motorized person trips
- Provide for rail passenger and intercity bus service analysis
- Include a truck travel component
- Have local transit analysis capabilities
- Demand is sensitive to demographic changes
- Transit demand is responsive to service changes
- Upgradeable with improved data
- GIS based

Urban/Statewide Modal Application Process



TRAVEL DEMAND AND MODELING AND THE MDOT’S BUSINESS PROCESSES

The statewide and urban travel demand models and associated data bases are an integral component to the department’s business process. They quantify the change in the number of customers, their characteristics and their distribution within the state. They estimate the travel demand impacts of changes in the customer base to the state’s transportation systems. The model VMT forecasts are an input into forecasts of motor vehicle fuel taxes. The model’s data bases provide the customer profile and travel demand components to the management system. Further the models establish a base line for deficiencies or needs relative to system performance and test the potential impact of changes in the customer base or the transportation system on overall system performance.

Exhibit 1 illustrates the technical processes that support the policy development and investment decision making process.

ACTORS AND ROLES IN THE PLANNING AND MODELING PROCESS

The major players in the planning and modeling process include MDOT, the Metropolitan Planning Organizations (MPO's), the State Planning and Development Regions, and the Rural ISTEA Task Forces.

MDOT is responsible for the Statewide Model, ten small urban area travel demand models (population less than 200,000), six management systems, air quality conformity analysis in rural and small urban areas, coordination of the technical and planning processes in all urban areas, the Sub State Plans, the State Long Range Plan and the State Transportation Improvement Program (STIP).

The small urban area MPO’s, jointly with MDOT, develop Long Range Plans and Transportation Improvement Programs (TIP’s).

The Five Transportation Management Areas (urban areas with population more than 200,000) are responsible for travel demand models for their respective areas, as well as the urban area long range plan, air quality conformity analysis and the urban area’s transportation improvement program. MDOTworks closely with the MPO staff during model development and applications and is an active participant on their Technical and Policy Committees.

Working with the MPO’s and MDOT, the State Planning and Development Regions are responsible for coordinating the development of the socio-economic data bases, the local network data bases, and assisting with public involvement outside of the urbanized areas.

The Rural ISTEA Task Forces, which contain the rural transportation service providers, are responsible for the selection of federally funded local rural projects for the STIP.

Hardware Used for Statewide Modeling

The Statewide Travel Demand Model is currently run on a Pentium II 400mhz, with 128 megabyte of RAM, two 7 GIG hard drives and a built in100 megabyte ZIP drive. These are the current standards for

high end users at MDOT and aren’t necessarily modeling requirements. The operating system is Windows

NT.

MODEL DATA BASES

TAZ Boundaries

MDOT has divided Michigan into 2307 Traffic Analysis Zones (TAZ's) for use in the Statewide Model. In addition, TAZ's have been defined for the rest of the United States, Canada, and Mexico, bringing the total to 2392. The number of zones in the urban models varies from 124 in the Niles/South Bend Area to 1442 in the seven County Detroit Region. Within Michigan's urban areas, the statewide zones are a combination of urban zones. In non-urban areas, the zones are typically minor civil division boundaries. In states immediatly adjacent to Michigan, county boundaries, or some combination of county boundaries are used. State or province boundaries make up zones for the remaining states and Canada. Population and employment data is gathered from the Census and other sources and aggregated or disaggregated into the individual TAZ's.

The TAZ portions of the statewide and urban models were selected from the Census Tiger line files. These files contain polygons by several levels of geography, all of which have census data available to them. The smallest level of Census geography, the census block, was used as a building-block for TAZ’s. Data that was only available at the block group level was disaggregated to the block level then re-aggregated to the zonal level. Individual census blocks were selected and aggregated to TAZ’s within the GIS component of TransCAD for all 2307 instate traffic zones. Since outstate zones never get smaller than a county, a national county GIS database was used as a base, and provinces were used in Canada. The model zone system includes all of the United States (except Hawaii and Alaska) and all of Canada plus Mexico as a single zone.

Network Inventories

The computer networks used in the modeling process were selected from the Michigan Information Resource System (MIRIS) line files, which were originally digitized by the Michigan Department of Natural Resources from USGS Quad Maps. The network inventory items include geographic information such as county name, the Physical Roadway Referencing System (PR) number, federal aid designation and functional class, the roadway type such as (freeway, two way divided uncontrolled access, two way undivided or one way), number of through lanes, lane width, area type (urban, suburban, fringe, rural), signals per mile, the ADT, percent commercial, the presence of parking as well as other characteristics. State trunkline data are from the MDOT’s trunkline sufficiency files. Local road data are from the local needs study files or from other local sources.

Current Employment Data Bases

The Michigan Employment Security Agency (MESA) provides MDOT with current employment data that is used extensively in the travel demand modeling process. Employment categories that may not be included by MESA include proprietors or other self employed individuals as well as those working solely on commission. Government employment is also not fully reported and some government employment (public schools, colleges and universities) is reported in the service sector. MESA data is available by address and by SIC code so there is a high level of detail in terms of both the type and location of

employment. Multi site employers are often a problem and special procedures are employed to adequately locate that employment. The addresses may also require significant review and cleaning by local agencies before they can be geocoded. The MESA data may be supplemented with data from local sources to provide a more comprehensive data set. The final employment data is the result of a cooperative analysis effort by MDOT, the MPOs and the Regional Planning Agencies. This data is aggregated by type and summarized by traffic analysis zones and minor civil division for use in model development. Maintaining confidentiality is an issue in the use of the data.

Forecasted Employment and Population By County

Integral to the statewide and urban travel demand modeling process is a population and employment forecast model developed by Regional Economic Models Inc (REMI). The REMI Model for Michigan has three major components relevant to the Travel Demand Models; demographic, employment and income. This county based model was developed by the REMI Corporation and calibrated for use in the statewide and urban modeling process by the University of Michigan, Institute of Labor and Industrial Relations under contract with MDOT. The U of M will update the forecast on a three to five year cycle. The population by age group is converted to Households by size and Income with a household Classification Model.

Population, Household, Employment Disaggregation

MDOT's Travel Demand and Intermodal Services Section work with the MPO's and the State Planning and Development Regions to modify the forecasts where appropriate. Once the County level control totals are established, the data is disaggregated to traffic analysis zones. In the statewide model these are typically the size of a township in very rural areas. Urban models have zones that may be as small as a block however they are more typically larger as their boundaries are generally defined by the arterial and collector street system. The statewide model zone boundaries within urban areas are generally comprised of several urban zones.

There are a number of different techniques used to disaggregate county control totals to traffic analysis zones. The seven county Detroit region (SEMCOG) uses DRAM EMPAL, a land use allocation model that considers available developable land, proximity to compatible or supporting land use categories, availability of public utilities, etc. The smaller urban areas and the regional process are more subjective. Primarily a GIS or spreadsheet processes, they take into account known development proposals, available developable land and future land use plans or trends. The local forecasts are also updated every three to five years.

URBAN AND STATEWIDE MODELS

TranPLAN and TransCAD Travel Demand Modeling Software

Urban Travel Demand Models in Michigan currently use the Urban Analysis Group's TranPLAN modeling package and most use the Caliper Corporation TransCAD GIS System as their data manager. A translation routine has been written in TransCAD's DSK language to translate files from one format to another. The Statewide Model relies on TransCAD's GIS and modeling capabilities. The Urban Models are structured to accurately model travel on the major urban arterials and collectors. The Statewide Model

is intended to model travel on the state trunkline roads outside of urban areas. The coarseness of the Statewide Model's network and zone structure within the urban areas make it unsuitable to forecast or analyze urban travel.

The basic model structure includes a network file with travel times and a traffic zone file which includes the socio - economic data required for trip generation. In addition the model includes a series of equations or formulas that predict the number of trips by purpose produced by a zone and attracted by a zone (trip generation), the trip interchange by purpose between zones (trip distribution), and the portion of those trips that are auto trips (mode choice), and the travel paths those trips will take for traffic assignment.

Typically model formulas are based on household surveys where travel and household characteristics are gathered and analyzed. The most recent survey in Michigan was conducted in 1991 in the seven county Detroit region and is the source of that model's structure. Models have also been developed from secondary sources such as the National Personal Travel Survey (NPTS). This is the source of the trip generation components of Michigan's other urban models as well as the statewide model.

Trip Generation

The Urban and Statewide Models use a cross classification model for trip generation. The statewide model uses trip rates based on household size and income. The statewide model currently uses three income levels and five household sizes. The SEMCOG Model uses household income and life cycle. The remaining urban models use households by the number of autos available. Trip attraction equations are a function of employment type by purpose. In those instances where average trip attraction rates by employment type do not adequately reflect unique trip attractors (special generators), adjustment factors are developed. These are typically recreation facilities, shopping centers, hospitals, high schools, colleges, governmental offices and heavy manufacturing centers.

Trip purposes for the Statewide Model include: home-based work / business, home-based social recreation / vacation, home-based other, non home-based work / business, non home-based other and truck travel by eleven commodity groups. The SEMCOG model trip purposes include; home based work, non home-based work, home-based work, home- based other, non home-based other, home-based shopping, and home based school. Trip purposes for the remaining urban models include; home-based work, home-based other, non home-based, cordon and through trips. Truck trips in the urban models are assumed to be included in non-home based category and the models are calibrated to an ADT.

Trip Distribution

The trip distribution component of the Statewide Model was developed from the NPTS data. A two-curve distribution process, combined with an extensive use of K factors, was required to obtain sufficient number of long distance trips and to get them to the right city pairs. A generalized cost function was also used that takes into account the impact of tolls at toll bridge crossings and future changes that the relative cost of travel will have on average trip lengths. The smaller Urban Models utilize distribution factors developed from travel surveys done in the past. The SEMCOG model utilizes data from its 1991 survey.

Mode Share

The mode share process translates total person trips into auto trips. This component typically assumes a percent auto trips by trip type to remove the transit trips then divides the number of person auto trips by an auto occupancy factor to estimate the number of auto trips. SEMCOG, Grand Rapids and Flint have more sophisticated mode share modules that look at the availability of transit to serve the trip interchange and the relative cost between auto and transit (both in terms of time and dollars) to determine the mode share before applying a vehicle occupancy factor. Modifications similar to SEMCOG are currently being made to the Ann Arbor Model. Lansing expects to modify their model as well.

The Statewide Model estimates auto trips based on household size and income, area type, trip purpose and trip length. A network based mode share model for intercity trips has been incorporated into the Statewide Model software but currently remains un-calibrated. Calibration, based on existing data, is a proposed future activity for MDOT staff.

System Level Capacities

System level network capacities are included in the network data bases. The urban models use an adaptation of the Florida process. SEMCOG uses a very simplified process. The Statewide Model uses capacities from the Departments Sufficiency file. The capacities provide input into the various assignment techniques. The capacities, in conjunction with the traffic assignment, also provide an indicator of the level of future congestion that will occur under the assumed growth scenario. They also provide a means to estimate effective speeds for use in air quality analysis. MDOT is initiating an effort to update the capacity calculation process across all model applications.

Traffic Assignments

There are numerous traffic assignment techniques available in both TranPlan and TransCAD. As a matter of policy, a modified user equilibrium assignment is used in the urban models. This is considered state of the practice if not state of the art for urban models. The term modified is used because no individual link speed is allowed to drop below 50% of free-flow speed. Because congestion is primarily an urban phenomena, the Statewide Model is calibrated using an all or nothing assignment technique. The Statewide Model software TransCAD has a full complement of capacity restraint assignment techniques which may be used in project analysis.

Goods Movement/Truck Model

Past efforts to model the flow of goods or trucks at the systems level have not been highly successful. However new efforts are being made nationally, within MDOT, and locally within the Southeast Michigan Region. The current urban process assumes truck flows are accounted for in the Non Home Based (NHB) trip category and the models are calibrated to total Average Annual Daily Travel (AADT). The statewide model has a Goods Movement/Truck Model component. Truck flows and Automobile flows are calibrated separately. The Statewide Truck Model was developed from Customs Data, MDOT truck Surveys, the US Input Output Account and the 1993 National Commodity Flow Survey. Outputs include the flow of goods in terms of tons, dollars or trucks by commodity type.

The overall Statewide Model structure is shown in Exhibit 2. The plaque shaped boxes are sub- models within the overall model structure. The other boxes represent input and output files.

Urban Rural Integration

A major issue that is important to address in a statewide modeling process is to what degree should the statewide and urban area travel models be integrated. Michigan's answer has been to integrate the two to the greatest extent possible. This first was achieved by using TransCAD as the data manager for most Urban Models. This provides a direct GIS interface between the two.

Beyond data transfer, there were a number of other related technical concerns that were addressed. The first was to develop a process to arrive at consistent socio-economic estimates and forecasts. Use of a consistent data set for calibration is relatively easy however, getting agreement on forecasts is more difficult. MDOT sponsors the development of a consistent set of population and employment forecasts through the University of Michigan (U of M). The U of M utilizes a linked set of county level population and employment models. An initial review of a preliminary set of forecasts provides local scrutiny and feedback. Adjustments can then be made by the U of M prior to the final forecasts. Further adjustments may be recommended by the local planning agencies once the final model runs are completed. This allows Michigan to reach a consensus on a reasonable and consistent set of forecasts for the urban and statewide models.

We currently use consistent trip generation rates for the statewide and most urban models. While SEMCOG has its own trip generation rates, an analysis of the results are fairly consistent with the Statewide Model.

Another means of integration is the development of nested zone structures with equivalencies to allow urban area data to be aggregated to the statewide level. Similarly, while we have different levels of detail at the network level, we are using GIS technology to pass data from the urban models to the statewide model.

The Statewide Travel Demand Model is also used to help develop "cordon" and "through" trip tables for the Urban models. This is assisted by a program, developed by the Caliper Corporation, which creates through and terminal trip tables for the Urban Models or for subarea analysis from selected links on the Statewide Model.

The department is also aggressively pursuing the completion of a common road referencing system for all roadways. This will provide the linkage between the Travel Demand Models and the management systems. We have attached this referencing system to all modeled roadways under state jurisdiction. This gives us immediate access to the most current network inventory information and allows for the transfer of model data to the management systems.

Past efforts to model the flow of goods or trucks at the systems level have not been highly successful. However new efforts are being made nationally, within MDOT, and locally within the Southeast Michigan Region. The current urban process assumes truck flows are accounted for in the Non Home Based (NHB) trip category and the models are calibrated to total Average Annual Daily Travel (AADT). The statewide model has a Goods Movement/Truck Model component. Truck flows and Automobile flows are calibrated separately. The Statewide Truck Model was developed from Customs Data, MDOT truck Surveys, the US Input Output Account and the 1993 National Commodity Flow Survey. Outputs include the flow of goods in terms of tons, dollars or trucks by commodity type.

The overall Statewide Model structure is shown in Exhibit 2. The plaque shaped boxes are sub- models within the overall model structure. The other boxes represent input and output files.

LINK TO THE MANAGEMENT SYSTEMS

Process

The Statewide Model Unit has written a file manager FoxPro program that takes adjusted model output files, calculates performance measures and other necessary information and reformats it for input into the management system. The data files are imported into an Oracle data base for use in the management system.

Network Variables

Network variables exported to the management system include: primary route numbers with beginning and ending mile points; National Functional Class (NFC); availability of transit; roadway characteristics such as signals, width, lanes, etc.; annual average daily traffic volume (AADT); commercial vehicles and peak hour volumes for each assignment network; hourly and daily capacities; level of service (LOS) for each network; years until unacceptable level of service; and free-flow speed and effective speed.

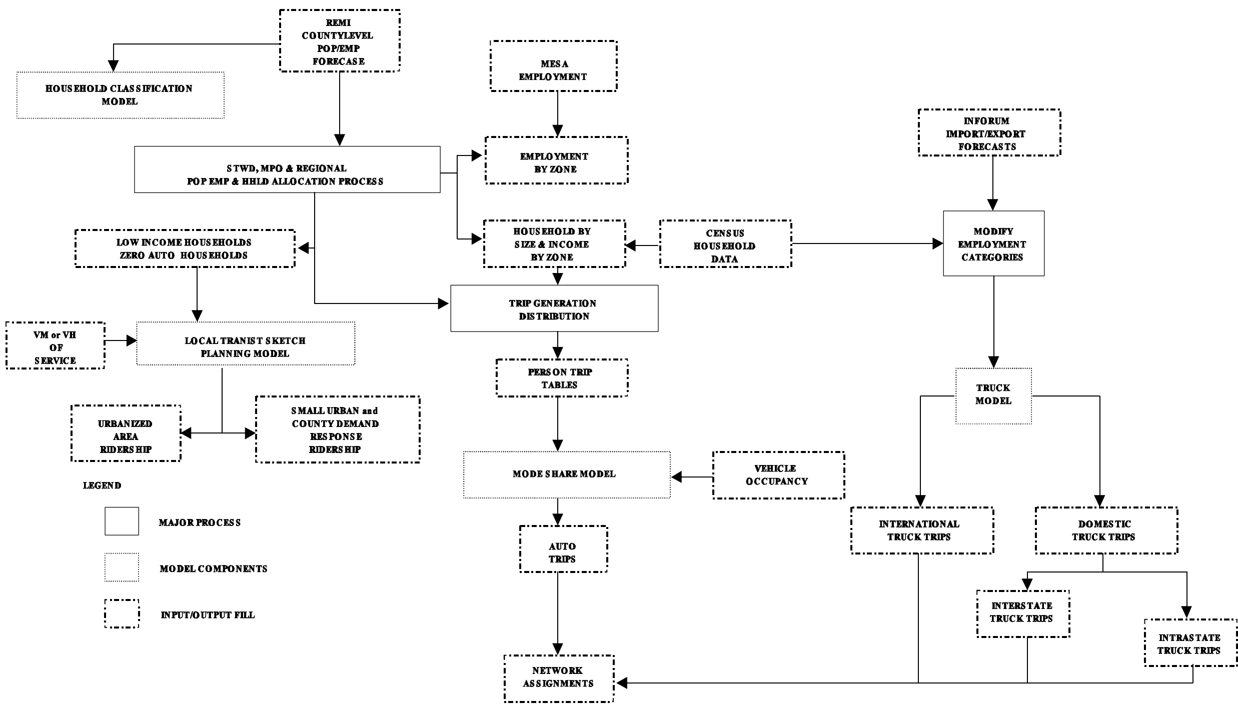
System Variables

System variables exported to the management system include vehicle miles of travel (VMT), vehicle hours of travel (VHT), person miles of travel (PMT), commercial miles of travel (CMT), deficient highway vehicle hours of service and vehicle miles of service by time period. Local transit system variables include route miles, vehicle hours of service, and annual passengers.

Zonal Variables

Zonal variables exported to the management system include population, households, a zone number, county name, average household income, autos per household, population density, manufacturing employment, retail employment, other employment.

Exhibit 2 - Statewide Model Structure



RECENT STATEWIDE MODEL PLANNING APPLICATIONS

US-131 Bypass of Three Rivers and Constantine

US-31 Bypass of Grand Haven

US-23 Freeway- Standish to Alpena

The Statewide model was used to analyze bypass, freeway and/ or local road alternatives for these projects.

US-131 Freeway Justification - Cadillac to I-75

The Statewide Truck Model was used in combination with the REMI Econometric Model to estimate the economic impact of a potential freeway improvement.

US-27 BL Access Study in Mt. Pleasant

This project, through the use of a sub area model, analyzed potential changes in access to the existing business loop from US-27. The subarea model utilized the network inventory data, the terminal and through trips and the socio-economic data from the statewide model as part of its data set. However a more detailed zone structure and network were required. TransCAD's Quick Response modeling package provided the trip generation and distribution components.

M-24 Detour Analysis

This project analyzed the traffic impacts associated with staging various road closers during construction. This project used TransCAD's sub area model routine. While some additional detail was added to the statewide model network, the current statewide model zone structure and trip table were maintained.

Local Freeway Overpass Alternatives - Gaylord

This project was treated similar to the Mt. Pleasant Study. A sub area model is being used to analyze the traffic impacts associated with a proposed local road extension over I-75 in Gaylord. The subarea model utilized the network inventory data, the terminal and through trips and the socio-economic data from the statewide model as part of its data set. However, a more detailed zone structure and network were required. TransCAD's Quick Response modeling package provided the trip generation and distribution components.

Interim Transit Service Strategy

This project currently in process, utilizes data from the Public Transit Management System and the Statewide Models Local Transit Sketch Planning Tools to estimate the costs and ridership associated with expanding local transit service to all of Michigan's Counties.

Transit Planning

The Transit Sketch Planning model has been used in a number of areas to evaluate either service expansions or the establishment of new service.

Trunkline Rationalization

This project, currently in process, is examining the amount of traffic that will be served and the activity centers that will be served by expanding the current trunkline service.

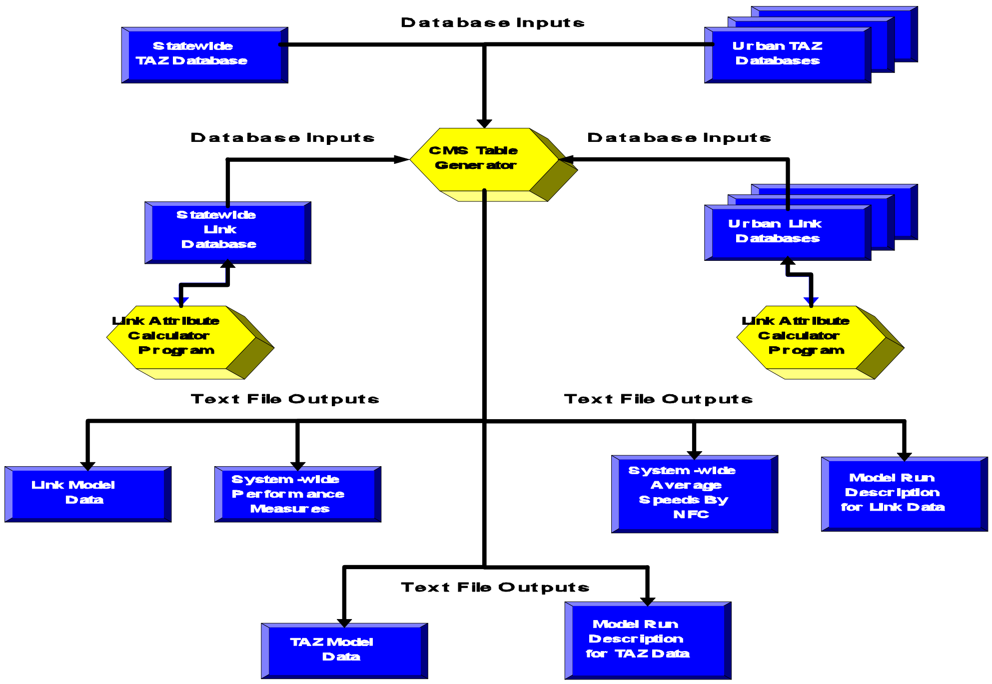
State Long Range Plan Update Support

This project, currently in process, will define the socio- economic context and transport-ation issues to be addressed by the State Long Range Plan Update.

City Pair Trip Tables

The Statewide Model zonal trip tables were collapsed into city pair trip tables for use in the Seven State Midwest Rail Initiative.

External to Internal Trip Tables



The state legislature requested an estimate of auto travel in Michigan by out of state residents. While not a direct answer, because it also included travel by Michigan residents to out state destinations, it was adequate to satisfy their inquiry.

Michigan Aviation System Plan

We have linked all 240 public use airports in Michigan to the Statewide Model network. This allows us to do service area analysis and provide other information for use in evaluating service standards and for use in the Michigan Aviation System Plan (MASP).

MDOT Transportation Service Center (TSC) Analysis

During MDOTs decentralization restructuring, one customer service goal was to provide one hour access time to an MDOT Transportation Service Center (TSC). This project utilized Caliper's Network Partitioning Function to estimate the population within selected time bands to the proposed Service Center locations.

FUTURE ACTIVITIES

The following tasks have been identified as potential future activities that will enhance the Statewide Travel Demand Models capabilities.

Update The Truck Model Module in TransCAD

The Truck Model was recently updated based on the 1993 Commodity Flow Survey. This program needs to be incorporated into the TransCAD interface using the TransCAD developers kit (DKS).

Incorporate Air Mode Into the Model

Because high speed rail is viewed as a substitute for short distance air-travel, we would like to upgrade the model structure to include air travel. We have obtained the Intercity Travel Demand Model developed for Michigan and six other states as part of the Midwest Rail Consortium. We intend to explore the adaptability of that work for Michigan.

Update the Zone Structure and Network for 2000 Census

The model network is compatible with, but not the same as, that being used in the roadway referencing system. We would like to revise the Statewide Travel Demand Model network using the roadway referencing system network as a base. This will minimize the problems of data transfer between the Department's data bases and the models.

New Surveys

We are proposing both home interview and on board ridership surveys in conjunction with the 2000 Census. These surveys will be used to update the trip generation and distribution components of both the Urban and the Statewide Travel Demand Models.

Expand the Roadway Referencing System to All Network Links and Tie to The Needs Files

The final and most problematic activity is the expansion of the roadway referencing system to the designated STP system and the rest of the roadway network and linking the referencing system to the local needs study files. This will be part of a future Department wide effort.

TIPS ON GETTING STARTED

Know what is doable. Talk to those that are currently using models.

Avoid raising expectations beyond your capabilities.

Know your customers needs (Level of effort should match expectations **within your capabilities**).

Stage your efforts (**Don't bite off too much at once**).

Hire good staff. Ensure they have adequate training. Experience is the best teacher.

Partner when you can (Universities, MPO's and Planning Regions, Consultants).

If you use a consultant:

- Keep your wish list simple. Costs are directly proportional to its length.
- Do what you can in-house.
- Develop calibration summary report capability in advance.
- Use simplified procedures to deal with complicated issues until staff gains experience to upgrade procedures.
- Include forecasting as part of the test phase.
- Have alternative approaches to identify overall forecast targets. (VMT and cutlines).

Obtain good reliable network and zonal data but be cognizant of the fact there is no perfect data.

Develop a data maintenance process. Forecasted or estimated data that represents the current situation is usually preferred by your costumers than old census data.

Monitor changes in all relevant data to keep model components current.

- Auto and commercial VMT.
- Licensed Drivers & Population over age 15.
- Registered Autos.
- Volumes at State Borders, Urban Model Cordons and Cross-state Cut Lines.
- NPTS trip rate changes.

Incorporate ability to change model component at all stages and update as needed.

- Trip generation rates.
- Trip Distribution.
- Vehicle occupancy.
- Travel assignments.

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The Washington State Travel Demand Forecasting Decision Process: From Vision to Products

Todd Carlson
Washington State Department of Transportation

ABSTRACT

There are a number of elements that can contribute to the successful implementation of a vision. The application of travel demand forecasting, a fundamental planning tool, is no exception.

Our current vision is to develop a coordinated travel forecasting process where local, regional and state roles are played out in a collaborative manner to produce output necessary to answer the policy questions derived through the planning process.

In order to ensure that our view of the vision is clear, it is critical to have a clearly stated outcome to achieve. Currently at the Washington State Department of Transportation we have one primary outcome we are striving to achieve: Enhanced data and analysis assisted decision making (opposite of so called "data-free" analysis).

In order to continue to move in the right direction to achieve this outcome, we have identified four primary objectives necessary for the state to fulfill its role in the travel forecasting process:

1. Ensure that all travel forecasting efforts within Washington State are coordinated and follow a set of agreed upon procedures (Travel Demand Forecasting Framework).
2. Provide each of the 8 Metropolitan Planning Organization (MPO) regions of the state, existing and forecasted interregional travel.
3. Determine how much travel occurs as statewide throughput (e.g., between Canada, Oregon, Idaho and Washington Ports).
4. Test effectiveness of "new corridors" for passenger and freight statewide travel.

To achieve these four objectives we will need to create two products: 1) a best practices' procedures manual, used statewide at the local, regional and state level, for the application of travel demand forecasting; and 2) a statewide travel demand forecasting model.

When we are successful in developing these two high quality products, we will be able to meet our four objectives that will lead us to the desired outcome and ultimately fulfill our vision.

The key issue which I have observed thus far in this process, is that it is very important to "go slow" to "go fast". In other words, promising too much too soon can jeopardize the entire process. Being clear about the objectives and making steady progress towards those objectives with incremental deliverables will give the greatest likelihood for success.

VISION

Travel forecasting and analysis are fundamental to planning and project development in the department.

These technical methods provide data to determine, the location of congestion and the extent to which various strategies solve congestion problems, benefit-cost analysis, project design, safety analysis and system performance. Currently, the Washington State Department of Transportation (WSDOT) relies largely on Metropolitan Planning Organization's travel demand models for regional forecasting and analysis of travel. These models can not provide the needed forecast and analysis data for statewide and inter-regional movement of people and goods, which is a fundamental mission of the WSDOT.

Our vision is to develop a coordinated travel forecasting process where local, regional and state roles are played out in a collaborative manner to produce output necessary to answer the policy questions derived through the planning process.

During the 1998 legislative session, numerous legislators requested that the Legislative Transportation Committee (LTC) staff provide information on how effective past and proposed system improvements have been or will be in relieving traffic congestion. Without a system analysis tool, we were limited to providing benefit/cost analysis for "spot" (e.g., new construction of interchanges) improvements. Although knowing the benefit of individual congestion relief projects is an important part of the equation, the ability to answer the larger questions of, "are we improving the overall performance of the system and thus improving the quality of life for our customers?", will become even more important as we enter an era of performance-based budgets and expectations for effective investment of limited dollars.

Within Washington State, the planning profession continues to struggle to implement the state Growth Management Act and the consistent themes of the Intermodal Surface Transportation Efficiency Act and now the Transportation Equity Act for the Twenty First Century. In order to appropriately forecast and evaluate the impacts that growth (population and job growth) has on the transportation system, planning professionals continue to pursue more effective tools to link the impact of land use changes, technology advances, and environmental constraints on the transportation system.

At the WSDOT, we are currently striving to fulfill our role in this struggle. Even after nearly 10 years of growth management, the analytic understanding of the movement of people and goods between Washington, Canada, Idaho, Oregon and through Washington ports remains too great a mystery. Our effort must resolve both our role as coordinator of regional processes and provider of interregional (statewide) and interstate travel.

OBJECTIVES

In order for the WSDOT to contribute to our vision, we have identified four primary objectives:

1. Ensure that all travel forecasting efforts within Washington State are coordinated and follow a set of agreed upon procedures (Travel Demand Forecasting Framework).
2. Provide each of the 8 Metropolitan Planning Organization (MPO) regions of the state, existing and forecasted interregional travel.
3. Determine how much travel occurs as statewide throughput (e.g., between Canada, Oregon, Idaho and Washington Ports).

4. Test effectiveness of “new corridors” for passenger and freight statewide travel.

The state of the art and application of travel demand forecasting (TDF) today varies greatly from one region of the state to another. Major urban areas, like the Central Puget Sound in Washington State (Seattle metropolitan area), pose very different challenges than sparsely populated rural areas. In addition, a variety of local governments, regional agencies and consultants are doing work in the field creating a coordination challenge to the Washington State Department of Transportation (WSDOT).

With so many professionals involved in the process, the opportunity for miscommunication, while working on these complex processes, can and does occur with surprising regularity. These miscommunications can result in the need to simply re-evaluate the analysis done for a particular location. Yet in other cases procedural or methodological inconsistencies can result in the inappropriate design and ultimate construction of an inadequate or inappropriate transportation facility. This can result in very costly mistakes.

Ultimately to avoid making costly mistakes and to achieve statewide consistency in plans, programs and project delivery, a common set of assumptions and procedures is essential. A framework will help to ensure that all of the public sector agencies and private consultants, which are required to forecast travel, do so in a coordinated and collaborative process.

If in fact the WSDOT does have trained, educated and effective planners and engineers working the issues in the field (within the MPO structure), we will greatly increase our ability to deliver the appropriate transportation systems for our customers.

OUTCOME

If we are successful in meeting the four objectives state above, we will have attained the technical ability to answer key questions within our planning, programming and evaluation process and from our customers (the public, Legislature, Governor, Transportation Commission, local elected officials, WSDOT executives etc.).

PRODUCTS

The resulting products from this process will be first a collaboratively designed procedures manual (patterned after the Oregon Department of Transportation) with an incrementally created statewide model.

Travel Demand Forecasting Framework Development Process

(Five Phased Approach)

In order to make the process to achieve our four objectives more understandable and implementable, we have divided the process into five distinctive phases:

Phase One – Review of TDF at WSDOT

During 1996, a series of regional meetings were set up with WSDOT regional planners to clarify and define travel forecasting applications and issues. The primary purpose of these meetings was to gain an understanding of regional needs, and our collective roles and responsibilities in travel demand forecasting.

This phase was designed to determine the WSDOT's desired policy direction before any visits to non-WSDOT forecasting stakeholders took place. In order to develop a policy recommendation, a one day meeting was held to choose one of many possible policy recommendation scenarios or create some hybrid.

These scenarios addressed two fundamental questions: 1) how should WSDOT forecast travel demand to determine deficiencies on state owned facilities? and; 2) who (what group, etc.) will be responsible to "carryout" this function? Based on these meetings and the work of the WSDOT TDF Steering Committee, the Olympia Service Center's Transportation Planning Office produced "The Washington Travel Demand Forecasting Framework: Phase I—A Review of Travel Demand Forecasting at The WSDOT – Issue Paper"

Phase Two – Outreach

This phase consisted of visiting non-WSDOT travel demand forecasting stakeholders (such as MPOs, and Universities, etc.). It was critical to assess their needs, roles and responsibilities as they are tied to similar WSDOT planning requirements. The outcome of these stakeholder meetings forged an understanding and working agreements regarding how the WSDOT and other stakeholders will carryout forecasting within the adopted framework.

A future feedback loop may be necessary to revisit other scenarios or refine the existing one based on stakeholder discussions.

Phase Three – Policy Direction

At the end of phase two, we presented the WSDOT Steering Committee's recommendation to the WSDOT Executive Board. The Board agreed to pursue the framework and encouraged the Steering Committee to continue with the process.

Phase Four – Procedures and Methodology (beginning winter '99)

Phase four will focus on the development of a procedures/methodology manual. The intent of this manual is to help put forecasters (with different forecasting purposes, needs, budgets, abilities, etc.) around the state on the same page concerning procedures/ methodologies. This is very important for abutting jurisdictions with differing models, data sources, and informational requirements. This document will focus on the best practices of forecasting.

Phase Five – Continuous Improvement

This final phase is the continuous improvement process. Items such as training and continual updating of the forecasting framework (procedure's manual, etc.) are examples of work that will occur within phase five.

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION (WSDOT) ROLES AND RESPONSIBILITIES

At the WSDOT TDF Steering Committee’s meeting in April 1996, a consensus was reached to create a core travel forecasting group by re-focusing existing resources. Additionally, it was agreed to introduce a decision package that would augment the existing *core group* of forecasting staff with 1 new position. The *core group* will provide support to WSDOT regions, consultant forecasting oversight, develop quality standards for all WSDOT traffic forecasting efforts and manage the research and design of a statewide model.

Generally, the WSDOT Regional offices are the forecasting model *user group* and are to be lead in all planning activities, including travel demand forecasting, unless otherwise specified. This is to assure that those closest to the activities direct the WSDOT actions.

The lead role for technical forecasting overview and partnering with MPOs, local governments, transit agencies, and consultants should clearly be the responsibility of the WSDOT regions' *user group*. This lead role will be supported directly by the *core group* that will supplement both the technical work of the regional planner and communications with our public and private transportation partners. Some functions of the *core group* will be lead but will also require that regional planners be acutely aware and involved in all of those processes.

The primary responsibility of the *core group* is to support regional planners' *user group* in their planning and engineering travel forecasting applications. This support is intended to supplement or take the place of the lack of resources that can not be feasibly maintained at each regional office. This *core group* will function as an interdepartmental (cross service center) team serving the specific needs of each travel forecasting application.

The following table lists the lead and support roles of either the Regional Office *User Group* or the Olympia Service Center (OSC) *core group*:

Core Group & Regional Roles and Responsibilities

Activity	**Regional Office** *(User Group)*	**OSC** *(Core Group)*
◆ Long and mid range travel forecasting activities in urban and rural areas. • MPO Metropolitan Transportation Plans, • RTPO Regional Transportation Plans, • MPO three year Transportation Improvement Program, • RTPO six year Transportation Improvement Program, • Major Investment Studies, • Assuring consistency of MPO/RTPO plans with the modal components of the Washington Transportation Plan (primarily the Highway Systems Plan).	Direct, manage and validate results locally	Support and offer training and forecasting services
◆ Technical forecasting overview and partnering with MPOs, local governments, transit agencies, and consultants	Primary lead - direct responsibility to represent WSDOT at all intergovernmental meetings and communications (e.g., RTPO TAC, TPB etc.)	Secondary support - responsibility to the WSDOT regional *user group* Validate technical travel demand modeling process and product
◆ Development Services applications (distribution and assignment for new development) • Review traffic distributions for all applicable traffic impact analysis • Ensure plans are updated based on land developments	Direct, manage and validate results	Support and offer training and forecasting services
◆ Environmental Impact Statements analysis applications.	Direct, manage and validate results	Support and offer training and forecasting services
◆ Travel demand forecasting for special projects.	Direct, manage and validate results	Where appropriate If necessary to add value to process and discussion

◆	Travel forecasts for project scoping and design, highway safety analysis and benefit-cost analysis.	Direct, manage and validate results	Support and offer training and forecasting services
◆	Lead the development and continually update the Washington Travel Demand Forecasting Framework.	Secondary support	Primary lead
◆	Lead MPO/RTPO Forecasting Capabilities Review.	Secondary support	Primary lead
◆	Lead acquisition/dissemination of Census, Employment Security and Licensing data.	Primary WSDOT staff role	Primary lead
◆	Organize and staff the Washington State Modelers' Group meetings.	Secondary support	Primary lead
◆	Attend Technical Advisory Committee and Transportation Policy Board meetings when appropriate.		

DEVELOP TRAINING AND TECHNICAL ASSISTANCE

Clearly there is an ongoing need to supply the appropriate training and technical assistance to the *user group* and the *core group.* Currently a new travel demand forecasting course is under development, under the direction of University of Washington Professor Scott Rutherford. This course will be the baseline for training in the application of travel forecasting (both statewide traffic growth factors; and land use based travel demand models).

In addition to the U of W course, the OSC *core group* will offer informal training and technical assistance opportunities to the WSDOT regional *user group*.

Recruit and Retain Qualified Planners

It is, and will continue to be, critical to bring in the necessary travel forecasting talent to the WSDOT. Equally important is the ability to retain those professionals who have institutional experience and have been trained within the organization. With these two objectives met, the WSDOT will have the capability to lead and participate in statewide travel demand forecasting.

Seek Additional Resources

As opportunities present themselves, it will be imperative that WSDOT executive leadership recognize the importance and necessity to support the TDF effort within WSDOT. In addition to the one new FTE requested in the 1999/01 decision package, as existing staffing patterns change, a reorientation of positions should take place within both the OSC and Regional offices.

How do we ensure we "fail"?

Clearly this decision process is ambitious. One of the tools that is useful in determining potential problems,

which most likely will be encountered along the way, is a contingency diagram. This tool uses counter logic to identify the most likely and serious problems that could occur by inverting the desired outcome.

In this case, we asked: How do we ensure that we fail to achieve our four objectives?

The following are ratings that reflect the extent to which the identified issue is either likely or serious (1 = low & 5 = high). After the scoring is completed, we multiply the likelihood by the seriousness to get an overall score.

	likelihood	seriousness	total
1. Lack of inter-agency communication	3	4	12
2. Instability in staffing commitment	5	4	20
3. Lack of leadership			
• Legislative	5	5	25
• Executive (MPO/WSDOT)	3	5	15
• Staff	1	4	4
4. Failure to product a quality product for customers	4	5	20
◆ Too onerous of a project (dies of its own weight)	4	3	12
◆ Inadequate resources (WSDOT)	5	5	25
◆ Inadequate staff resources (partners)	4	4	16
◆ Lack of legislative mandate	5	5	25
◆ Failure to identify the right goals	1	5	5
◆ Incorrect approach (failure to get buy-in from stakeholders	1	4	4
◆ Process precipitateness	1	3	3
◆ Mandate the procedures manual	1	5	5
◆ Failure to acknowledge the need for differing outcomes	3	4	12

Collaborative Process

With the above issues identified a marketing strategy is necessary. Currently we have simply been

communicating with the individuals and groups identified in the contingency diagramming exercise.

First we have developed a partnership with Legislative Transportation Committee staff. This is a very natural partnership in order to give LTC staff the ability to answer members question through legislative session as well as during off session.

During the last two years, we have continued to present varying aspect of the planning process to LTC members in order to answer their policy questions, involve them in the policy debate and gain their confidence that we are capable of providing the necessary investment decision information that they need.

As Legislators grow in their knowledge of the travel demand forecasting process, we will encourage legislators to champion the vision of the TDF framework. And, as opportunities provide themselves, we will continue to develop support from our Washington State Transportation Commission, the WSDOT Executives, regional planners and the MPOs.

Research and Design Issues

In a response to the challenge to achieve the four objectives stated thus far, a research and design effort must be undertaken.

Following up on Phase three -- Policy Direction, we wrote a request for a two year research and design process to begin in July 1999. This could be funded out of an increase to our planning budget or through the research program.

To begin this process, in 1997 the WSDOT Transportation Planning Office directed a consultant to draft a "conceptual design" for a Washington statewide forecasting model. This report sketched out the requirements for the development of that model as well as looked at a few other states' programs. The next phase is to develop a detailed design of the model based on the conceptual design and driven by the application needs shown above.

We anticipate that if we are successful in securing the necessary funding, we could begin model development as early as July 2000.

The Kentucky Statewide Transportation Focusing Process

Rob Bostrom
Kentucky Transportation Cabinet

INTRODUCTION

This purpose of this paper is to review the Kentucky Transportation Cabinet's statewide traffic forecasting function. Traffic forecasting's role in the structure of the organization and its impact on policy issues will be covered first. Next, the various techniques that are used will be reviewed with emphasis on the traffic modeling tools. Finally there will be discussion of possible future directions in both the policy and technical spheres.

TRAFFIC FORECASTING: POLICY REVIEW

Kentucky Transportation Cabinet

Structure

In order to properly understand the impact of traffic forecasts on Kentucky Transportation Cabinet policy, it is useful to understand what the Cabinet is and to know its structure. The Cabinet - in many states known as the Department of Transportation - is Kentucky's responsible authority for the state maintained transportation system in Kentucky. Exhibit 1 shows the organizational structure of the Cabinet. The Highway Department is the portion of the Cabinet that contains the engineering and planning functions.

Planning Function

Within the Highway Department is the Office of Intermodal Planning. This office contains two divisions that perform traffic forecasting tasks. The Division of Transportation Planning is responsible for statewide traffic forecasting and the Division of Multimodal Programs is responsible for urban traffic forecasting. Other groups that are involved in the planning function are the district planning offices, the metropolitan planning organizations, the area development districts, the Kentucky Transportation Center (the Cabinet's research partner) and the consulting industry.

Empower Kentucky

State government began a radical new look at all functions when Governor Paul Patton was elected three years ago using Total Quality Management principles. This initiative is called Empower Kentucky. Empower Kentucky has resulted in many changes in the Transportation Cabinet in an effort to better serve the taxpayers. One of the results of Empower Kentucky is an increased emphasis on project development. The Cabinet has decided that project development needed to be done more seamlessly and quickly. This has increased the importance of timely traffic forecasts since traffic forecasting occurs early in the project development process.

Another by product of Empower Kentucky has been the restructuring of many engineering processes.

Planning functions have not yet had a process review but are in the process of making significant changes. One change has been the reorganization of the Division of Transportation Planning into teams of no more than four to five people per team in order to improve productivity and customer service. This has resulted in separating the traffic forecasting function from the traffic data collection and processing function. Another change under consideration is the unification of two traffic forecasting units (statewide and urban) into one team.

TRAFFIC FORECASTING FUNCTION

The traffic forecasting function is currently administered by the Division of Transportation Planning. All traffic forecasting requests are initially sent to the Division of Transportation Planning. Urban projects (about 20% of all projects) are then sent to the Division of Multimodal Programs who either completes the work in-house or sends the request to an MPO if the project is in the MPO study area. The Division of Transportation Planning does most of the statewide traffic forecasts in-house. A statewide traffic forecasting consultant is used to complete about 10% of the incoming forecasts.

Demand for Traffic Forecasts

About 180 to 240 traffic forecast requests are received every year. The source of the forecast requests and the use of the forecasts are shown on Table 1 - Types of Traffic Forecasts. The major customers of traffic forecasts are project development (highway design), planning, research, materials and others. The types of traffic forecasts received by the Cabinet and the products given are shown on Table 1.

This demand has recently undergone an increase due to Empower Kentucky. Empower Kentucky, in an effort to expedite the construction letting process, has started developing some projects before they have formally received funding. This improved readiness should allow the Cabinet to respond more quickly to changes in funding and to shorten the time to get a project constructed.

Importance of Traffic Forecasts

One of the Cabinet's assistant state highway engineers recently stated "make no mistake, traffic forecasting and financial resource commitment are closely tied." This statement - and many others by top management within the Transportation Cabinet - have underscored the importance of accurate traffic forecasting. Even with the additional funding due to TEA-21, the state of Kentucky's unfunded needs greatly outnumber the finances available. For example, Kentucky's draft 20-year Long Range Highway Plan estimates funding at $8.5 billion for new highway construction or reconstruction while the database of unfunded needs exceeds $32 billion.

The reason that traffic forecasting and financial resource commitment are so closely tied is because of the importance of traffic forecasts in determining what is built. Traffic forecasts are the main input into highway capacity analyses which in turn determine the geometric requirements for highway projects. Geometric requirements have great impacts on costs. For example the growth rate used on a traffic forecast frequently makes the difference between a project having two lanes or four lanes. Obviously, the cost differential between the two geometric scenarios can cause other worthy projects to go unbuilt.

Traffic forecasts are also very important for pavement design. Equivalent single axleloads (ESALs) are usually the most important parameter in the pavement design process. Often the success of the pavement of a new or reconstructed highway is dependent on the accuracy of the forecasted ESALs. Because of the importance of traffic forecasts in the design process, the decision-makers within the Transportation Cabinet have sought to respond appropriately.

The Cabinet budgets about $500,000 per year in traffic forecast related expenditures in order to provide for an accurate product. This includes staffing, model updates and other major expenses. One difficulty the Cabinet has had is keeping the function adequately staffed. ISTEA and TEA-21 have produced a demand for transportation engineers that has made it difficult for government to compete with the private sector, especially in respect to starting salaries. The Transportation Cabinet has dealt with that difficulty by hiring engineering students as interns and by using the services of a statewide traffic forecasting consultant. These measures have helped the Cabinet maintain a high quality and timely product.

The Cabinet has recognized the importance of traffic forecasting by maintaining excellent tools for its forecasting staff. The Cabinet has had a statewide traffic model since 1971 for statewide traffic forecasts. The Cabinet has also generated small urban traffic models for all 37 of the cities in Kentucky with population of greater than 5,000 and less than 49,999. Finally, all of the MPOs have their traffic models. It is safe to say that the Cabinet is highly committed to traffic modeling as a tool for high quality traffic forecasts.

Other tools that the Cabinet has provided for traffic forecasting are state-of-the-art computers, plotters, printers and other computer equipment. GIS/mapping tools such as ArcInfo and Maptitude are provided for displaying the information to forecasting customers. Finally, the Cabinet has always provided the best traffic modeling software for its analysts and engineers.

Traffic data collection has always been highly responsive to the traffic forecasting function with more than 700 counts made annually as special counts. Additionally the Cabinet performs another 4,000 counts made for its traffic volume data collection program which are available on-line for forecasting use.

Another area that has supported the traffic forecasting function is research. The Cabinet's research partner - the Kentucky Transportation Center (KTC) - has performed numerous research studies that have had forecast related themes. There have been several studies that have improved the equivalent single axle load processing area and traffic data collection/processing, including vehicle classification, weigh-in-motion and volume data processing. There are currently two ongoing studies related to traffic forecasting. One is the creation of a computer program to estimate ESALs for Superpave asphalt mix design and the other is a study which is creating seasonal factors for improving the data quality of vehicle classification data.

The only real deficiency that the Cabinet might be said to have in respect to traffic forecasting is the current lack of origin-destination data. The Kentucky Attorney General issued a ruling in 1994 that prohibited stopping vehicles for the purpose of conducting an origin-destination survey. This has made it more difficult to collect origin-destination data since the non-intrusive alternative (video tape origin-

destination surveys) are very expensive to conduct. The Cabinet has had to resort to using synthesized external-external trip equations to make up for the lack of real O-D information.

TRAFFIC FORECASTING TRENDS

Personnel

The trends experienced by the Kentucky Transportation Cabinet are probably similar to those of other state highway departments. We have experienced some staff reductions in all areas of state government in an effort to cut costs and increase efficiency. Largely, this has not impacted traffic forecasting due to its perceived contribution to the project development area. No one has been dismissed nor have any vacant positions been eliminated. As stated above, the main staffing difficulty has been to attract engineer-in-training personnel to the function in view of the great opportunities available in the private sector.

The Cabinet currently has four full-time employees involved in traffic forecasting and two engineering student interns (part-time employees). There is also one engineer devoted to monitoring traffic modeling update efforts by consultants retained by the Cabinet. Finally, there is approximately one-half of a staff person in the three major MPOs in the state involved in traffic forecasting. Cabinet forecasting is supplemented by a statewide traffic forecasting contract that is used to handle forecasts beyond Cabinet staffing availability.

Information Technology

The Cabinet's Division of Information Technology has been very supportive of the traffic forecasting function. State-of-the-art tools have always been available such as personal computers, laser printers, plotters, software and technical support. Recently, there has been an interest in using GIS for various tasks within the traffic modeling area. GIS has been used primarily for product displaying traffic assignments and recently - for the first time - used in producing link-node/zone maps. It is anticipated that we will have much more wide-scale GIS applications since most of the 120 county level base maps are now complete. The Cabinet has a statewide database - the Highway Information System - that can be associated with the GIS maps fairly easily.

Workload

The traffic forecasting workload has increased in recent years due to several factors. The quantity of forecasts needed has increased due to the need for equivalent single axle load (ESAL) information by the Division of Materials. The Division of Materials uses ESAL information for designing Superpave asphalt mixes. Another factor that has caused the workload to increase is the need for traffic forecasts - particularly time consuming intersection turning movements - for the purposes of determining the impact of highway projects on air quality.

Issues

Since traffic forecasting is a major contributor to several processes within the Kentucky Transportation

Cabinet, it is only natural that some issues would arise. The Cabinet has formed a Traffic Model Users Group to help discuss some of the issues and to share information. The Traffic Model Users Group consists on Cabinet forecasters/modelers, MPO modelers, consultant partners, research partners (Kentucky Transportation Center and the University of Kentucky), the Federal Highway Administration and interested Cabinet decision makers.

The Model Users Group has mostly been a forum for technical issues but has also seen the discussion of topics of interest such as the availability of data owned by the state. Current issues that have sparked discussion are:

- Should low design year values be used in order to conservatively prevent overbuilding or should higher design year values be used in order to account for possible unanticipated growth?
- Vehicle mile travel estimates in the future. Should they be prepared using HPMS or with a traffic demand model? Also, how should future values be determined for statewide VMT and county-level VMT?
- Traffic modeling software is rapidly changing. Which software package best serves the Transportation Cabinet and should the Cabinet's software be compatible with the state's MPOs?
- Documenting traffic modeling is very time consuming. To what extent should procedures be documented and standardized?

These issues will be resolved by a combination of feedback from management, the Traffic Model Users Group, by insights from other practitioners and the passage of time.

TRAFFIC FORECASTING: TECHNICAL REVIEW

While the policy questions are of great interest, it is difficult to separate the role of the technical preparation of traffic forecasts. This part of the paper will review traffic forecasting techniques, especially the statewide traffic model, and a brief look will be given to possible changes in the future.

Forecasting Techniques

There are many tricks of the trade used in producing the typical traffic forecast. Some interesting facts about the Kentucky Transportation Cabinet's traffic forecasting standard practice are listed in Table 2. The basic product consists of some measure of traffic - ADT, DHV, truck percentage, ESAL, MOE - in different points in time and in different geometric scenarios. The first area that needs review is the method used to estimate existing traffic.

Current Year Traffic Estimation

The Kentucky Transportation Cabinet has a strong traffic data collection program that is the source of most of its traffic forecasting information. The Cabinet makes approximately 4,700 counts annually including about 700 special counts made just for traffic forecasting. The Cabinet has 65 automatic traffic recorders that are excellent sources of information. The Cabinet also makes about 300 vehicle classification counts annually to provide detailed information concerning the vehicle types. Finally, the Cabinet has collects weigh-in-motion data from nearly 90 sites on a three year cycle.

The traffic data is available in many formats: reports, databases, maps and summary reports. The forecaster takes the source traffic data, smooths and factors the data so that it is consistent with the other data in an area. It is absolutely critical for the forecaster to be knowledgeable about the source of the traffic data. Since traffic data is only one "snapshot" of the traffic at a given point or area, the forecaster must produce a rational estimate of current conditions. Therefore the experienced forecaster must review the count factors (axle, temporal), the count area, and the count history in order to arrive at a reasonable estimate of the current traffic.

The forecasting analyst is also required to make diverse data that doesn't fit perfectly into a smooth, balanced seamless flow of information.

Future Year Traffic Forecasting

Once the current year traffic is finalized, the traffic forecaster must project this traffic into the future. There are two main sources of information used to accomplish that task. The first is historical traffic data. The historical data trends are computed and assumed to be reliable indicators of future travel patterns. The data is then extrapolated into the design year (or other desired future year). The Cabinet uses two main extrapolation tools. The first is a computer program that produces current year estimates based on previous counts at a location and functional class averages when there is not much data available. This microcomputer program is known as the "Counts" program, primarily uses weighted linear regression to produce the estimates. It also produces a 20-year estimate based on linear regression. The other main extrapolation tool is the use of trend line analysis programs available in commercial spreadsheet packages.

Socioeconomic information is also used to produce estimates of future travel. Traffic models, of course, have population and employment information embedded in the trip generation step. Socioeconomic data is also used to get a "feel" for an area to see if conditions are right for higher growth rates. The Cabinet relies on the Kentucky State Data Center to produce reliable estimates of population in the future (see reference 1).

This area involves a tremendous amount of engineering judgement. Traffic forecasts in Kentucky tend to average around 2.5% growth compounded per year. Areas with high growth (for example new highways) often exceed that rate while other areas might have lower growth rates due to capacity restraint or lack of economic vitality. There has never been a study reviewing the traffic forecasts by the Cabinet compared to actual traffic. This might be interesting and useful. It should be noted that the annual VMT growth average in Kentucky over the past 10 years is about 4% per year! This would seem to indicate that we are under forecasting.

Hourly Estimates

While average daily traffic is the most common and widely used traffic parameter, design hour volumes are of most use in the design process. The 30th highest hour of traffic in the year is the designated design hour used by the Transportation Cabinet. The Transportation Cabinet relies heavily on data obtained from continuous traffic recorders (ATRs) to obtain factors (k-factors, directional factors and

peak hour factors) to convert daily traffic to the design hour traffic. The report *Traffic Characteristics of Kentucky Highways 1996* (see reference 2) contains a list of Kentucky's ATRs along with the k-factors for each ATR.

Short term 48-hour counts are used to get a relative idea of the amount of traffic in the peak hour. The peak hour traffic is then adjusted, based on ATR data, to obtain the design hour volumes. Although a true k-factor is not obtainable from a short term count, the directional factor from a short term count is usually acceptable. Thus, thefactors for the hourly counts usually come from more than one source.

Turning Movements

Many of the traffic forecast requests involve the calculation of turning movements at key intersections. The Transportation Cabinet has a fairly refined process for determining turning movements. A recent report *Turning Movement Estimation Guidelines* (see reference 3) summarizes the methodology used for estimating turning movements. Actual turning movement counts are made for most design projects, while the Cabinet is usually content with computer generated turning movements for other purposes. The estimation of turning movements is a time intensive task that requires good judgement from the analyst.

Traffic Diversion/Generation Tools

One of the most important tasks that the traffic forecaster must perform is the estimation of traffic on new facilities or alternate alignments to existing facilities. This requires that the forecaster must have tools to divert and/or generate traffic. The most commonly used technique for estimating traffic on new highways is with a traffic model. The Cabinet's use of traffic models is covered in the next section. Other tools used by the Cabinet include the Modling external-external trip estimation equation (see reference 4), the California Diversion Curve (see reference 5) and the "manual gravity" method.

The manual gravity method is used to estimate the travel demand between two locations and the diversion curve is then used to estimate the percentage of the traffic demand diverted to the new facility. The manual gravity method is based on successively reducing the through traffic due to turning movements. This technique requires excellent count coverage in an area in order to calculate turning movements at all intersections on the subject corridor.

The main trip generation tool used is the ITE Trip Generation Report (see reference 6). This report is used if there is no local trip generation information available. One slight divergence from the national ITE trip generation rates is the use of eight trips per household when estimating traffic on rural dead-end roads. Our experience has shown that the trip making of most rural Kentucky households is less than the national 9.57 average.

Traffic Models

The Transportation Cabinet uses traffic models heavily within the traffic forecasting function. Traffic models have been developed for all seven of Kentucky's Metropolitan Planning Organizations (MPOs) and most of Kentucky's 37 small urban areas (areas with population greater than 5,000 but less than

50,000). In addition, the Cabinet has developed the Kentucky statewide traffic model. The traffic models used by the MPOs and the small urban areas are used for traffic forecasting purposes as well as for developing transportation improvement programs (see reference 7).

Most of the current small urban models are being developed by consultants under contract to the Cabinet. Usually, the hardest data to collect for traffic models is through trip data. The state of Kentucky has synthesized data for that purpose using regression equations developed by the Kentucky Transportation Center.

Statewide Traffic Model

The Kentucky Transportation Cabinet has used a statewide traffic model for many years. This section will discuss the history of the model, current model specifications, model usages and the ongoing model update. Table 3 gives a capsule summary of the Kentucky statewide traffic model and it is covered in more depth below.

History

The first Kentucky statewide traffic model (KySTM) was developed in 1971. This model had a large network which included zones in many states outside of Kentucky. It was similar in principles and methodologies to traditional urban models. It had several trip purposes including truck trips. It was updated in 1973 using new origin-destination data, household interviews, and 1970 census information. The model was recalibrated in 1975. Unfortunately, maintenance of the model was not deemed practical at that time and was therefore not maintained well for several years after that.

The model was updated in 1991 by Wilbur Smith and Associates (see reference 8). This update took the 1975 model and adjusted the trip table using a ground count calibration program. It reduced the network to contain only zones inside the state of Kentucky. The final products included a 1990 current year trip table and a 2010 future year trip table.

The next update was in 1997 by Wilbur Smith and Associates (see reference 9). The model was updated as a part of a corridor study on I-66. This new model significantly improved the 1991 model. It restored trip generation, added a truck trip purpose and enlarged the study area to include all of the surrounding states. The final products were a 1995 current year model and a 2025 future year model.

Model Specifications

The 1997 Statewide Traffic Model update was a major effort since the network was expanded beyond Kentucky and trip generation capability was added. The model took approximately 18 months to develop and cost about $190,000. The model update was included as a part of a larger task which was a corridor study on the proposed I-66 high priority corridor in Kentucky. This larger task helped “sell” the need for updating the model.

No new travel data was collected for the model. It used data available from existing databases. A network was produced containing 1,530 zones (including 823 Kentucky zones) and 28,282 separate links

(see Exhibit 2). The modeling software used is MinUTP, and the assignment methodology is "all or nothing." The traffic model has five trip purposes: Home Based Work, Home Based Other, Non-home Based, External-External and Truck. These purposes are similar to most urban models and were agreed upon after much discussion.

Other notable aspects of the Kentucky statewide traffic model are the use of the National Highway Planning Network Version 2.0 to create the MinUTP roadway network outside of Kentucky. This network was combined with the 1991 model network to create a seamless network. Another interesting characteristic of the model is the use of a program that calibrates the generated trip table to ground counts. This program adds an extra measure of accuracy that is needed because of the large area that is being modeled.

Statewide Traffic Model Usage

The Kentucky Statewide Traffic Model was designed for use in major statewide highway projects. It is less accurate in urban areas and is not used there. It is very useful for corridor studies, for alternative analysis and for new rural highways. For corridor studies, the model can produce measures of effectiveness, such as vehicle miles traveled and vehicle hours traveled, that can be used to perform economic analyses. For new statewide highways, the model can be used to determine the estimated average daily traffic that will use the proposed new road.

As with any traffic model, care must be taken to inspect the fineness of the highway/zonal system to see if the "answers" given by the model are useful. In general, most assignments from the model must undergo some adjustment before being used in the actual traffic forecast. This adjustment is based on both the accuracy of the specific highway link volume accuracy and the surrounding subarea volume accuracy. Since the model is relatively easy to recalibrate based on new traffic volume information, recalibration is an option. Another means of producing accurate assignments is the creation of a subarea model that can contain a refined highway/zone network.

Consideration has been given to using the model for intermodal freight movement prediction but this would probably require further refinement of the truck trip information.

1999 Update

The upcoming 1999 KySTM update will be a "minor" update compared to the previous effort. It will recalibrate the network based on new count data and on improved network link information. The new data years will be 1998 for the current year and 2030 for the future year. Several programs will be written that will allow easier post-processing use of the model for the average user. Other new planning data will be incorporated into the model such as origin-destination data (where available), commodity flow data (if available) and possibly aggregated MPO model data.

This model update will also provide for training, staff support and conversion to new modeling software if that comes to pass. The 1997 model is still useful but this update is aimed at making incremental improvements and to recalibrate the model. This update will cost an estimated $37,000.

After the year 2000 census (by year 2002 or so), will probably be a good time for another traffic model update which would incorporate the new census data and would take a look at the need for collecting actual origin-destination data on key corridors, the incorporation of freight modeling, the use of aggregated MPO model data and, then, unforeseen changes.

Traffic Forecasting Improvements in the Future

It isn't easy to anticipate what changes will occur in the future so these predictions should be taken with the usual shaker of salt:

- Improved feedback loop to decision-makers using GIS will help improve data collection needed for traffic forecasting.
- Improvements in technology will allow for the easier creation of traffic models and will allow for some overlap between travel demand modeling and traffic simulation modeling.
- The new AASHTO Pavement Design Guidelines should eventually result in improved ESAL forecasting.
- Length-based vehicle classification and ITS data sources will be valuable additional sources of data for traffic forecasting.
- The accuracy of traffic forecasting will increase if population growth finally slows down.
- Designers will become comfortable working with traffic forecast ranges or intervals which will further increase the sophistication of the forecasting discipline since confidence intervals will vary based on the data available and the tools available.
- Staffing DOTs will continue to be a problem and so the relationship between the consulting industry and government will grow closer.

The crystal ball is growing cloudy ...

CONCLUSION

Traffic forecasting performs several valuable roles in the Kentucky Transportation Cabinet including providing data to designers, planners, researchers, enforcement personnel, materials engineers and decision-makers. In order for traffic forecasting to remain useful, it is essential that the Cabinet use state-of-the-art tools; for the Cabinet to allow traffic forecasting to evolve into new areas; and for individual forecasters to be mission-driven in order to serve the customers.

We think that we are successfully meeting the challenges in Kentucky and intend to continuously improve in the future.

REFERENCES

1. *How Many Kentuckians,* Kentucky State Data Center, 1995.

2. *Traffic Characteristics of Kentucky Highways 1996,* Division of Transportation Planning,

Kentucky Transportation Cabinet, 1997.

3. *Turning Movement Estimation Guidelines,* Division of Transportation Planning, Kentucky Transportation Cabinet, 1997.

4. "Synthesized Through-Trip Table for Small Urban Areas", *Transportation Research Record 842,* David G. Modlin, Jr., 1982.

5. Homburger, Wolfgang S. & Kell, James H., *Fundamentals of Traffic Engineering,* 11th Edition, 1986.

6. *Institute of Transportation Engineers Trip Generation Report*, 6th Edition, 1997.

7. *Small Urban Area Travel Modeling Using MinUTP*, Division of Mass Transportation, Kentucky Transportation Cabinet, 1988.

8. *Statewide Traffic Model Review/Update,* Wilbur Smith Associates, 1991.

9. *Kentucky Statewide Traffic Model Final Calibration Report,* Wilbur Smith Associates, 1997.

Commodity Flow Modeling

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INTRODUCTION

The project reported on here was undertaken with the primary objective of creating a database of commodity flows into and out of the counties of Indiana and to allocate this commodity traffic to the transportation network of the state. Such a database was to form the foundation for a general transportation model for Indiana that would assist state decision-makers in evaluating the various alternatives for public investment in the transportation infrastructure of the state.

The project had two phases. The first phase was completed in 1993 [1]. It was recently described as "one of the most sophisticated modeling exercises done by or for state transportation departments" [2]. This paper covers the second phase of the project [3].

The organization of this paper follows a classical transportation planning process. It begins with an identification of the study area and the existing transport network, or networks in the present case. This is followed by a discussion of the commodities examined and the commodity traffic generation for the counties of Indiana. The models developed for estimating the production and attraction of these commodity flows are also presented and discussed. Distribution of the traffic from origins to destinations is accomplished using a gravity-type of distribution model. This is followed by the use of a modal split procedure, which allocates traffic to specific modes of transport on the basis of historical (1993) patterns of mode use. The final component of this process is an assignment of the distributed traffic to links of the appropriate modal network. This process was undertaken here for nineteen groups of commodities that include the entire range of manufactured goods, coal, farm products, non-metallic minerals, and waste products. There is also some analysis of mail flows, although much of this is at a rudimentary level of analysis due to a lack of data on these flows.

The end result of the above process is a database that can be used to estimate future flows on the Indiana's rail and highway networks. This estimation of future commodity traffic flows was accomplished with traffic projections for 2005 and 2015, however space limitations preclude a discussion of that portion of the study here.

Before proceeding a few words are in order on the geographic information system (GIS) used in the preparation of this report. The system used was TransCAD [4], a GIS system developed primarily for transportation applications. Most of the databases developed here were generated by this system. Although independent estimation procedures, such as multi-variate regression analysis and entropy-based gravity model algorithms, were used in several cases, TransCAD was used for network creation, updating, and assignment of traffic as well as for the maps included here.

This study is in many ways the state or multi-state version of the transportation plans undertaken thirty years ago for the nation's metropolitan areas. It includes 145 "traffic analysis zones", two modes, two networks (70,000 miles of highways and more than 100,000 miles of railway), and the equivalent of 21 trip purposes (commodities here). It is no exaggeration to say that this study was made possible

primarily because of the availability of TransCad. It has made the most complex transport and mapping problems manageable.

STUDY AREA AND NETWORK DEFINITION

The primary study area for this research is the state of Indiana and its ninety-two counties. While the flows to, from, and between these counties are of interest, we can not look only at these; the analysis cannot be limited to intrastate flows. A significant amount of the commodity traffic in Indiana has neither an origin nor destination in the state, but instead represents goods or materials that are passing through the state. This overhead traffic may contribute little to the state's economy, but it adds to urban congestion, air pollution, wear and tear on the highways, and rail traffic. Therefore, what happens beyond the state's borders must also be examined here. As a result, this study includes, in addition to the 92 counties of Indiana, several major terminals outside the state. The latter group consists of 48 nodes representing the contiguous 47 states (excluding Indiana, since it is represented as a series of 92 areas) and the District of Columbia, as well as additional nodes for contiguous states: two for Ohio, and one in Illinois, Kentucky, and Michigan, for a total of 145 nodes. This study was concerned primarily with the highway and railway systems. Flows on the other networks are considered implicitly if motor carriers or rail are used in part of the movement.

THE HIGHWAY NETWORK

This study used the interstate highways of the 1992 digital highway network developed for the Federal Highway Administration (FHWA) by the Oak Ridge National Laboratory. Detection of boundary effects during flow assignments led the study staff to use a large circular ring of all digital highways centered on Indianapolis and extending out 200 miles. It was believed that the use of such a ring would eliminate the aforementioned boundary effects.

The Indiana Department of Transportation wanted this project to use a much more detailed state highway network than was available in the FHWA network. The detailed network of interest included the links in the State Roadway Inventory [5]. This database contains a wealth of information on links of the state’s highways. The resulting network consisted of 34,154 links, 31,557 nodes and 70,620 miles of highway. Of these amounts, 15,074 links, 14,330 nodes, and 11,319 miles of highway network were for these elements of Indiana’s State Roadway Inventory.

The Railway Network

The rail network developed by the Federal Railroad Administration (FRA) is based on topographic maps with a scale of 1:2,000,000. The accuracy of such a map is approximately 1,200 meters, about three quarters of a mile, in terms of root-mean square. There are other networks available at a scale of 1:100,000, but these did not contain some of the data necessary for analysis purposes in this study. For this reason the 1:2,000,000 network was used here. It consists of approximately 16,000 links and 11,500 nodes. Among the attribute data available in this network are a link identification code, origin and destination end nodes for each link, owner of the link, abandonment status, and traffic density. It was

this latter variable that was critical to later analysis.

COMMODITIES EXAMINED AND DATA SOURCES

It is desirable to have the commodities in a flow study be as detailed as possible. There is a very good reason for this. If the commodity groups are too general it is possible to get nonsensical results during flow modeling. For this study, all two-digit categories of the Standard Transportation Commodity Code (STCC) were examined in terms of their significance to Indiana's economy. A set of 18 commodity groups was identified. An additional group of five commodities was included in what is called “STCC 50" here. These additional manufactured goods include commodities of little economic significance to Indiana (see Table 1).

Also examined here are the flows of mail by the U.S. Postal Service and overnight express mail operations of companies such as FedEx. In these cases the analysis is of movements not covered by the other analyses, e.g, the movement of manuscripts, contracts, magazines, and the like.

Data Sources

The original design of this project anticipated using primarily models derived from the 1977 Census of Transportation to estimate the volume of goods produced or attracted by counties in Indiana and the states of the United States. This design was chosen because the most recent commodity flow data available was from that former census. There was no other census of such multimodal flow traffic available, although a commodity flow survey was underway at the time this project began. The data of that commodity survey was to become available in 1996, but this project was scheduled for completion much earlier than that. In effect, much of what is included here in the way of modeling was done on the 1977 data. This could not be redone with the 1993 data simply because much of this is not available even now. On the other hand all of the discussion of commodity flows into, through or within, and out of Indiana pertains to the 1993 data. In addition to using elements of the 1977 Census of Transportation [6], and portions of the 1993 Commodity Flow Survey [7], this study also made use of the various years of County Business Patterns [8] and the carload waybill sample on CD-ROM [9] in the modeling.

EXISTING FLOWS OF MANUFACTURED GOODS

Based on the 1993 Commodity Flow Survey, Indiana originated commodity flows valued at $178.7 billion. These flows weighed in excess of 285.8 million tons. The major commodities involved in these moves in terms of value were transportation equipment (19.2%), primary metal products (9.8%), food and kindred products (9.5%), electrical machinery (8.9%) and chemicals and allied products (6.4%). The major products in terms of weight were slightly different: petroleum and coal products (21.9%), non-metallic minerals (20.1%), farm products (14.0%), primary metal products (9.8%), stone, clay and glass products (7.7%), food and kindred products (7.4%), and chemicals and allied products (4.2%) (see Table 1).

Destinations of Indiana Shipments

Data are not published at this time on the destinations of Indiana's commodity shipments as such. Data are published on the destinations for "all shipments." For these data the major destinations in terms of value were Michigan, Illinois, Ohio, California, and Kentucky. The major destinations in terms of weight were Illinois, Michigan, Ohio, Kentucky, and Louisiana.
As one might expect, Indiana was the major destination of its own shipments in terms of value or weight. This is typical of most states.

Modal Choices

Mode choices for all shipments originating in Indiana were primarily truck, 77.3% in terms of value, but it is considerably higher than that for some of the manufactured goods examined here. Parcel and express mail account for 7.1% (based on value) of the shipments and these are most likely all manufactured goods. Rail moved only 6.9% of the traffic based on value and 15.2% based on weight. Air freight (excluding parcels) and truck-air moves accounted for only 1.9% of the value and .05% of the weight moved. These numbers are not consistent with other national figures in part due to the nature of the data collected. The figures are based on traffic originating in Indiana. Traffic passing through Indiana (or the U.S.) or traffic originating outside the country are not included here.

A discussion of the 19 sets of commodities and their importance to the Indiana can be found in the final report. For many small communities in the United States the only regular motor carrier traffic is the arrival of a U.S. mail contract motor carrier. These communities may also see the occasional overnight express delivery truck. If the items being sent are economic goods in the sense of a manufactured product or a retail item, these were included implicitly in the 1993 Commodity Flow Survey as such a good shipped by parcel and delivered by any of the aforementioned services or the U.S. mail. There are some exceptions to this statement; these are printed matter. Books, magazines, newspapers, and the like were not included in the survey. U.S. mail flows were estimated at 25.7 pounds per capita and shipments by express mail carriers were estimated at 6.8 pounds per capita, both on an annual basis.

Intermodal Traffic

There is considerable interest today in traffic shipments that are intermodal. For Indiana as a whole intermodal transport is practically insignificant according to the 1993 flow survey. In terms of tonnage, intermodal traffic represented less than a quarter of one percent of the total. This is looking at truck-rail, truck-air, and truck-water moves. If we throw in private truck-for hire trucks as intermodal, the percentage climbs to just under 1.25. Intermodal traffic volume represents about 3.6% of the total traffic originated in the U.S.

If we look at the value of goods the numbers increase as one would expect. In this case intermodal traffic has 3.2% of the total shipment value in Indiana. For the nation this statistic is 4.7% of the total shipment value. Nearly half of these percentage totals come from intermodal truck-air transport.

Summary

The various commodity groups that are included in this study of traffic flows (excluding the mail flows)

represent 93.7% of the value of all products shipped from Indiana and 93.9% of the value of all products shipped in the United States according to the 1993 Commodity Flow Survey. In terms of weight the commodity groups represent 98.9% of the originating tons in Indiana and 96.0% of the originating tons nationally based on the same 1993 survey.

The 1993 Commodity Flow Survey is shipper based and (for obvious reasons) only shippers in the U.S. were surveyed. Therefore, we get exports from Indiana, but we get no imports since the shippers of these are in foreign countries. Some crude estimates were made to partially correct this problem.

There are other components of the traffic stream that are not examined here. One of these is household moving vans. Twenty percent of the population in the U.S. moves each year and many of these use established moving companies. Data on these companies were once compiled by the Interstate Commerce Commission; it is not clear that data are compiled on individual moves, but it may be possible to estimate this from the decennial census.

A second component of the commercial vehicle traffic stream not examined here is service transport. Armored trucks moving bank receipts, tow trucks moving disabled vehicles, carpet cleaner vehicles, commercial laundry vehicles, construction vehicles, plumbers, lawn care vehicles, and many more are included in this service transport sector. It is a sector that has all but been ignored by transport planners, yet these are the commercial vehicles that make urban area arterials significantly more congested than rural arterials. If such vehicle moves are addressed at all in urban transportation studies, they are frequently handled by a growth factor (e.g., ten percent additional vehicles to account for trucks) or as a component of traffic counts (e.g., ten percent of the flow is trucks). This data shortcoming is far beyond the scope of this study to correct. It should be addressed first at the national level by a group such as the Transportation Research Board, which could undertake an examination of common practices by state transport planning agencies.

These are relatively minor components for a study of interstate and inter-county commercial transport flows involving Indiana. One can feel confident that the major non-local commercial vehicle flows are included here.

MODELING THE FLOWS

Let us now examine the methodologies used in estimating coal, non-metallic mineral, farm products, and manufacturing commodity flows for the state of Indiana. We will begin with an overview of the research design used here. This will be followed by specific discussions of the procedures used in the commodity production and attraction phases of the traffic generation analysis. The distribution of traffic, identifying the origins and destinations of commodity flow shipments, is discussed next. Once the origins and destinations of flows are known the next concern is estimating the modes taken by these flows; the method of splitting this distributed traffic between modes is discussed next. The final step in the analysis is to assign the traffic to the appropriate transport networks. In this case these are the highway and railroad networks discussed earlier in the paper.

Traffic Generation

As part of this commodity flow study it was necessary to identify the traffic originating and terminating within geographic areas across the United States. The approach used here involved determining the functional relationships that exists between production and attraction of commodity traffic and key variables capable of statistically explaining these flow variables. It is well established that the total flow of a commodity from a given place is statistically related to the total amount of the commodity produced there. Similarly, total flows to an area are related to measures of local markets. The objective then is to model these productions and attractions. In order to model productions and attractions, it is necessary once again to work with the flows of 1977. The flows existing at that time are statistically explained by using the levels of related variables at that time. The models derived can then be used with the level of the explanatory variables for 1993 to yield 1993 commodity productions and attractions. This research utilized multiple regression analysis to develop traffic production and attraction models for each of the nineteen commodity groups examined here.

The quantity of a manufactured commodity exported from an area is a function of the level of production of that commodity within the area or its supply. Unfortunately, commodity production data are also not available. Nevertheless, it has been demonstrated repeatedly that an excellent indicator of a sector's production is employment in the sector. Therefore, a key variable in the traffic production models developed is employment in the sector of interest or related sectors. Some of the commodity may never leave the production area since it is consumed locally. To incorporate this tendency, use is made of a population variable to represent this consumer market in several cases.

Flows of manufactured commodities into an area or the attractiveness of an area is a function of the demand for the product. For most manufactured goods there are two markets: the personal consumer market and the industrial market. With regard to the personal market, it is not meant that the manufacturing firms deal directly with consumers; they will most often go through a retailer or wholesaler. Nevertheless, the magnitude of this market is best reflected by the level of local population. The industrial market is often more difficult to identify. As an example, consider a commodity group such as food and kindred products. This group includes all the processed foods consumed by individuals as well as all the ingredients used in preparing other foods. As a result the level of manufacturing in these further stages of manufacturing also represent a market. Once again, employment is used as an indicator of this industrial market.

Returning to the problem at hand, the 1977 production and attraction levels formed the basis for models of the same based on 1977 population estimates derived by the U.S. Census and employment data derived from the 1977 *County Business Patterns* [10]. Models of non-manufactured goods (coal, non-metallic minerals, farm products, and waste) were not developed in the Phase 1. Models were developed for these sectors here using the 1993 CFS and census data.

The models derived along with an indicator of model accuracy appear as Table 2. While other variables important in explaining the levels of production and attraction will no doubt come to mind, there has been a conscious effort made here to keep the variable base limited and readily accessible. All of the models have used only variables on employment by sector, population, or some economic indicators. Forecasting the variables used into the future may be required and all of these have series available from

the aforementioned *County Business Patterns*, from population forecasts, or from other government censuses. On a couple of occasions the variables used are a function of other variables estimated. For example, the level of lumber and wood product flows into an area is a function of the level of traffic production in that sector. Derivation of these models yielded a method of estimating traffic produced and attracted by sector for all states of the United States and counties of Indiana in 1993. Overall the models tend to be accurate based on the adjusted coefficients of determination presented.

The appearance of the 1993 commodity flow survey changed the need to use the models derived for estimating state level productions and attractions to some extent. No data were published on the activities at the county level and as a result the models were used to generate Indiana county level productions and attractions.

The 1993 Commodity Flow Survey

As noted previously a commodity flow survey was undertaken in 1993. It was a survey of approximately 200,000 firms in the United States. It was not expected the data would be available for use in this study and this is part of the reason why the alternative methods noted above were developed. As the progress of the study slowed it became apparent that at least some of the data from the survey might be available before the project was over. The United States summary volume appeared in November of 1996 and some state volumes (including Indiana's) have also been published. In January of 1997 a CD-ROM was released by the Bureau of Transport Statistics of the U.S. Department of Transportation that gave among other things data on the amount of commodities produced (in a traffic generation sense) for the nearly all of the industrial sectors of interest here. After considering the quality of the data being released it was clear that the 1993 data being released was of a much higher quality than the 1977 Census of Transportation data. This was due in large part to the fact that the 1977 commodity flow data was based on a sample of 20,000 shippers and the 1993 data was based on a survey of 200,000 firms. The latter study is also much more aware of the statistical nature of the data collected, e.g., coefficients of variation are presented for most data and "unstable" data (usually based on small numbers in the sample) are not published. It seemed logical to use production and attraction data from the 1993 flows if this was at all possible.

Traffic originations were simple, but traffic attractions presented more of a problem. Recall that all of the state volumes had not been released. It is not clear that this would solve the problem or not. The problem quite simply is that there do not appear to be any figures given for total attractions by state and industry. There are tables on the CD-ROM that yield flows from an origin state to destination states by commodity and this might appear to yield a route to the data of interest, i.e., one could add the flows of each commodity of interest from all states to the destination state and get total attractions. This would be quite possible if all the data appeared on the CD-ROM, but interstate flows are often very scarce and the data are withheld for proprietary reasons. These same proprietary concerns would not enter into consideration if the data included the total traffic attracted by industrial sector. In other words the Bureau of Transport Statistics has the data and could do a special aggregation of the data for state modeling purposes.

There was not sufficient time to pursue negotiations for the release of attraction data by the Bureau of

Transport Statistics. Instead two pieces of aggregate information were used along with the regression models previously noted to estimate the traffic attracted to destinations. In the first case the models were run to estimate the "volume" that would be attracted to each state. The sum of these estimates by commodity was equated with the total attractions by commodity for the country; the latter total attractions is one of the pieces of aggregate information that kept the system in line with actual data.

The second piece of information was the total traffic attracted by commodity for the state of Indiana. This piece of data was used in the same manner as the other national data were used. In effect, the aforementioned models were run to estimate attractions for Indiana counties and the total attraction for the state became the flow limit for allocating commodity traffic to destination areas.

The result of these various operations can be summarized succinctly as follows: the total flows produced by the states are equal to the total flow produced by the nation; the total flows attracted by the states are equal to the total flow attracted by the nation; these same statements also apply to the counties of Indiana and the sum of their productions and attractions are equal to these values for the state. These controls enhance the accuracy of the methods used here.

Traffic Distribution

The distribution of traffic in the Phase 1 report was accomplished by developing several statistical models for traffic generation, as described above, and using these models to identify the production and attraction vectors for input to a fully constrained gravity model. The latter model is also sometimes called an entropy model (see Wilson [10] and [11]). Such a model can, given productions and attractions and an average length of shipment, yield estimates of the flow between all origins and destinations. It does this in such a way that the estimated traffic volume from any origin is equal to the value inputted to the model, the estimated traffic volume to any destination is equal to the value inputted to the model, and, in general the average shipping distance of the estimated flows is equal to the value inputted to the model. In effect, the outcome is constrained to meet all of the initial input parameters of the problem. This tends to yield the most accurate results of any general flow model currently in use. One could alter the output of any model and get more accurate results.

But the basis for such alterations is not clear, nor is it usually defensible.

This model has the general form:

$$S_{jk} = A_j B_k O_j D_k \exp(-\beta c_{jk})$$

where

S_{jk} = the amount of a given commodity shipped from origin area *j* to destination area k;

O_j = the amount of a given commodity available for shipment at origin *j;*

D_k = the amount of a given commodity demanded by destination *k;*

c_{jk} = a measure of the cost or impedance of moving from *j* to *k.*

In addition,

$$A_j = [\Sigma B_k D_k \exp(-\beta c_{jk})]^{-1}$$

$$B_k = [\Sigma A_j O_j \exp(-\beta c_{jk})]^{-1}$$

and

The above formulation is rather straightforward. Some comments are in order on the impedance or cost of movement factor, c_{jk}. This factor is defined here as the distance between a location *j* and a location *k*. Obviously other functions could be used, but this seemed as good as any [12]. The purpose of the impedance factor is to exercise a negative influence on interaction at increasing distances, other things being equal. Some researchers believe that this function should be actual road distance between places. If it were this would certainly complicate subsequent analysis which in part tries to identify the need for additional roads.

The model should be viewed as capable of replicating major shipping patterns in the area of interest; this is the United States and Indiana in the present instance. In effect, if certain aspects of the flow are known this model should yield what could be called the most probable set of flows given this information. This is sometimes called the most probable macro-state. This yields the major patterns of flow, which should be the major concern of the analysis.

The project also used actual data for Indiana to refine the modeled estimates for the counties of the state, i.e., the sum of the county estimates for each category was set equal to the state total. As a result the following statements can be made with regard to commodity flows examined in this study:

1. Total flows from all states as used by the gravity model are equal to actual traffic productions by manufacturing category for those states.

2. Total flows from Indiana and total flows to Indiana, by commodity, as generated by the model are equal to the actual flows as given in the commodity census.

3. The sum of the total flows as generated by the states for productions and attractions are equal to national totals for these.

The primary item being modeled here is tonnage of commodities shipped between origins and destinations in the United States for the year of 1993. As a result these flows are annual tonnages. In order to have something to compare average daily traffic with, it was necessary to reduce the flows to a daily basis. An examination of the *Highway Capacity Manual* [13] revealed that truck traffic generation was approximately equal from Monday through Friday, but on the week end the truck traffic generation rate appears to be about 44%. Adding five days and two days at .44 each yields 5.88 days per week or 306 days per year of trucking. Therefore, dividing the total annual flow by 306 yields a good estimate of commodity truck trips per weekday. Multiplying this weekday rate by .44 gives a reasonable estimate of the traffic on a Saturday or Sunday.

Modal Split

Once traffic is distributed between origins and destinations there remains a question of the modes selected for the movement of that traffic. The modal split computer model written for this purpose (NEWMODE) utilized 1993 data for nine single modes and eight multiple mode categories. While additional detail is always desirable it sometimes creates problems as well. The primary areas of interest in this document are highway and rail traffic. It would simplify the project if only truck and rail were given, but this would ignore several modal combinations that seemed to be rather common, e.g., truck and rail or truck and air. So that this traffic would not be lost all seventeen categories examined here has a set of distances (less than 50 miles, 50 to 99 miles, 100 to 249 miles, 250 to 499 miles, 500 to 749 miles, 750 to 999 miles, 1000 to 1499, 1500 to 1999, and 2000 or more miles) and for each distance group there are seventeen modal categories, plus some summary classes such as highway, or rail.

Commodity Density

To obtain density factors the tonnages of the 19 commodities coming into Indiana, and leaving Indiana by rail according to the expanded Waybill Sample were aggregated by commodity and rail carloads. Division of the former by the latter yields tons, by commodity, per carload, or commodity density. As one might expect these density factors differ based on whether they are in inbound or outbound and this may reflect the commodity's stage in the manufacturing process. A weighted average of these inbound and outbound density factors was calculated for rail cars and these appear as Table 3.

The density factors for motor carrier traffic assume that a rail car can handle 100 tons and a truck can carry 40 tons or 80,000 pounds, or 40% of the same product. In other words it was assumed that the motor carriers could handle 40% of the density factor of a rail car by commodity, and this is the source of the motor carrier density factor in the table. One could argue that some states permit vehicles with weights in excess of 80,000 pounds, but there is also a considerable amount of highway traffic moving in vehicles smaller than this. As a result, assuming all motor carriers are 40 ton vehicles seems a reasonable standard for use here.

Mail arriving in your local community usually arrives by a contact mail carrier operating a tractor-trailer or semi. Included in the trailer are bags of mail that can weigh no more than 70 pounds. Most are filled to this limit. A typical trailer can hold an estimated 450 bags or 31,500 pounds of mail. This translates into 15.75 tons per motor carrier.

Some counties may receive considerably more trucks than estimated here. That does not mean that our estimates are off. We were looking only at non-commercial mail (letters, manuscripts, photographs from your children or parents, contracts and the like). Other mail that may include commercial materials, e.g., a shirt from a mail order house, or some fresh fruit from a popular West Coast mail order firm, are included as parcel moves in the commodity flows examined elsewhere in this report.

Traffic Assignment

Methods of assigning traffic to a network are numerous. The simplest of these methods is referred to as "all or nothing" assignment. In this procedure the methodology assigns traffic moving between some

area *j* and some area *k* to the shortest path (route) between this origin and destination. All possible pairs of origins and destinations have their traffic assigned in exactly the same manner. There is no consideration given to the capacity of links in the paths selected or whether travel time on the links will be affected by congestion.

"All or nothing" traffic assignment has more than a few critics against its use in urban transportation planning, however the focus here is on regional or statewide transportation planning and most of the criticisms seem inappropriate in the regional context. For example, nearly everyone in Indianapolis that found they suddenly had to drive to Chicago would take Interstate 65 simply because of the shortest travel time of this route. In an urban context there might be some question about your route in getting to this interstate highway, and probably other assignment procedures would be appropriate for this portion of the trip. This does not matter in the present study because the flows being examined are inter-county and interstate trips.

The Highway Network and Cost of Movement

Traffic assignment techniques requires the construction of a network over which movement can take place. This network connects all origins to all destinations and includes the "cost" of movement over the links and in some cases the capacity of the links to hold traffic. Cost may be a misleading term because the measure used is rarely in dollars and cents. Instead studies over the years have used distance, travel time, or traffic flow functions related to distance or travel time. This project used travel time as its initial measure of travel cost. For large scale studies over an area the size of the United States travel time is rarely known. Instead it is approximated by the following:

Install Equation Editor and double-
click here to view equation.

Here the length is in miles and the speed is in miles per hour. This results in travel time being measured in hours or parts of hours.

One final point on the network is that whenever the cost of travel, or the way in which it is being measured, changes, or whenever the links in the network change for some reason, it is necessary to generate a new network for assignment purposes since the network expects to move flows between centroids, the network nodes must be consistent with the defined network.

Target Flows

The flows used by the traffic assignment procedures were the flows for all goods examined in this study. In other words, it included shipping the total highway tonnage of all 15 manufacturing groups and the four resource based commodities and two types of mail included in this study. This represented the sum of the 21 gravity model distributions by O-D pair. The reason for evaluating the traffic assignment routine using total flow was that this was the only variable that came close to existing data on actual flows. Existing traffic count data are actually expanded numbers of commercial vehicles per day on Indiana's highways over the period from 1991 to 1994. This became the target to which the traffic assignment had to demonstrate a relationship.

It goes without saying that commercial vehicle count data is not the best measure of manufactured or

primary commodity traffic on the highways. After all commercial traffic includes the movement of delivery and large service vehicles, as well as empty trucks. We have not examined the empty tractor trailer combinations here. The major implication of this is that the target flows were larger than the flows to be assigned. In addition, this study looked at inter-county flows, not intra-county flows, and as a result the target flows were generally larger within an origin or destination county.

The Highway Assignments

Initial applications of the 'all or nothing' traffic assignment routine to the travel time network resulted in too many vehicles being assigned to the Interstate links and virtually nothing being assigned to other links. This was not that surprising, but it clearly required some adjustments be made.

Redefining Highway Travel Cost

To handle some of the other problems a new mathematical function was defined for speed. It was:

$$New\ Speed = Old\ Speed + (2 * \sqrt{(65 - Old\ Speed}$$

This results in the following changes in speeds:

Old speed	New Speed
65.00	65.00
60.00	64.47
55.00	61.32
50.00	57.75
45.00	53.94
40.00	50.00
35.00	45.95

and travel time was redefined as

$$Travel\ time = Length/NewSpeed$$

This new travel time function had the effect of making 55 or 60 mph routes that were slightly shorter than an Interstate link competitive with the latter. Therefore in cases where loading points were near two highways matching the above situation, traffic would be assigned in part to each route. A new travel time network was created and this was used in another run of the 'all or nothing' traffic assignment routine.

Assignment Results

This adjusted travel time network resulted in a more reasonable allocation of traffic across the highways of Indiana suggesting that perhaps individuals do not see a great deal of difference between these higher speeds, which is exactly what the new traffic function implies.

Evaluation of traffic assignment results is not an easy matter. A researcher's first impulse is to simply undertake a correlation and regression analysis of the statistical relationship between the assigned flows

and the target flows from the total commercial vehicle road counts. In general this is not done in transportation planning studies at the scale of this study. Instead planners look at the distribution of trips and retain the assignment if it is “close” to the observed distribution. Nevertheless, a statistical analysis was undertaken here.

A sample of 40 locations in rural areas of the state, but including all types of highways, was drawn. The overall model "explains" about 48% of the variation in total commercial traffic using the flows assigned here to the 40 rural locations. This is a very significant result. Nevertheless, a higher level of explained variation would have been desirable for the overall relationship examined here.
A further evaluation of the traffic assignments was undertaken using the assignments of all goods (not just manufactured goods) to the Indiana highway network. The overall relationship dropped slightly yielding an adjusted coefficient of determination of .435. This gives an F statistic of 31.07, which is significant at the .001 level.

The Railway Network and the Cost of Movement

Although highway traffic assignment is controlled by travel time and the user’s desire to minimize this, or a cost version of the travel time, railway operations are not so preoccupied with this. It is certainly true that railroads want to move from origin to destination quickly, but speed is usually measured in days for railroads as compared to hours for highways. However, the problem is actually more complex than this.

Although there is some desire on the part of rail carriers to minimize the length of haul, they have a tendency to use mainline trackage even though secondary lines may be more direct. The question was how to represent this tendency with the rail data available for the digital network. Track condition plays a part in such decisions, but this is a very dynamic variable that would change more frequently than the database available. It seemed a new measure of spatial separation was necessary. The new measure of spatial separation would still incorporate an attempt to minimize shipping distance, but it would also pick those routes that the railroads tend to use. Short line or regional railroads that originate or terminate traffic are not important in this methodology, since the origin and destination of shipments must be reached. In other words these moves can be replicated by any methodology regardless of the cost attached to it simply because the end nodes of these moves are used as input to the methods.

The measure finally adopted had the form

$$I = (L\ (1/(D+1)))$$

where

I = the index of spatial separation;

L = the length of the line segment of the network; and,

D = the traffic density of the line in millions of gross ton-miles per year.

This measure diminishes the length of line segments by dividing the segment by its traffic density, i.e., by gross ton-miles per year. Typical traffic density values vary from 0 to about six million gross ton-miles per mile of line. When used on lines with high traffic density these routes “become shorter” and are always selected. Lines of low traffic density, do not become “longer” since their traffic density always has a unit value added to it. Lines of 0 traffic density would become lines of 0 length, if it were not for this correction

factor.

Target Flows

In the railway case there are no target values that are route segment specific. Data that are made available in the public use carload waybill sample are too gross to be used for this purpose. Very detailed information that would allow comparisons are available in a complicated fashion for flows involving the movement to, from, or through the state of Indiana, but translating compiled data into this format is difficult. As a result one must visually examine the flows to see if they are consistent with expectations.

Flows Assigned

The commodities assigned to the rail network are a product of this project and programs developed by it. More specifically, the traffic assigned is the product of NEWMODE, the computer program that splits commodity specific traffic between modes based on the length of haul. The basis for these splits is data published for the United States in the 1993 Commodity Flow Survey. In the case of some manufactured goods this is a very small amount of traffic since railroads during the latter part of the 20th century have loss significant market share for many manufactured goods to motor carriers. The total rail flows assigned are consistent with expectations.

Sources of Errors in the Assignments

It is reasonable to offer some explanation for the errors observed in the assignment process, but in order to do this it is also necessary to examine possible sources of error throughout the planning and analysis effort undertaken here. Some of these reasons have been stated previously, but they are restated here simply as a catalog of items that should be considered in future applications.

1. The network used in this study is an abbreviated representation of the state highway network. In other words there are places in Indiana where a substantial amount of travel occurs on local or county roads.

2. A second network related problem resulted in some highways of the state simply ending at the state border.

3. Still another source of error related to the network is the placement of external nodes

4. A related point is that beyond the circular highway network that surrounds Indiana all of the highways are part of the Interstate Highway System.

5. The models used for Indiana traffic generation are not perfect, and this could also result in some error in the estimates of production and attraction.

6. Manufactured goods shipped to the U.S. from a foreign country are missing in the data used here, to some extent.

7. The distribution modeling did not perfectly replicate the average shipping distance. The major

reason for this is the average shipping distances between states in the western U.S. It is not possible to constrain flows if distances between places are very large, relative to observed averages. Nevertheless, this does not appear to be a major source of error here.

The use of “all or nothing” assignment procedures is probably the best choice for a study of this type. However, it does seem that highway traffic flows at the scale examined here are in need of a new traffic assignment method. This method would look at the three or four best (e.g., lowest cost) routes that could be taken between an origin and a destination and assign probabilities to these. Trucks would be assigned in a Monte Carlo fashion with assignments proportional to their probabilities. For example, truckers passing through Chicago en route to Pittsburgh may consider Interstates 80, 65-70, or even U.S. 30. The proposed method would consider all of these as possible choices. This would overcome some of the shortcomings of the single least cost route of "all or nothing" assignments being selected all the time.

TABLE 1 Value and Tonnage of Major Commodity Groups Originating in Indiana

STCC Code	Value (millions)	Tons (thousands)	Commodity Group
01	$ 5,794	39,902	Farm Products
11	281	10,759	Coal
14	463	57,341	Non-metallic Minerals
20	16,958	21,039	Food and Kindred Products
22	275	93	Basic Textiles
23	7,795	553	Apparel
24	3,235	4,131	Lumber and Woods Products
25	3,120	734	Furniture and Fixtures
26	3,194	2,814	Pulp and Paper Products
28	11,474	11,957	Chemicals and Allied Products
29	9,008	62,500	Petroleum and Coal Products
32	2,748	21,972	Stone, Clay and Glass Products
33	17,485	27,881	Primary Metal Products
34	10,363	4,572	Fabricated Metal Products
35	9,504	1,023	Machinery, except Electrical

36	15,914	1,909	Electrical Machinery
37	34,401	6,731	Transportation Equipment
40	703	4,474	Waste and Scrap Material
50*	14,811	2,421	Other Manufactured Products

* Category 50 here includes STCC 21 (Tobacco Products), STCC 27 (Printed Matter), STCC 30 (Rubber and Miscellaneous Plastic Products), STCC 31 (Leather and Leather Products), STCC 38 (Instruments, including Medical and Photographic, as well as Watches and Clocks), and STCC 39 (Miscellaneous Products of Manufacturing). However, no data are included here for STCC 27 due to sampling and definitional problems regarding shipments in the *1993 Commodity Flow Survey*.

TABLE 2 Models of Production and Attraction

Model Number	Model	Adjusted R^2
(1)	PROD01 = 1445 -.523 AGSER + .0048 CASH	.562
(2)	ATTR01 = .819 PROD01	.660
(3)	PROD11 = 7.6 COAL	.650
(4)	ATTR11 = 3.1 COAL + 5.3 MIN	.657
(5)	PROD14 = .078 MAN	.658
(6)	ATTR14 = .997 PROD14	.977
(7)	PROD20 = .282 FOOD	.940
(8)	ATTR20 = .832 POP + .162 FOOD	.965
(9)	PROD22 = .016 TEX	.931
(10)	ATTR22 = .003 APP + .0001 ALL	.743
(11)	PROD23 = .004 APP	.919
(12)	ATTR23 = .002 APP + .011 POP	.926
(13)	PROD24 = .668 LUM	.808
(14)	ATTR24 = .728 PROD24	.805
(15)	PROD25 = .017 FURN	.906

(16)	ATTR25 = .033 POP + .002 FURN	.960
(17)	PROD26 = .103 PULP + .056 LUM	.886
(18)	ATTR26 = .085 PULP + .259 POP	.953
(19)	PROD28 = .150 CHEM + 1.164 PET	.758
(20)	ATTR28 = .077 CHEM + .455 PET +.683 POP	.851
(21)	PROD29 = 6.857 PET	.945
(22)	ATTR29 = 4.007 PET + 1.881 POP	.938
(23)	PROD32 = 2.882 POP	.851
(24)	ATTR32 = 2.914 POP	.871
(25)	PROD33 = .085 MET	.982
(26)	ATTR33 = .093 MET + .061 FAB	.923
(27)	PROD34 = .013 MET + .034 FAB	.927
(28)	ATTR34 = .035 FAB	.861
(29)	PROD35 = .013 MAC	.883
(30)	ATTR35 = .010 MAC	.878
(31)	PROD36 = .004 MET + .004 FAB + .003 ELEC	.826
(32)	ATTR36 = .005 FAB + .034 POP	.915
(33)	PROD37 = .040 TRAN	.753
(34)	ATTR37 = .027 TRAN	.837
(35)	PROD40 = .00048 POP	.704
(36)	ATTR40 = .0067 MAN	.791
(37)	PROD50 = 1.097 ATTR50	.858
(38)	ATTR50 = .245 POP	.857

Notes: Most of the explanatory variables above are employment in specific STCC (SIC) industrial classes according to County Business Patterns. Exceptions are the PROD and ATTR variables which represent tons of product shipped or received by STCC, e.g., PROD01 is the tons of farm products shipped and ATTR01 is the tons of farm products received. Other variables are defined as follows: AGSER = employment in SIC 07; ALL = total employment; APP = employment in SIC 23; CASH = gross cash receipts (in $1,000s) from farming; CHEM = employment in SIC 28; COAL = employment in SIC 11; ELEC = employment in SIC 36; FAB = employment in SIC 34; FOOD = employment in SIC 20; FURN = employment in SIC 25; LUM = employment in SIC 24; MAC = employment in SIC 35; MAN = total employment in Manufacturing, SIC 2 and SIC 3; MET = employment in SIC 33; MIN = employment in SIC 14; PET = employment in SIC 29; POP = total population; PULP = employment in SIC 26; TEX = employment in SIC 22; TRAN = employment in SIC 37.

TABLE 3 Traffic Density Factors for Rail Cars and Motor Carriers by Commodity

Commodity STCC	Import rail traffic	Export rail traffic	Weighted rail density (tons)	Weighted truck density (tons)
01	94.90	96.20	96.13	38.44
11	100.60	99.10	100.42	40.17
14	97.10	97.40	97.20	38.88
20	77.35	80.36	79.52	31.81
22	25.00	15.00	18.33	7.33
23	-------	-------	*10.00	*4.00
24	73.88	55.50	72.27	28.91
25	-------	15.00	15.00	6.00
26	64.82	50.64	62.10	24.84
28	85.11	90.11	87.58	35.03
29	63.20	77.16	65.90	26.36
32	86.70	77.10	81.15	32.46
33	87.48	85.21	85.82	34.33
34	28.40	16.16	19.76	7.90
35	68.75	21.70	28.42	11.37
36	18.80	16.25	16.69	6.68
37	19.93	23.40	22.50	9.00
40	75.40	82.60	78.47	31.39
**50	92.85	14.88	86.56	34.62

* Estimated values

** There is no STCC 50. It is used here to represent STCC 21, 27, 30, 31, 38 and 39.

REFERENCES

1. Black, W.R. and Palmer, J.A. (1993) *Transport Flows in the State of Indiana: Commodity Database Development and Traffic Assignment, Phase 1*. Bloomington, IN: Transportation Research Center, Indiana University.

2. Transportation Research Board (1997) *A Guidebook for Forecasting Freight Transportation Demand, NCHRP Report 388*, Washington, D.C.: National Academy Press.

3. Black, W.R. (1997) *Transport Flows in the State of Indiana: Commodity Database Development and Traffic Assignment, Phase 2*. Bloomington, IN: Transportation Research Center, Indiana University.

4. Caliper Corporation (1996) *TransCAD: Transportation GIS Software*, User's Guide, Version 3.0 for Windows, Newton, Mass.: Caliper Corporation.

5. Indiana Department of Transportation, *INDOT Road Inventory Computer Print-Out Supplement, A Users Guide*, Indianapolis: Indiana Department of Transportation, Roadway Inventory Section, Division of Program Development, undated.

6. Bureau of the Census (1982), *1977 Census of Transportation*, Washington, DC: U.S. Department of Commerce.

7. Bureau of the Census (1996), *1992 Census of Transportation, Communications, and Utilities, "1993 Commodity Flow Survey,"* Washington, DC: U.S. Department of Commerce.

8. Bureau of the Census (1979), *County Business Patterns*, Washington, DC: U.S. Department of Commerce.

9. Bureau of Transport Statistics, *Railroad Carload Waybill Sample*, various years, Washington, DC: U.S. Department of Transportation, CD-ROM.

10. Wilson, A.G. (1967), A Statistical Theory of Spatial Distribution Models. *Transportation Research 1 (3)*, pp. 252-270.

11. Wilson, A.G. (1970), *Entropy in Urban and Regional Modelling*, London: Pion.

12. Black, W.R. and Larson, R.C. (1972), A Comparative Evaluation of Alternate Friction Factors in the Gravity Model. *The Professional Geographer 24 (4)*, pp. 335-337.

13. Transportation Research Board (1992), *Highway Capacity Manual, 2nd Edition, Revised, Special Report 209*, Washington, D.C.: National Research Council.

The Oregon Statewide and Substate Travel Forecasting Models

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ABSTRACT

The Oregon DOT has embarked upon a Transportation and Land Use Model Integration Program, designed to build a set of consistent and scalable analysis tools for studying the interaction of land use, transportation, and the environment. These models, which will operate at different spatial scales, are integrated models of land use and transportation. That is, they use consistent models of location and activity choice, as opposed to linked models of transportation and land use. Discrete choice and random utility concepts are employed throughout the model. While employed elsewhere in the world, models of this nature have only recently been attempted in the United States. The models described are aggregate models implemented in TRANUS, and are the first of their kind to be applied at the statewide and regional levels in North America.

This paper focuses upon a statewide land use-transport model for Oregon, which has been recently implemented. It focuses primarily on intercity tripmaking, and takes into account the economic interaction between places within Oregon. The market for land is represented by demand functions for several categories of households, businesses, and public uses. These socioeconomic sectors interact through a social accounting matrix, which is an extension of the regional input-output model formulation. The paper describes the collection of the data required to implement the model, as well as their role in model estimation.

The activity location and interaction component of the model is expressed in terms of production and consumption. Each sector in the model interacts with others through logit-based demand functions that vary as a function of production and transport costs. The spatial relationships are expressed in terms of flows between both sectors and zones. The structure of the activity location model are described in general terms, as well as the derivation of input-output flows for Oregon.

The activity flows are transformed into flows of persons and goods in an interface module. Data from passenger and freight surveys are used to convert activity flows (measured in dollars, acres, or employment) into daily vehicle and truckload equivalents. Trip matrices are generated for specific trip purposes, which are then assigned to a multimodal, multicommodity transportation network. A stochastic equilibrium assignment model is used to depict network flows and to calculate travel costs and measures of accessibility. These costs and disutilities are then fed back to the activity location model until convergence is reached. The final network costs influence activity location and interaction in the following time period. The model was calibrated to 1990-1995 data, and uses 5-year intervals for forecasts through 2025.

The resulting model can be used to examine a variety of transportation and land use policy actions and their interactions through time. The integrated structure of the model ensures that effects are consistently reflected in both the activity and destination choice models. The paper concludes with a discussion of the extension of the statewide model to the substate level in Oregon, integration with metropolitan models within the state, and ongoing research and development of both models.

INTRODUCTION

The Oregon Department of Transportation (ODOT) has embarked on an ambitious Transportation and Land Use Model Integration Program (TLUMIP). The metropolitan planning organizations have been key partners in the program since its inception. Now in its third year, the program seeks to develop a set of consistent, scalable land use-transportation models for use in transportation planning and policy analyses at varying scales of geography. A series of first generation models are now complete, which both demonstrate the overall validity of the concept as well as placing useful tools in the hand of Oregon transportation planners. A three-tiered modeling approach has been pursued in the work to date, focusing on statewide (intercity), substate (regional), and metropolitan levels of resolution. The substate model is actually an extension of the statewide model, both of which are discussed further in this paper.

Overview of Required Analytical Capabilities

The design of the land use-transport model began with an assessment of the policy and investment issues the model should be capable of addressing. The need to evaluate a number of issues unique to Oregon, such as the presence of urban growth boundaries, influenced the design of the model. The study team, with the assistance of the peer review panel and modeling steering groups, identified eleven issues that the candidate model should be capable of assessing:

1. The effect of land supply on land use and location decisions
2. The effect of land supply on travel behavior
3. The effect of highway capacity increases on travel behavior
4. The effect of rail investment on highway use
5. The effect of changes in the demographic and economic composition of Oregon
6. The effect of congestion on land use and location decisions
7. The cumulative effect of retail location choice
8. The effect of large commercial development on the periphery of the growth boundaries
9. The effect of network connectivity on travel behavior
10. The effect of parking supply on travel behavior
11. The effect of urban form on mode choice

All three levels of the candidate model - statewide, substate, and metropolitan - were to be able to address the first five issues. The next four issues were more germane at the substate and metropolitan levels, while the effects of the last two were considered only within the context of a metropolitan model.

The program began with an assessment of existing models of land use and transportation in both the U.S. and abroad. A number of important conclusions were reached. Consensus was quickly reached that existing models were not well suited to examine many of the key issues identified above. The study team concluded that a series of nested logit models of location and destination choice applied at the

disaggregate level offered the most promise. However, such a model had to be developed from scratch; such models had been postulated in the literature but none had been successfully implemented. The study team, working closely with the peer review panel, decided to build such a model for metropolitan areas, but concluded that significant risks precluded its development for the statewide level as well. Instead, it was decided to build a prototype statewide model using an existing modeling framework. After considerable discussion and research, the TRANUS package was selected for this task.

Structure of the TRANUS Model

The TRANUS system is a general and flexible tool for the simulation and evaluation of land use and transport policies. Unlike many other candidate models, TRANUS employs a totally consistent model of location and travel choice. It explicitly models the relationship between land use, economic activity, and the transportation system. While the framework of TRANUS is fully specified, it is flexible in the definition of the study area and its attributes; as little or as much detail can be included in the definition of the system under study. The TRANUS framework is discussed in considerable detail by De La Barra (1989); additional information about the package can be found at http://www.modelistica.com.

At the heart of the modeling system is a spatially indexed input-output representation of the study area. Input-output models have been extensively used to study the interaction between sectors of the economy. The economic activity in Oregon was aggregated into twelve sectors, as shown in the upper part of Figure 1. A separate economic model was used to exogenously generate the flows between these sectors for the entire state. An important goal in our project was to maintain compatibility with economic inventories and forecasts used by other state agencies. The ability to use exogenous estimates of both the marginal totals by sector as well as their interactions allowed considerable flexibility in this regard.

The input-output framework is extended in the TRANUS system in some important ways. It is extended into a spatial dimension in a manner analogous to traditional travel forecasting models; in effect creating the input-output table shown in Figure I for each of the 142 zones in the model. In this manner economic flows, measured in annual dollar terms, flow not only between sectors but also between zones. In order to introduce the land use and demographic components, sectors were defined for three types of households (low, medium, and high income) as well as for several land markets. The markets include single and multi-family urban residential, rural residential, commercial, industrial, and agricultural and forest lands. The resulting matrix has been termed a social accounting matrix in order to distinguish it from the simpler input-output models. In the matrix shown in Figure 1, businesses consume the output of other businesses, land, and households. In the case of the latter, the demand for households is for labor; the dollar flows moving in the opposite direction represent wages and benefits.

The TRANUS system is deeply grounded in random utility theory and discrete choice modeling. The latter are most often implemented as logit models. Their ability to be ordered in nests permits them to be used for modeling decision chains. In TRANUS they are generalized beyond their traditional application in mode choice modeling. All decisions at all levels in TRANUS, from location choice to route and mode choice, are modeled using logit models. In a sense, TRANUS can be viewed as a long chain of nested logit models. The random term of the function is used to account for the variation in the modeled behavior, as well as to account for non-modeled factors. This framework is used to model the spatial accounting matrix. Logit-based demand functions are defined to allocate the flow of goods between

sectors and zones. These functions are bounded by minimum and maximum values, elasticities, and spatial dispersion parameters. The social accounting matrix and the demand functions collectively make up the activity location component of the model.

The economic flows in the social accounting matrix are measured in annual dollars, which are tractable for the purposes of depicting the flows between sectors of the economy, but are not meaningful when expressed as transportation demand. A land use-transport interface is used to transform the flows in dollar terms to equivalent flows of persons and goods. This is shown in the middle of Figure 1, where transportable flows[1] are transformed into trip purposes found in traditional transportation models. Travel survey data were fused with data from the Public Use Microsample (PUMS) data to arrive at the factors used to render the economic flows in terms of trips. Once expressed in terms of trips, the flows by purpose are matched up with eligible modes of transport and assigned to a multimodal transportation network. A stochastic user equilibrium assignment technique is used for route choice and network assignment.

One important product of the network assignment is the calculation of accessibility indices for each zone. These indices are used directly by the activity location model, where it influences the spatial interaction between sectors. Indeed, the activity location model attempts to balance the cost of land with accessibility; decision makers are assumed to make trade-offs between the two factors within the constraint of available income. The feedback does not occur instantaneously, however, but rather becomes an input to the model in the following time period. This lagged effect represents the delay in which such effects are perceived by households and businesses in the real world. The progression of the model through time is shown in Figure 2. In the statewide and substate models, a time interval of five years was used.

To use the model in forecasting mode, increments of exogenous variables are specified. Such variables include employment by sector, imports, exports, and available land by sector. These increments can be specified for the entire study area (the entire state of Oregon in this case) as well as for specific zones. Transport costs and activity patterns from the previous time interval become the starting point for the new interval. The model attempts to balance supply and demand by sector and zone iteratively; a price mechanism is used to adjust price up or down as appropriate. The model steps through time in five year increments, beginning in our base year of 1990.

Development of the Substate Model

The statewide model divided Oregon into 142 zones. At this level of resolution the model could be applied to studies of intercity flows or of large changes in land use (such as the relaxation of the urban growth boundaries). The statewide model was also viewed as the backplane upon which a finer level of zonal and network detail could be arrayed in order to carry out major corridor studies. Many of the corridors identified as likely candidates for evaluation using the model were only partially included

[1] Some sectors, such as the land sectors, are not transportable. The economic flows to and from them are not included in the transport model, although trips to and from them are.

within the boundaries of the traditional urban travel modeling areas, and some corridors connected two metropolitan areas. A prototype substate model was designed for use in these studies. It was decided that the Willamette Valley, the eleven counties in Northwest Oregon that contained the majority of the state's population and employment, would be focus of the substate modeling efforts. This area extends from Vancouver, Washington in the north to Eugene, Oregon in the south, and includes most of the popular tourist destinations in the state.

Using the candidate corridors and the zone systems of the existing urban travel demand forecasting mod els as a guide, the study team broke the substate area into approximately 350 zones. Census tracts were used to define the zone boundaries. All but one of the metropolitan planning organizations used tracts to define the traffic analysis zones in their travel forecasting models, allowing their zone system to nest beneath the substate model zone system.

A typical application of the TRANUS framework encompassed between 25 and 50 zones. The state wide model (142 zones) already pushed the limit on the number of zones that could be handled using it.[2] Because of concerns about data availability and model performance, it was decided to pursue a hybrid modeling approach, illustrated in Figure 3.

The statewide model was used to simulate the interaction between the economic and land sectors described earlier. Once the statewide model iterates to convergence, the trip matrices by purpose are exported to an external program that synthetically allocates the origins and destinations (at the statewide zone system) to the substate modeling zones. The flows are evenly distributed to the substate zones nested beneath each statewide zone if no better information is available. In the most parts of the Willamette Valley, however, land use data at the substate zone level are used to apportion the flows. These expanded trip matrices are then assigned to a finer roadway network than is used at the statewide level, which allows a broader range of alternatives to be modeled at an appropriate scale.

The TRANUS transport model is used for the substate network assignment, maintaining a consistent methodology and user interface. Finally, the substate model zone-to-zone impedances and accessibility indices are passed back up to the statewide model. A weighted average, based on the share each substate zone comprises of the statewide zone it is nested beneath, is used aggregate the values back up to the statewide zone system. If the resulting statewide zonal accessibility indices change in a significant way, the statewide model is run again with the new values. This feedback loop continues until a user-specified degree of convergence between the substate and statewide transport model results is achieved.

Model Calibration Targets

A surprising finding of the research into current practice was that no clearly defined model calibration or validation criteria existed for integrated land use-transport models. The study team and peer review

[2]The software is not limited to a maximum number of zones. The limit on number of zones is more a function of the ability of the user to obtain the required data for model calibration, and the immense amount of output which the user has to grapple with in order to understand how the model is working. Recall that each zone has up to 21 sectors active within it, as well as several derived trip purposes - a lot more information than a traditional model would encompass.

panel together developed several criteria for assessing model performance:

1. Match economic production (measured in dollars) by sector and zone
2. Match number of trips and average trip distances by trip purpose
3. Minimize zone-specific constants by sector
4. Network flows to match counts by mode of transport, with emphasis on interurban
5. Match increments of land to changes in land price
6. Match CTPP county-to-county patterns of commuting flows.

Each of these criteria have specific numerical targets. The network flows, for example, must fall within specified ranges based on total observed volume. Some of the targets are more liberal than for traditional urban travel models, owing to the greater complexity of the integrated model. In addition, several subjective tests of model performance were developed. In each case the model was required to produce sensible and reasonable results, although specific numerical targets could not be defined:

1. Destination and route choice response behavior
2. Trip generation sensitivities
3. Path and transport cost testing

The statewide model met the calibration targets and was judged to perform well. The substate model has only recently been completed and has not yet been subjected to rigorous calibration. These criteria appear to be achievable regardless of the geographic scale the model is applied, although additional thinking needs to go into the development of criteria for the land use side of the model. Even in their present form, the standards can be useful for measuring the performance of any integrated land use-transport model.

Data Requirements

A common obstacle to the use of land use-transport models has been the amount of data required beyond those needed for traditional travel forecasting models. The widespread deployment of geographic information systems have provided many of the required data and tools needed to manipulate and render them. Many of the data required to develop and apply integrated land use-transport models are not overly burdensome to acquire, although they are unfamiliar to most transportation planners.

The data required to develop the statewide and substate models in Oregon are shown in Table 1. The transport supply and demand data are comparable to those required to develop traditional travel demand forecasting models. The same is true for the land use-transport interface data, except that factors must be developed to translate flows in dollars to equivalent person and freight movements.

Robust land price and supply data proved to be the most difficult to obtain. Residential land sale transaction data were readily available, but non-residential sales were not very plentiful even over a five-year period. We eventually convened a Delphi panel of commercial realtors to help derive current

and historical trends in non-residential land prices for the three metropolitan areas in the Willamette Valley (Salem, Eugene, and the Portland/Vancouver area). The use of Delphi panels to collect certain types of land data is likely to play a larger role in future model development work.

Future Directions

The first generation prototype models have recently been completed, and the results have been very positive. A successful Symposium reviewing the work to date, as well as research and development work in activity-based travel modeling, was held in Portland on 30 September-1 October 1998. In addition, a formal training program in both the theoretical underpinnings of land use-transport modeling as well as this specific implementation is being developed, and will be presented in early 1999. The model development work is ongoing; the following tasks are planned for the next stage of the program:

- Reassessment of the system architecture
- Begin work on the second generation models
- Continued refinement of the land price and supply data
- Better user interface, to include tighter GIS integration and a scenario manager
- Tighter linkages with Portland Metro and Port of Portland work
- Incorporation of the 1995 American Traveler Survey results

These efforts began this past summer (1998) and are expected to last from 24 to 36 months. More information about the TLUMIP program, including the technical documentation, can be found on the TLLTN41P web page at http://www.odot.state.or.us/tdb/planning/modeling/modeling.html.

CONCLUSION

The goal of the first phase of the TLUMIP was to develop a set of prototypical integrated land use-transport models at the statewide, substate, and metropolitan levels. The statewide and substate models have been successfully implemented and calibrated in TRANUS. The prototypical models will be implemented and used by ODOT staff for planning and policy analysis work while the second generation models are under development. The experience gained to date suggests that integrated land use-transport models are plausible and can provide policy-makers and planners with timely information about the interaction between land use, transportation, and the environment. The models developed to date have proven that such models can be developed and deployed by transportation planning agencies in the U.S. in a cost-effective manner.

REFERENCES

De La Barra, Tomas. (1989) Integrated Land Use-Transport Modeling. London: Cambridge University Press.

CHANGES

	AGFF	CONS	OMFG	WOOD	PRNT	TECH	TCPU	WLSE	RETL	FIRE	SERV	GOVT	HHIncLo	HHIncMi	HHIncHi	AGFF	IND	COM	SFR	MFR	RUR
Land Supply Exog. Demand	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r
ECONOMIC FLOWS	PRODUCING SECTORS																				
CONSUMING SECTORS	Industries												Households			Land					
Industries																					
AGFF	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f	e	e				
CONS	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f		e				
OMFG	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f		e	e			
WOOD	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f		e	e			
PRNT	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f		e	e			
TECH	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f		e	e			
TCPU	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f		e	e			
WLSE	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f			e			
RETL	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f			e			
FIRE	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f						
SERV	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f						
GOVT	f	f	f	f	f	f	f	f	f	f	f	f	f	f	f						
Households																					
HHIncLo	f	f	f	f	f	f	f	f	f	f	f	f							e	e	e
HHIncMi	f	f	f	f	f	f	f	f	f	f	f	f							e	e	e
HHIncHi	f	f	f	f	f	f	f	f	f	f	f	f							e	e	e

TRANSPORT FLOWS / TRANSPORT CATEGORIES	AGFF	CONS	OMFG	WOOD	PRNT	TECH	TCPU	WLSE	RETL	FIRE	SERV	GOVT	HHIncLo	HHIncMi	HHIncHi	Passenger	Freight
	PRODUCING SECTORS: Industries												Households			MODES	
CmuteLo													1			1	
CmuteMid														2		1	
CmuteHi															3	1	
Recreation	4								4		4	4				1	
HBOther									5	5	5	5				1	
NHBOther									6	6	6	6				1	
NHBWork	7	7	7	7	7	7	7	7	7	7	7	7				1	
VisitorBus																1	
VisitorOth																	2
FreightLo	8	8	8	8	8	8		8									2

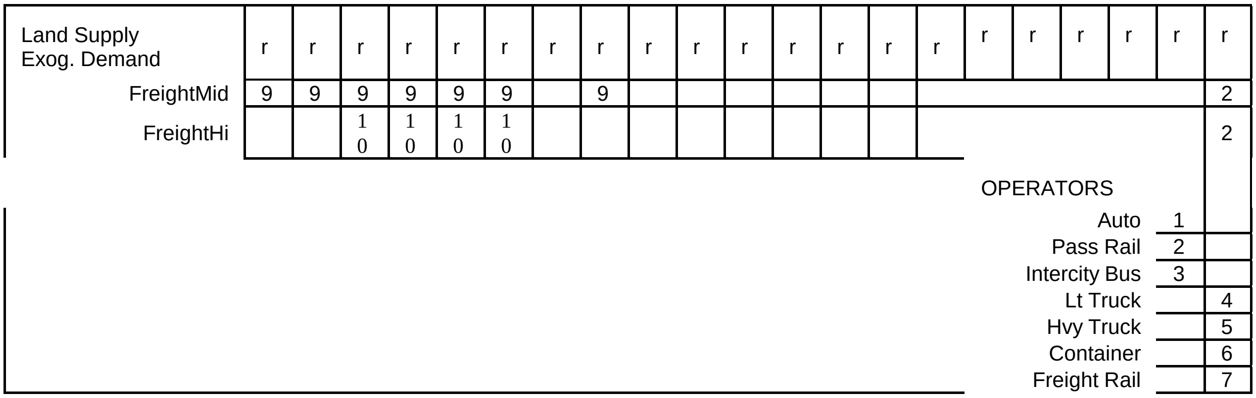

FIGURE 1 Flow Relationships in the Statewide Model

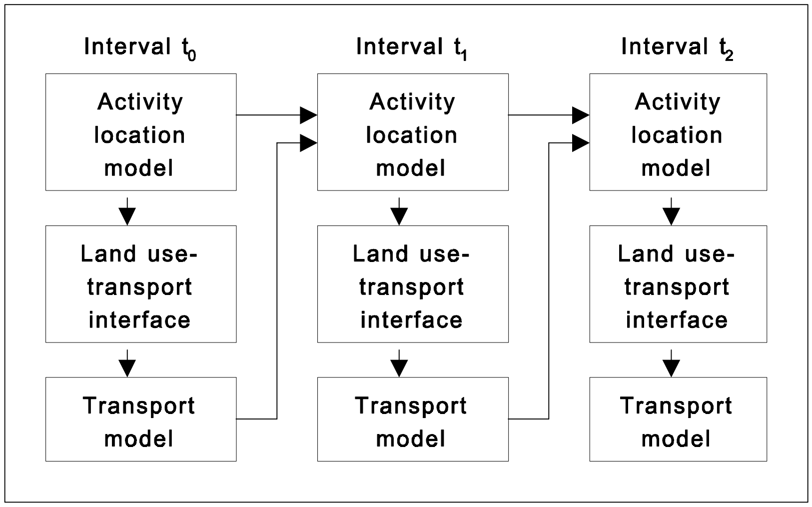

FIGURE 2 Relationship Between Components Over Time

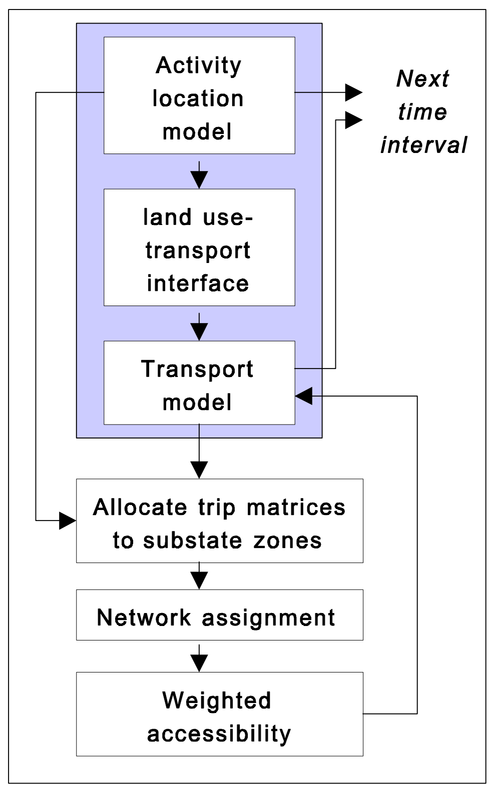

FIGURE 3 Substate Modeling Framework

TABLE 1 Land Use-Transport Model Data Reports

Land use and socioeconomic data
Base year socioeconomic data (input-output accounts, induced production, etc.)
Exports by sector
Imports by sector
Restrictions on internal production by zone and sector
Location utility function parameters
Demand function parameters
Demand substitutions
Attractors of exogenous demand
Attractors for induced production
Global increments of exogenous production and consumption
Increments of exogenous demand, production, and external zone exports and imports
Increments of endogenous location attractors, production restrictions, and value added to production
Land use-transport interface data
Time and volume conversion factors, directionality of flows
Intrazonal costs
Exogenously defined trips
Transport supply and demand data
Network (link endpoints, length, capacity,

etc.)
Transit lines
Trip purpose characteristics (available modes, value of travel and waiting time, etc.)
Trip generation and mode split parameters (elasticity, dispersion, and scaling factors)
Energy and operating costs
Vehicle operating characteristics
User charges (fares and tariffs)
Speed-flow curve parameters (for network assignment)

The Wisconsin Multi-Modal Intercity Passenger Demand Forecasts

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INTRODUCTION

In 1995 the Wisconsin Department of Transportation (WisDOT) concluded a long-range statewide transportation planning process called *TRANSLINKS 21.* At its completion, *TRANSLINKS 21* outlined a comprehensive transportation system to move people and goods efficiently, strengthen the economy, protect the environment, and support the quality of life within Wisconsin.

This paper focuses on the multi-modal, intercity, passenger transportation analysis component of *TRANSLINKS 21*. The scope of this "multi-modal intercity freight" analysis is defined as follows:

- "Passenger" refers to the transportation of people instead of goods or commodities. The TRANSLINKS 21 planning process included a parallel "multi-modal intercity freight" analysis.
- "Intercity" travel comprises longer distance trips generally between states, counties, and major urban areas. This does not include "local" travel within urban areas, which was addressed in *TRANSLINKS 21* through the existing metropolitan planning organization (MPO) planning process at the local level.
- "Multi-modal" refers to the analysis of more than one mode, or method of travel. The *TRANSLINKS 21* intercity passenger analysis addressed the following existing and future intercity modes of travel:
  - Automobile, including car/van/truck travel by highway
  - Air, currently provided by airlines
  - Rail, currently provided by Amtrak
  - Intercity bus, currently provided by Greyhound and other operators
  - Feeder bus/rail - a proposed integrated bus-rail system with coordinated schedules and through ticketing
  - High speed rail - a proposed new rail mode capable of 125 miles-per-hour speeds over improved track

The purpose of the multi-modal intercity passenger analysis was to provide a technical foundation and basis for the evaluation of alternative future multi-modal scenarios and for the selection of a preferred future multi-modal scenario by WisDOT. Specifically, this included developing estimates of future (1.) Travel demand, ridership and revenue, and (2.) Capital and operating costs for each intercity passenger mode under each of the future statewide multi-modal

scenarios.
A significant portion of the multi-modal intercity passenger analysis effort was dedicated to the development of base data, models, and related tools for forecasting future travel demands and costs. In particular, this included the development of a new multi-modal intercity passenger model system for the Wisconsin study area - the first such modal system addressing intercity passenger travel demand statewide on a multi-modal intercity passenger analysis to WisDOT for continuing use by WisDOT staff.

The multi-modal intercity passenger analysis consisted of the following key task activities:

- Define study area and geographic detail
- Conduct travel surveys
- Develop travel data base
- Develop multi-modal network/service inputs
- Assemble socio-economic inputs
- Develop multi-modal intercity passenger demand model system
- Define future *TRANSLINKS 21* scenarios
- Prepare future cost estimates
- Prepare future travel demand forecasts

Each of these task activities effectively represents an input, a process, or an output of the multi-modal travel forecasting approach applied in the intercity passsenger analysis and illustrated by Exhibit 1.

Travel surveys provide the foundation for the multi-modal travel forecasting process. Two types of travel survey data were assembled and collected in the analysis:

- Origin/Destination survye data, which quantify the size of existing current travel markets by trip origin, trip destination, mode, trip purpose, and other characteristics
- Preference survey data, which provide onfromation on travelers’ existing behavior and stated intentions in response to different travel service scenarios

In addition to the travel suveys, the other two key inputs to the multi-modal travel forecasting process include:

- Socio-Economic inputs, which define population growth and changes in economic activity at trip origins and destinations between existing and future forecast year conditions
- Network/Service inputs, which define the level of service (e.g., travel time, travel cost/fare, frequency of departures, etc.) Between trip origins and destinations provided by each mode

fro existing conditions and future scenarios

These inputs feed the development and application of demand models for multi-modal intercity passenger travel. These models consist of two major components, which address:

- Total travel volumes of intercity passengers by all modes between each origin and destination
- Mode share captured by each competing intercity passenger mode of travel between each origin and destination

The total travel model component addresses growth in total intercity person travel volumes, including both: "Natural" growth resulting from changes in population and economic activity

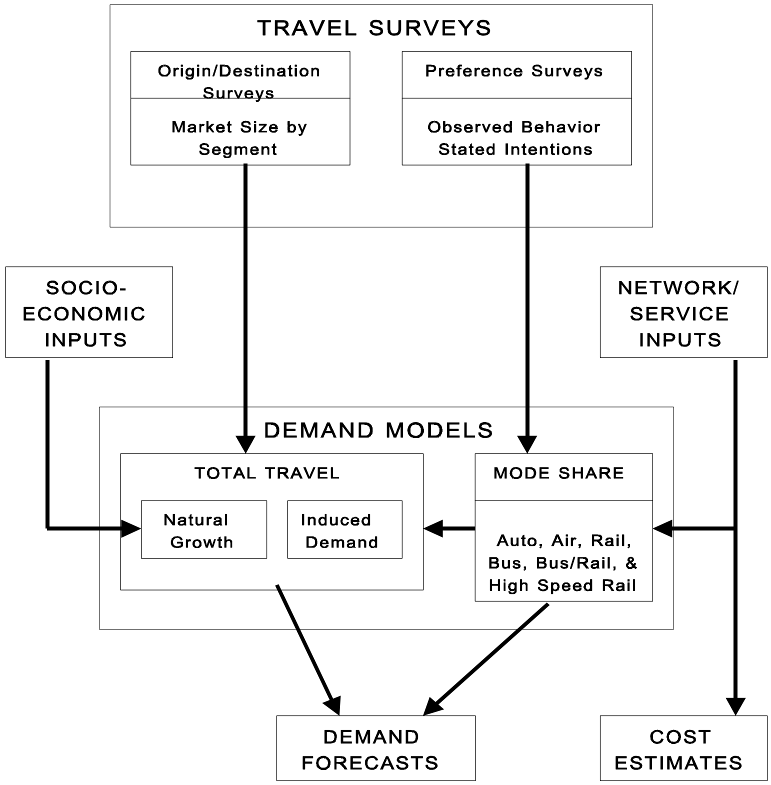
- "Induced" demand resulting from improvements in the combined levels of service provided by all modes

The mode share model component predicts the market share of total person travel for (1) automobile, (2) air, (3), rail, (4) intercity bus, (5) feeder bus/rail, (6) high speed rail as a function of the level of service (e.g., travel time, travel cost, etc.) Provided by each mode. Forecasted travel demand by mode is then simply the product of the results of the total travel and mode share model components.

In the multi-modal intercity passenger analysis, travel demand forecasts and cost estimates were developed for several different future years and transportation system service scenarios and for the selection of a preferred future statewide multi-modal intercity passenger scenario by WisDOT.

EXHIBIT 1

Multi-Modal Forecasting Approach



Research Recommendations
Statewide Travel Forecasting Model Workshop

WORKSHOP 1

Travel Survey - Conduct a nationwide survey of freight vehicles, carriers and commodities crossing state lines and a simultaneous port of entry survey. The surveys should be designed to capture the origin, destination and mode of shipments and should be used to establish a basic interstate flow matrix which the states could use as a start for their analysis of intra-state movements.

Economic Effects - Develop a better understanding of the relationships between commodity flows and models of the economy. Consider the implications of economic projections from economists and econometricians for commodity flows and demand for transportation facilities and services which are or might be supplied by or regulated by the states.

Synthesis of Practice - Conduct a review and synthesis of statewide travel demand forecasting and modeling practice across the states. This should be larger and deeper in scope than typical NCHRP Synthesis projects and should have greater resources than were available to Alan Horowitz for preparation of his draft manual. This would serve as a source of information about and contacts for statewide travel forecasting work. This would include an evaluation of the appropriateness of different techniques for various needs and circumstances. Guidelines should be prepared to help practitioners understand what is good and what is available for different uses.

Comparison to Urban - A comparison and analysis of the differences and commonalities between urban, regional and statewide travel demand forecasting procedures should be conducted.

Preference Surveys - Well designed, administered and coordinated stated preference and revealed preference surveys of choice of inter-city travel modes should be conducted. The choices offered in the survey should include both actual and prospective modes.

Model Options - There is no single best model or technique for statewide travel demand forecasting or for analyses and forecasting travel at the sub-state level. States should be encouraged to adopt techniques which best suit their particular and specific needs and available resources.

Training and Coordination - There is a need for better training for transportation planners in the use of GIS software and tools, better spatial data and geo-coding of currently available data, and better coordination by transportation planning and analysis agencies and staff with other users of spatial data at the state and local levels.

WORKSHOP 2

Data Issues - Research should be conducted to describe national data bases and their potential for use by states for travel forecasting. The research should also identify the similarities among travel model parameters and input data used by the states for travel models. The commonalities and similarities among inputs used by the states' travel models should be used to validate or modify the national data

bases. Research should also investigate the sensitivity to input data of models and decisions based on them. The research should attempt to determine if, what and when national data can be used in lieu of or in addition to local data. The research should provide the states with guidance on the potential use of national data in their travel models and an assessment of the sensitivity of their models and decisions to particular inputs.

National data should be used more often and more extensively in statewide travel forecasting. Borrowing data and transferring travel model parameters between states having similar situations should be encouraged. These steps will help to reduce the cost of statewide travel analysis and will improve multi-state studies.

Procedures should be developed for estimating portions of freight movement not in the Commodity Flow Survey (CFS), such as waste and imports and considering dead-heading. Data should be developed on the total amount of commodities received at destinations.

Trip generation rates should be developed for rural areas. Changes in trip generation rates due to changes in employment and worker productivity should be examined.

Freight Issues - Tools should be developed that analyze the impacts on transportation of ports, sea borne commerce, railroad mergers and the global economy. Tools should be developed to treat intermodal transportation appropriately, particularly dealing with cost issues. Better data should be developed on intrastate freight movements. Models should be developed to incorporate freight logistics into statewide travel forecasting with particular emphasis on traffic assignment, and non-modeling solutions should be examined. Multimodal networks should be developed for use in these and other freight analyses.

Model Applications - The relationship between the economic health of a state and its transportation system should be investigated. The states and their MPOs should coordinate their travel forecasting procedures used for analyzing transportation policy issues. State and MPO models should at least be coordinated if not fully integrated. The trip purposes used for the 4-step urban travel forecasting process should be considered for use in statewide modeling. The potential for simulation based modeling should be considered for statewide modeling. Another enhancement would be developing transportation models for commercial trips.

Land Use - Research is needed on the relationship between land use and transportation for statewide travel. Incorporating land use into the statewide travel forecasting process will require resolving the issues associated with obtaining the data needed by the travel models. Among these are determining the ability of state and local agencies or other sources to collect and maintain a consistent statewide data base that includes land use and land price. The potential role and benefit of using expert panels to develop statewide land use plans should be investigated.

Alternative Modes - Tools should be developed that evaluate new modes, such as high-speed rail and air, versus truck freight, for multi-state, multimodal analysis. Research should be conducted on the potential effect of teleworking and electronic commerce on statewide freight transportation and how to incorporate that effect in statewide travel models.

External Trips - Methods should be developed for models to consider travel that extends beyond state borders. Travel models should be developed to assess impacts of snowbird/sunbird migrations and how to collect data and forecast growth in that travel. The gaps between local and national data on interstate travel should be assessed.

WORKSHOP 3

Internet Website - A world wide web site for statewide travel forecasting should be established to promote and establish new modeling techniques and case studies, to provide for ongoing sharing of information on travel model improvements, and to facilitate evaluation and critique of those improvements as they occur and become available. The new web site should facilitate access to technical documents (especially case studies), data sources, resources to aid model users, including a list of experienced contacts willing to provide technical assistance, and training opportunities. An electronic mail list for interchange of information and a search engine for scanning the Internet for further information on travel forecasting should also be provided. This should be an on-going activity funded by contributions or assessments from individual states signed up to use the web site and matched by contributions from the federal government agencies.

Secondary Data - The states should be encouraged to research, locate and use data available from various sources to supplement any data collected for statewide travel forecasting. A clearinghouse of data available from state and national data collection efforts should be created and made available as a resource for statewide travel forecasting. The existence of this clearinghouse should provide awareness of what is available, assess usefulness of the data, identify opportunities for enhancing usability of data and identify state and national contacts for obtaining that data.

An annotated directory of national and state data sources/contacts should be prepared, and it should provide data specifications for use in statewide forecasting model development (e.g., geographic referencing, time, stratification, etc.). The clearinghouse should specify requirements for ongoing maintenance of the validity of the data with federal and state participation in the effort.

Funding for this activity should be provided by subscriptions to the states with matching funding from the federal agencies.

Existing Freight Data - Research should be conducted to identify the existence, characteristics and location of data on freight movements for use in statewide travel forecasting. All potential public and private sources should be investigated. The availability of such data should be documented and advertised to facilitate its use. Such documentation will encourage cooperation among users of the identified public and private freight data bases. The documentation should include best practices in data "mining," data fusion, ITS data for planning, and data warehousing. This work may be helpful for reducing expenditures for data collection and increase confidence in use of secondary source freight data.

This effort should be supported by cooperative funding between the states, the federal government and

organizations of freight providers.

Using GIS - Experience with GIS has shown that it can contribute greatly to improving the effectiveness of the travel forecasting process. It can help make the black box of travel forecasting transparent. It can help to demonstrate the relationship between point data (special generators) and the network. It is important for demonstrating and varying the levels of spatial aggregation. Applications of GIS for travel forecasting are still in infancy. Precision geo-coding required is necessary for effectiveness but time consuming.

The research should conduct a technology review and case studies of different actual applications. The review should identify software requirements for various applications and design a means of interfacing with jurisdictional data, and cross platform data exchange. It should also develop guidelines and understanding of the relationship to GIS-T, demonstrate its use, and how to get quick turn around on query and analysis

Transferable Parameters - A review of the potential and experience of "borrowing" travel model parameters from other applications should be conducted. Such a review would demonstrate the cost effectiveness of using existing data for estimating travel forecasting models. The review should critically assess the validity of the commonality of data across state borders. One particular value of such commonality is that it provides a data base for statewide model development. This approach will provide seed data for states just beginning freight modeling.

Identifying this validity would contribute to better cooperation between states and would encourage federal agencies to provide dis-aggregated data for states and sub-state levels. Applying this concept would require uniform data formats.

WORKSHOP 4

Statewide Tool Box - Research should be conducted to develop a toolbox of statewide transportation planning techniques that could be used to address the different issues various states are facing. The synthesis would not necessarily develop new techniques but would aid planning officials in identifying and matching transportation planning procedures with their states' problems. The techniques would range from simple trend analysis to complex 4-step statewide modeling. Characteristics that would be used to match problems with techniques would include:

- Data availability
- Scale or size of problem
- Accuracy requirements
- Risk (consequences of poor planning)
- Performance criteria
- Cost effectiveness

The toolbox would identify techniques necessary for strategic policy planning as well as demand forecasting. The project would prepare a topology of statewide techniques and describe the advantages, disadvantages and limitations of each technique. The general structure of the final report would be an expert system that would assist managers in determining what level of planning techniques is best suited for their state.

Freight Traffic Indicators - Research should be conducted to compile freight movement production and attraction indices for use in statewide freight transportation studies. In some cases these may be derivable from the Commodity Flow Survey (CFS). In other cases special analyses may be required, particularly on the destination and attraction end of flows. An attempt should be made to obtain these data for other flows not currently included in the CFS. These would include mail flows, municipal and construction waste flows and finer detail on certain crops and minerals and imports. The project should produce reports stating the derived flow productions and attractions.

Major Changes - Research should be conducted to identify the major changes that affect goods movement trends and how these will affect future goods movement forecasting at the national and state level. An expert panel should be assembled to identify the major trends expected to produce major changes in goods movement patterns and to recommend how to incorporate consideration of those trends in forecasting procedures at the abstract and operational levels. A process should recommended for tracking these changes over time.

Discussion Notes

GROUP 1

The premise for this conference is that statewide travel forecasting is a subset of transportation investment decisions and needs a better analytical foundation for those decisions. Current urban travel forecasting doesn't speak to decisions for smaller urban areas or to rural areas through or within which facilities need to be provided.

To support better decision-making, statewide analyses and statewide travel modeling are needed. Statewide transportation planning should be combined with other statewide functional area planning, such as economic development, recreation or land development.

MANAGEMENT/ADMINISTRATIVE ISSUES

Staffing is a significant issue; Should the states staff in-house or engage consultants? The real issue here is *qualified, trained* staff, which raises, in turn, the problem of training staff and retaining them .

Cooperation among the states is another issue. The Interstate System satisfied many of the functional issues of accessibility, but there remain questions of continuity and connectivity which can be resolved only by communication between states.

DATA

Despite a wealth of various kinds of data, not enough is adequate for use in statewide travel forecasting. For example, despite a large amount of employment data, rarely is it adequate for conventional travel forecasting. There are concerns and questions about both availability and format of data needed by one or another travel forecasting model.
Much of the data needed for statewide planning will be similar to that needed for urban transportation planning. These include substitutes for roadside surveys because of the danger and congestion they cause. Statewide population, employment, and vehicle occupancy data are needed. Other data needs are different because of their relative importance for statewide as opposed to urban forecasting.

FREIGHT

What analyses of freight movement do the states want to do? The states may use that information for facility planning in response to traffic or capacity problems, especially in heavy truck corridors or for port or airport access. They may also use it as a catalyst for economic development.

There is a lack of good freight data (for both commodity movements and the carriers' vehicles). There is not a good understanding of the relationship between commodity movement and volume and economic development (and the physical development which accompanies economic development)

There is a tendency among transportation planners who have experience in passenger travel forecasting to attempt to treat freight movement in the same way. They see it as an origin-destination movement of units when, in fact, freight may be consolidated or disaggregated between it's "origin" and it's "destination." Because the sources of commodities and the selection of carrier and route are so price sensitive, the patterns of movement are much less predictable (and may be statistically less stable) than passenger movements. Compared to passenger flows, freight flows also are "lumpy," which compounds the problem.

A nationwide survey of freight crossing state lines and a simultaneous "port of entry" survey should be conducted to establish a basic interstate flow matrix which the states could use as a start for their analysis of intra-state movements.

There is a reluctance of shippers and carriers to share information, presumably because they fear losing competitive advantage, fear government interference or worry about confidentiality of data in government hands for tax or other reasons

A better understanding of the relationship between commodity flows and models of the economy is needed. What are the implications of economic projections, from economists and econometricians for first, commodity flows and second, demand for transportation facilities and services which are or might be supplied by the states or regulated by the states?

GIS

Informal contacts with several states found that generally they are not using GIS capabilities for analysis or modeling, but primarily for visualization and presentation. Apparently capabilities supplied by

vendors are not as effective for analysis or modeling as other software available for planners. Most GIS software is not designed to efficiently support network analysis. What GIS does do better than other software is facilitate integration of spatial data using location coding as the common linkage. Many planners do not know the potential of GIS software because their only training is from the software vendors. Consequently they do not realize the full potential of GIS software and don't "push" vendors/providers to include capabilities or expand software to its capacity.
There is also poor communication and lack of mutual understanding between planners and engineers on the one hand and GIS users on the other, particularly when they are separated from one another in an organization's information technology department.

Most of the good applications and uses of GIS in planning and analysis have been developed by the planners rather than by GIS specialists. In combination these factors cause planners to not use GIS to its full potential.

Need: There is a need for training planners and engineers so they can take advantage of GIS strengths and provide better spatial data. The software providers/vendors need to interact with users more so they better understand potential for using GIS for transportation planning and analysis. There also needs to be better coordination with other state and local agencies collecting and using geographic data.

MODEL APPLICATIONS

It seems wrong to try to have one model to meet all needs. It is clear that the needs of Rhode Island are different than those of Texas and California, and there is a range of needs in between. Those different needs are created by varying circumstances, both among and within individual states. There may be entirely different modeling frameworks for analysis of statewide flows than for analysis of corridor truck traffic or the congestion near a major generator. The states have a great deal to learn from each other, but "one size won't fit all."

There is a tendency to treat statewide travel demand forecasting as urban modeling and to simply expand what has been done at the urban area level to the state level. Whether this tendency is appropriate or not, there needs to be better understanding of the similarities and differences between urban/regional and statewide travel demand forecasting and of techniques to interface the two where appropriate.

There is a potential problem, which may exist for some applications now, as urban/regional models are integrated with statewide models, where study boundaries and trips are not integrated well resulting in loss of trips (by classifying them as intra-zonal) and failure to reproduce or anticipate congestion.

TECHNICAL PROCESS

Traffic volumes on highway network links common for the MPO and the state procedures should be compared and rationalized.

The effects of land development on transportation facility needs and vice versa need to be incorporated in the forecasting process.

Modal alternatives for both passengers and freight should be considered and evaluated in the planning process.

Travel attributable to trips originating and/or terminating outside the state should be considered along with intra-state travel. Information is needed on the entry and/or exit points for such trips as well as the origin and/or destinations within the state.

The appropriateness of a state's boundary should be considered as a "cordon" line. Major traffic generators need to be considered in a special way as do weekend and occasional trips. Special treatment of weekend travel should be included when it is significant because of tourism or other recreational activity. Why are we meeting; why are we talking about statewide travel demand forecasting?

Premise: We are talking about statewide travel demand forecasting because a subset of transportation investment decisions needs a better analytical foundation. Current urban area transportation planning doesn't speak to decisions for small urban areas, outside the MPO areas, or to rural areas through or within which facilities need to be provided. To support that decision-making, we need state level analysis and state level modeling.

State level analysis is statewide travel demand forecasting. It should be combined with other statewide functional area planning such as economic development, recreation or land development.

MANAGEMENT/ADMINISTRATIVE ISSUES

Staffing is a significant issue; do we try to staff in-house or engage consultants?
The real issue is *qualified, trained* staff, which raises, in turn, the problem of training staff to perform the work and retaining them, once trained.

Cooperation between and among states is an issue. The Interstate System satisfied many of the functional issues of accessibility, but there remain questions of continuity and connectivity which can be resolved only by communication between states.

DATA

There is a wealth of data, but not enough is relevant to the needs of statewide travel forecasting; for example, good employment data. There are questions and concerns about both availability and format of existing data.

Need: Many data needs are similar to those for urban transportation planning:
substitute for roadside surveys because of danger and congestion, population, employment, vehicle occupancy, etc.

Other data needs are different because of their relative importance in and to statewide as opposed to urban analysis.

FREIGHT

Why do states do what they do or want to do with analysis of freight movement?

Occasionally for facility planning in response to traffic or capacity problems:
heavy truck corridors, port or airport access, for example as a catalyst or incentive for economic development.

PROBLEMS

There is a lack of good freight data (for both commodity movements and the carriers' vehicles) and there is not a good understanding of the relationship between commodity movement and volume and economic development (and the physical development which accompanies economic development).

There is a tendency among planners with experience in passenger travel analysis to attempt to treat freight movement in the same way: to see it as an origin-destination movement of units when, in fact, freight may be consolidated or disaggregated between it's "o" and it's "d." Because the sources of commodities and the selection of carrier and route are so price sensitive, the patterns of movement are much less predictable (statistically stable?) than passenger movements. Compared to passenger flows, freight flows also are "lumpy," which compounds the problem.

Recommendation: A nationwide survey of freight crossing state lines; a simultaneous "port of entry" survey to establish a base interstate flow matrix which the states could use as a start for their analysis of intra-state movements.

There is a reluctance of shippers and carriers to share information, presumably because they fear losing competitive advantage, fear government interference or worry about confidentiality of data in government hands for tax or other reasons.

Need: Better understanding of the relationship between commodity flows and models of the economy. What are the implications of economic projections for commodity flows and demand for transportation facilities and services which are or might be supplied by the states or regulated by the states?

GIS

Informal contacts with a number of states show that generally they are not using GIS capabilities for analysis or modeling, but primarily for visualization and presentation. Apparently capabilities of current GIS programs are not as effective for network analysis or forecasting as conventional travel forecasting programs. What GIS seems to do better than planning software is facilitate integration of several types of spatial data using common location coding.

Many planners do not use the full potential of GIS software because their only training is from vendors who only know the conventional applications of their software. The planners don't "push" vendors or providers to include or demonstrate planning capabilities or expand software applications to capacity.

There is poor communication and lack of mutual understanding between planners and engineers, on the one hand, and GIS people on the other, particularly when the latter are in information technology units

separated from the planners and engineers. Most of the good applications and uses of GIS in planning and analysis have been developed by the planners, rather than the GIS specialists.

In combination, these factors have usually limited planners' use of GIS to less than its full potential.

Need: Training for travel forecasting personnel to take advantage of GIS strengths for developing better spatial data; interaction between planners/engineers and software providers/vendors so they all better understand potential uses of GIS for transportation planning; better coordination among personnel responsible for geographic data preparation both within and between states.

MODEL APPLICATIONS

It seems unlikely that one model will meet the needs of all states or even needs within a state. The needs of Rhode Island are different than those of Texas and California, and there is a range of needs in between, created by varying circumstances. Also within a state there may be entirely different modeling frameworks for analysis of statewide flows, a corridor's truck traffic or the congestion near a major generator. States have a great deal to learn from each other, but "one size won't fit all"

There is a tendency to treat statewide travel demand forecasting as urban modeling "writ large," to simply expand what has been done at the urban area level to the state level. Whether this tendency is appropriate or not, there needs to be better understanding of the similarities and differences between urban, regional and statewide travel forecasting and of the need for integrating them.

There is potential for problems, which may exist now, for some applications as urban and regional models are integrated with statewide models. Traffic analysis zones, study area boundaries and trips may not be integrated well, resulting in loss of trips (by classifying them as intra-zonal) and inability to reproduce or forecast congestion.

TECHNICAL PROCESS

Interfacing with MPO models: compare volumes on links common to MPO and statewide models at the points where they interface.

Using land use models: incorporate the impacts of land development on transportation facilities and vice versa.

Provide for alternative modes, for both passenger and freight: consider and evaluate modal alternatives to highways for transporting both passengers and freight.

How to handle trips external to state: consider intra-state travel of trips originating and/or terminating outside the state.
-Obtain entry and/or exit point for such trips
 as well as the o-d within the state.
-Obtain origin and destination location as well
 as state entry and/or exit point(s).
-Examine appropriateness of state boundary as

"cordon" line.

Special generators: consider special generators.

Weekend and occasional trips: include weekend travel when significant because of tourism, recreation or other.

GROUP 2

MANAGEMENT/ADMINISTRATIVE ISSUES

Staffing
- Hiring freezes
- Staff named by default
- New Hampshire – 2 of 4 in charge of model
- Massachusetts – staff of 1 for traffic modeling; budget constraints
- Contract out a lot of work – time consuming, can't run model
- Michigan – 4 people – staff depends on what requirements are (everyone specialized)
- DBase, FoxPro, or some database application
- One person for data, one for modal model, one for GIS
- Separate unit supporting urban models
- Closely coordinated staff in one unit
- Data collection in another section
- MD – consulting team developed – had to train staff
- Retaining talented staff

Cost/benefit – not worth the cost to maintain models for questions asked
- Models don't handle statewide issues well
- Minnesota has statewide license for TranPlan
- $2 million on data collection – data prohibitive
- Cost issue – depends on what you need the model for; depends on states regulating issues – non-attainments need VMT estimates
- Michigan uses urban and fills in with state
- Can keep cost down with federal data – can't get current modeling framework to answer questions being asked
- Keeping models from a lot of agencies compatible
- Need a person interested in modeling to maintain models in house
- Data collection not glamorous – won't put money into it;
- Hard to find and keep staff people
- DOT staff change positions
- Cooperation among adjacent states – trade corridor studies
- Use of CTS, NPTS for north state planning projects

- Michigan – SEMCOG coordinating with Canada
- New Jersey – coordinating with Pennsylvania and New York
- Common referencing of facilitates and data sharing
- Simplified procedures for multi-state corridors
- What are models used for – just traffic forecasts?
- Need to evaluate policy; can't just extend to trucks and recreational
- Need help from federal government
- Need good network models

FEDERAL REGULATIONS

HPR funds inadequate for some states

- 22 factors to 7 (broader) factors
- Reorganization of offices; resources centers don't have as much bite don't know what new roles are
- What do they have to do outside urban areas?
- What does it mean to involve public?
- Air quality standards change; how big will non-attainment areas grow? rural counties, conformity analyses for rural areas
- What do they mean by statewide model?
- Some want/some don't
- Governor, legislators need to define questions that the state needs to address
- Different sets of issues in different states, need tools to address policy issues, share methodology

DATA ISSUES

- Making better use of data we have
- Survey responses are down
- New Jersey - $1 million HH survey 1986
- NYMTC – $700k
- Traffic counts – HPMS – but done anyway
- New Hampshire - $160k O.D. 29,000 HH
- Transit, vehicle intercept $200k
- Michigan – Supported SEMCOG
- SCAG – 16,000 HH $100 per hour to collect
- CALTRANS
- Oregon – Urban – 15,000 HH 7-9 rural counties
- Minnesota – count program – twelve highways and county roads

FREIGHT DATA

- Indiana – Data free – used all BTS data
- Michigan – Same data sources and truck weight commodity classification
- California – Truck volume by axle class every year; developing a trip table

RESEARCH ISSUES

- Borrowing data from other states
- Density factors from rail
- Trip generation rates in rural areas
- Rural areas – on board survey important since they are so rare
- Portions of freight movement not included in CFS: waste, dead headings, imports – don't have good grasp on information there
- No data on total amount received at destination – CFS
- Productivity issue related to trip generation, changes in employment

FREIGHT ISSUES

- Private, government as adversary, specific problems
- What is the benefit/cost (value) of analyzing freight?
- Commodity focus – specific interest groups; what an improvement means for movement of grain
- Dollar value of goods moving over system
- Washington study – commodities on rail vs. truck
- Issue of smoothness of pavement
- Barge – truck transfers
- Impact of investment choices
- Where commodities originate and where they are going – through trips
- New Jersey doesn't really care about commodities – wants to know how many trucks, OD
- Maryland – not doing 24 hour truck weighing, need improvement in vehicle classification
- Enforcement problem
- Indiana – difference in values: 1 ton coal = 1 ton furniture – truck may weight the same but need to know commodity to get truck equivalent
- Service transportation not addressed – vending machines, police cruisers.
- CALTRANS – anything with dual tires = truck in model
- Ports, seaborne commerce, rail mergers, global economy – don't have tools to analyze effect of these things

INTERMODAL TRANSPORTATION

- Build intermodal task force to discuss freight needs/problems
- Modeling freight flows – absence of intermodal network, how to handle cost of movement over dual mode system – rail haul doesn't minimize lengths of haul, highway does
- Air freight – not an issue of tonnage – volume – congestion around airports
- Freight data – lack of good data – Reebie or BTS – Reebie too expensive, good data between states, not good data within states
- What actions can USDOT take to lower cost, increase efficiency of freight
- Do not know how to model behavior of shippers/transport companies. (decisions made by a small group of people)
- Freight logistics not transferred to transportation

- Forecasting issue of truck related accidents
- Non-modeling solutions
- How to assign truck traffic to network

GIS – Intermodal Networks
- Models need GIS component
- Useful for different types of analysis; graphic presentation and display useful
- Florida doing good job with GIS – what are other states doing?
- GIS maintenance and updating of data
- Michigan – partnership with OMB – TIGER – used by state agencies
- CALTRANS – used in planning part of department. Labor intensive to develop, help with partnering with local agencies.

- Virginia – enterprise level initiatives for GIS, data warehousing project, integration (GIS talk to warehouse)
- Keep GIS and modeling software separate – let them talk to each other need expertise in both areas
- What is being displayed in GIS – flow, accidents, bridges
- Indiana – Using it for everything
- New Jersey - growth
- Institutional/Enterprise issues (how to implement)

MODEL APPLICATIONS

- Oregon model – economy, land use, multitiered, not quite complete, prototype
- Not realistic to do everything with one model
- Some things are best done at certain level of geography
- Too tightly integrated – nothing works unless everything works
- Need to be independent, but interact with each other
- Michigan model –quick turnaround, but sometimes bad numbers (management expectation unreal, limited resources, have to anticipate management questions) models constantly evolving
- Have to know what you want to use model for;
- limits scope, initial phase of model specification
- Virginia – simplified user interface – Michigan thinks it's unrealistic doesn't have to understand model
- Modelers versus users
- Update cycles
- New Jersey – meets 2 times a year
- True models never finished
- A lot tied to census – 3 year typical base year update
- Depends on attainment and non-attainment areas
- Policy sensitive issues
- MPO – State role interaction
- Mode policies, smart growth
- Economic health of state, transportation
- Education on GIS, planning

TECHNICAL PROCESS

Interfacing with MPO models

- Several already doing
- Same answers among competing models
- Recognize differences in needs of application
- When to use statewide and when to use regional
- If moving away from 4-step process and trip purposes are different, may have different models
- Network detail and content different
- Make statewide networks more flexible – intermodal facilities

Base statewide model on regional models

- Smaller states, not larger states
- Extend 4-step process to statewide
- applies more to larger states

Simulation

- Implies greater level of detail
- Traffic operations tool
- Data issues
- Jury still out – certain events might be more amenable to simulation/replicability
- Is TRANSIMS applicable at statewide level?

Use of land use models

- Statewide activity allocation model
- need to promote economic models at county level
- SCAG – tried to adopt Dram Empal – no success
- Oregon model – designed to deal with land use issues
- like growth management, investment impact
- Big data problems – land use and price information hard to get on consistent basis statewide
- Need to think in long terms (timeframe) to collect data, calibrate, and validate
- Research link between transportation and land use at regional level – amount of land use change caused by policy relatively small.
- Policies (large increase in gas tax, preserve farmland) need extremely large changes to impact
- New development – special impact study
- Maryland – 50 mile corridor – effect on land use
- Expert panel – don't use MPO land use forecast
- Research – use of expert panels

Provide alternative modes for passenger and freight

- Try to model
- High speed rail vs. air
- High value commodity flow – truck versus air
- New modes – mag-lev – existing techniques won't adequately address – stated preference won't cut

it

Service modeling
- Electronic replacement of freight – models miss commercial trips
- Telecommuting impacts
- Rural delivery systems
- Research on better understanding impact of intercity commercial trips
- Freight mode designs, truck versus rail, distribution decisions
- Shipper on advising committee
- HOV & TDM as alternative models (statewide versus urban)
- Commuting modes
- HOV – regional

Integrate demand models with other
- Integrate too much – becomes very complicated loosely integrated
- Air quality must be added on to all models

External trips
- Defining external generators/attractions
- Difficulty in getting data
- Forecasting
- Differences in modeling if trips stop at state border versus extending into neighboring states
- Develop appropriate ways to extend beyond border
- National data versus local data – gaps in data

Special generators
- Casinos, recreation, parks, campgrounds, marinas, airports, major shopping malls, military bases and hospitals
- New data on recreational trip generation
- Attraction rates

Weekend and occasional trips
- Need to include weekend and recreational travel
- More corridor analysis than statewide model
- Weekend – separate data collection effort
- Snowbirds/Sunbirds – how to collect data and forecast growth

GROUP 3

MANAGEMENT/ADMINISTRATIVE ISSUES

- Cooperation and coordination
- Resource needs for statewide models
- Federal education and training

Cooperation and Coordination

State of Practice

- Between states
  - · Cross border TAZs
  - · Western transportation network – pooled fund research
  - · Data sharing
- Inter-regional
  - · Modeling steering committee
  - · Air quality district modeling
  - · Florida – interconnected state, regional and metropolitan models
- Intra-organizational
  - · Washington plans bring together all programs (maintenance, operations, capacity) planners don't do all planning
  - · Florida designers must follow modeling methodologies
  - · California planning division manager oversees programming of funds for maintenance and operations

Conclusions

- Need documentation of what is taking place (case studies)
- Need information on how to apply good practice
- Need study of what kind of institutional cooperation arrangements are necessary and how to transfer them
  - · Example – studies of ITS cooperative arrangements.
- Study model user group techniques that work

Resource Needs for Statewide Models

Issues and State of Practice

- Not well documented
- Too many surveys
- No threshold information on who should do it
- What policy issues drive modeling issues?
- Need to look at multi-year over time
- Is consistency among states needed?

Conclusions

- We don't know how effective forecasting program are
- Need to evaluate a matrix of resources; not just modelers, but support/input/ review staff as well
- Resource needs to depend on the complexity of models. There's no ready information about the resources needed to address issues

Federal Education and Training Issues

State of Practice

- Federal short courses
- Identify FHWA & BTS people to call
- Florida teaches twelve courses a year – 1/3 state, 1/3 local and 1/3 consultant
- California has some university extension training

Issues

- Federal courses aimed at DOTs; consultants left out
- Federal training courses cannot compete with private courses
- Could universities develop and maintain ongoing training program?

Conclusions

- Necessary but hard to train when practice is so new
  - Training needs to react to changes.
- All local people need training
  - Decentralize training. Bring to audience.
- Training needs management support.
- Not enough funding for training.

DATA ISSUES

- Inventory data systems – HPMS
- What is the value of data elements?
- Transferability of data
- To what extent does national data meet local needs?
- Reusing data collected by others; surrogate data.
- Are there ways to make federal data more usable?
- Availability of private sector data
- Tradeoff between secondary and primary data.
  - How much primary data necessary?
  - What is the ability to use secondary data?
- Florida – all data collected is to satisfy TMIP to be able to move to activity based models
- All federal data should be collected for use at state level
- Timeliness – how old is too old?
- Using ITS data in planning
- Difficulty in sharing data collection costs between states
  - Multi-state collection needs federal support.
- Data enrichment – over sampling
- Collected data needs to be geocodable

MAJOR TOPICS

Maximizing Secondary Data Use

- National data, surrogate data, other people's data

- Transferability – meta data
- Archiving data – times series data
- Federal databases that can be used – what is available and what could be available?

Primary Data Collection
- Data enrichment – enhance surveys, greater sample frequency
- Interdependence with model structure and format
- Need minimum data specifications. If collecting urban model data, might as well get statewide model data
- Value of data: inventory and timeliness – what is the amount needed to get the product?

GIS

State of Practice

Increasing use of GIS
- Primarily an interface – visualization
- Problems with transferring changes between GIS and modeling packages. Some software aids this
- Need consistent identifier across all data
- Build model network off GIS database
- Kentucky(?) molding a model out of Oracle database
- Interoperability of software is an issue – standardization
- Linear Reference System
  - LRS – GIS – model
- Starting with a good network
- Data referencing consistency
  - Florida – start with state highway base map
  - MPOs enhance network, network and parcels
  - Needed for land use/transportation linkage
- Training in GIS application – state staff and consultants
  - Florida has automated procedures for passing updates between GIS and model (TranPlan); also teaches GIS; agreement with ESRI to use and loan software for training.

Issues
- Interface of model and GIS
- Building model networks from GIS
- Interoperability of GIS software
- Data referencing consistency
- Training in GIS
- Organization – IS, mapping, planners – coordination and ownership

FREIGHT

- Difficulty getting private shipper data. There is private data available at modest price (Russ Capelle BTS) BTS has some data now and will have more. TIUS database (will be VIUS - vehicle

inventory and use survey); www.bts.gov has papers on using – check Boston area trip table generation from TIUS

- FRA has truck-rail diversion model commodity flow survey
- Need more talking between planners, engineers, business, geographers; need methods for using the existing freight data in modeling
- Modeling truck-car equivalency
- More plausible to model trucks at statewide level – better methodologies at state level; technology has helped
- Integrating freight (multimodal) into statewide model or parallel; can run on same platform
- Modelers and planners lack knowledge about freight logistics; sequence of modes and transfers; business schools – supply chain management – is a supply chain as opposed to truck trip
- Commodity to vehicle conversion needs development converting freight data (commodity) to what is useful in planning
- Appropriate performance measures: tonnage, vehicle volume, value and economic
- Air quality – particulates
- Traffic safety issues
- Increasing amounts of commodities are moving in non-truck vehicles (small trucks, package and courier)
- Multimodal freight
  - Rail, air, marine and pipeline
- Develop interactive intermodal model
- Functional classification of facilities for other modes.
- Validation information available
- Study case studies of ports
- Florida: treating intermodal facilities (water ports, airports)
- Land use – Neotraditional development; impacts on freight movement and accessibility

MODEL APPLICATIONS

- Help to decision making
  - Technical justification of decisions
- Modular – can grow, evolve, expand, new applications
- Always interoperation. Manage expectations. Just because answer tomorrow is different than today, doesn't mean wrong
- Need risk assessment; scenario testing. Present ranges, not averages
- Model outputs can be marketed to more parts of organization.
  - Example – economic development department can use data
    - Innovative applications
    - Often organizations that can use outputs
    - Linkage between secondary data providers and the results for the model outputs
  - Update cycles and air quality estimates. Danger that statewide models will be pulled into a regulatory environment (regional air quality). Potential misuse of models
- Real time analysis capabilities
- Incident inclusion in modeling – non-recurring delay

TECHNICAL PROCESS

Response to Economic Conditions

- Data availability
- How to incorporate an economic model into a transport model
- Oregon – statewide economic activity model; what can be learned and transferred to other states – critical look and evaluation
- Transportation planners tend to look at land use differently than land use planners: “activity” versus “land use”
- Model should include a real economic activity component
- Land use is the shell – economic activity is the flow
- Cost of living differences, effects on travel behavior; how it effects the parameters of the model

Relative Error of Forecasts

- Acceptable ranges of error for different uses of forecasts
- Need to communicate relative error of forecasts
- May need several forecasts with a probability distribution faster computers allow this
- How to deal with uncertain future?

Effects of Taxes and Speed Limits

- How do people choose their routes. A lot of issues beyond simple impedance functions
- Dulles toll road: price sensitivities vary; market segmentation
- Origin of trip assigned to centroid, but actual costs faced by driver vary across zone
- Statewide recreation trips – different route selection criteria
- Responsiveness of models to speed limit policy, communicate back to policy decision makers

Compatibility between travel and air quality models

- Coordinate between travel and emissions forecasts

Zone Structure for Passenger Versus Freight

- More passenger zones than freight (tends to be available on a county or larger level
- Freight tends to travel on fewer links – freight centroid can be more easily located
- Freight centroid can be different than passenger centroid
- Appropriate zone structure for intermodal movements
- One structure related to trip length

Time Series vs. Cross-sectional Analysis

What Level of Statistical Accuracy

Transferability Between States

- Can you transfer across states

- · ATS and CFS – use as a backdrop for comparing state data
  · Need to develop transferable parameters for states as in NCHRP 187
- Need to analyze national databases for use by all states
  · Not on a state-by-state basis
- Need to model different border states differently
  · Dependent on culture, weather and topography
- Should there be national networks and models?
  · BTS – Oakridge – International transportation database
  · Los Alamos – National Transportation Network Analysis Capability
  · Share assumptions and data

What Network Size and Detail

- Oregon – nesting with regional models to get more detail
- Many just use state system
- States have different state highway systems
- Functional classification should be basis, not state highways
- Don't need to model low-volume roads
- Need consistency with zone structure; freight and passenger may be different
- Compatibility between TIGER/GIS route descriptions and how states describe routes

Include Refinements from Corridor Analysis

- Is total state coverage needed, or would analysis of substate corridors be sufficient?
- Do corridor studies officially get adopted into statewide models? Documentation is important
- Multimodal intercity corridor studies not well accepted practice
  · How to incorporate into statewide model?
- Incorporate and use data from ITS corridor studies
  · Truck transporters
- FHWA borders and corridors study results need to be incorporated into statewide models

GROUP 4

STAFF & STRUCTURE

- Staff and funding for statewide planning are limited
- Statewide planning techniques are a function of the state structure
  · Strong central technical staff is more likely to have a technical planning process
  · Separate modal administrations are likely to have separate planning processes for modes statewide
- Model task force forums promote technical processes and are a valuable tool for statewide planning

FEDERAL ROLE

- Provide training courses for statewide planning
- No technical requirements and no standards

- Facilitate more multi-state corridor studies
- Rural officials will be involved and may impact statewide planning
- Federal government should continue to provide and maintain national databases to assist statewide planning – commodity flow survey, NPTS, ATS

GENERAL COMMENTS

- Statewide planning is input to decision support systems
- Statewide planning is important for evaluating multimodal tradeoff
- First step in statewide planning is to determine what questions you want the planning process to answer
- Tourism is an important issue for some states
- Statewide planning procedures include several types of techniques:
  - Trend analysis
  - State Planning Panels
  - Management Systems
  - HPMS Evaluation Systems
  - Surveys
  - Four-step models
  - Synthetic models
  - Traffic counting programs
- Level of planning on a statewide basis is a state by state decision.

Statewide Model Conference Survey (Condensed)

A survey of the states was conducted by the Texas Transportation Institute. A total of 37 states responded to the survey.

PLANNING QUESTIONNAIRE SUMMARY FOR THE TRB CONFERENCE ON STATEWIDE TRAVEL DEMAND FORECASTING

STATE	NAME	DOES STATE HAVE TRAVEL DEMAND FORECASTING PROCEDURE? IF YES, ELABORATE ON TYPES OF ISSUES	PROCEDURE DESCRIPTION	IF NO FORECASTING PROCEDURE, ARE YOU GOING TO DEVELOP ONE?	ADDITIONAL POLICY QUESTIONS SUGGESTED TO BE EXPLORED AT CONFERENCE	ADDITIONAL TECHNICAL ISSUES SUGGESTED TO BE EXPLORED AT CONFERENCE
AK	Tom Brigham	Yes, we currently have a regional travel demand forecasting procedure for southeast Alaska, which is as large as many states. It is used in regional, long-range transportation planning. The forecasts are used to determine future travel volumes between communities. The results are used as inputs to a least loss planning process. The plans determine investment priorities in the region (ferry, road, air).	We are currently using an adaption of a logit model. Above is zones. Passenger only. A logit models seems valid in this case as there are no roads between southeast Alaskan communities, and typically no one living in the area between communities.		How effective have statewide travel demand forecasting methods been — how successful? What special issues or problems have been encountered while developing statewide freight movement forecasting?	
AL	George Ray	No.		No.	None	None
AR	Paul Simms	No.		Yes, commodity flow and intemodal shipment data, shipper surveys and trucker surveys at weigh stations. 3 years .	Need/demand for additional intermodal facilities.	None.
AZ	Joe Flaherty	NO		We currently forecast traffic on a corridor specific basis. A 20 year forecast is developed from a data base with 23 years of traffic data. Linear Regression is used to produce the forecast. We are planning a study later this year. Outside of the MPO areas, the distance between towns and cities is long and sparely	What are the tradeoffs between the building expenses and maintaining a model and any increase in accuracy compared to current procedures?	What are the tradeoffs between time series analysis and cross sectional analyses? What level of statistical accuracy is obtained

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				populated. It is difficult to think of as a network.		
CA	Les Jones	Yes, the Statewide Travel Model (STM) and the Motor Vehicle Stock, Travel, and Fuel Forecast (MVSTAFF). The STM provides statewide and regional estimates of average daily light duty vehicle rips using a three-step process of trip generation, distribution and assignment. It also provides regional X-X and X-I trip percentages for calibrations and validation of regional models. MVSTAFF (Motor Vehicle Stock Travel and Fuel Forecast) is an econometric model which provides historical estimates and forecasts of the number of vehicles, miles of travel , fuel consumption, and fuel economy on statewide basis. Forecasts are intended for short/long range statewide transportation planning, traffic forecasting and projections of revenue from excise tax on fuel.	We use the standard 3-step (trip generation, distribution, assignment) gravity model originally developed on UTPS, and now in MINUTP also. Zones: currently 1908; Capabilities noted in Q.5: Used for light-duty vehicle forecasting only.		Which states currently have statewide travel forecasting Guideline? Are the Guidelines published? What should be contained in these Guidelines? Are the Guidelines a standard? Do they advocate or direct modeling acceptability for the State or are they just truly a guideline which may or may not be followed? Does the Guideline discuss and present acceptable practices, consistent methodologies, parameters, and assumptions? What is the potential for simulation models and will they work at the macro-level (i.e., state, and regional)?	What are the critical parameters, assumptions, and data requirements necessary to develop an acceptable truck model? What are the critical parameters, assumptions, and data requirements necessary to develop an acceptable truck model? What are the transferability and compatibility issues between light-duty vehicle models and heavy-duty vehicle models? What is the potential to develop 100% compatible statewide transportation and air quality models and factors into one package of models?
CO	Bill Springfellow	No.		We have discussed and considered it, but have been concerned with the length of time to develop it, the data requirements, the accuracy and reliability and the costs.		How are mode split, and TDM elements included and estimated? What are the minimum data requirements needed as input to the models? What network assumption (size, number of links, etc.) are necessary?

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CT	Joseph Spragg	Yes. Used for developing project level highway and transit forecasts for transportation proposals, to evaluate alternatives, to develop VMT estimates for emission (Conformity, CO hot spot) and noise analysis.	Using TRANPLAN software, supplemented by a consultant developed mode split model. Utilizes the traditional 4 step process with 5 trip purposes home based work, home based other, non- home based, truck & thru state. It deals with 4 modes, drive alone, shared ride rail & bus & has a 1300 zone system. Truck trips are a trip purpose, but we don't have commodity flow capability.		The level of analysis that travel models are an appropriate tool for. Combining and refining modeling results with other tools (post analysis, spreadsheet calculations, manual adjustments, consensus building, etc.)	Connecticut Dept. Of Transportation employees we would recommend (ConnDOT, Bureau of Planning, 2800 Berlin Turnpike, Newington Connecticut, 06111) The interface between travel and omission models. The transferability of modeling assumptions and relationships.
DE	Eugene Abbott	Yes -Highway Project Planning: Capacity Issues, Connection Issues . -System Evaluation /Congestion Monitoring. -Land Use Scenario -Air Quality Plus we need to develop new models to model transit - something that helps decision makers with transit solutions in the same way that the travel demand model helps with highway capacity decisions.	Tranplan model covering 13 coun. Delaware & Maryland. Portions of Delaware about 750 zones, 3500 links with 550 zones and 3000 links of these totals in Delaware. Use a 3 axis x 4 &2 cross class fraction trip generator model for 8 purposes. Use standard gravity model for distribution, constrained by travel time friction curves. Uses nested log it mode split model. Guilibrium Assignment with truck prohibition, tall diversion & HOV model (for alt. Analysis), used for passenger vehicles.		How to fill in the missing pleas in the transportation puzzle. Travel demand modeling is a great for part of what we plan for in the highway capacity piece - need service modeling as well as activities? Transit and roads; need to be able to model various mode scenario - i.e. rail freight vs. truck freight and the impacts of each.	
FL	Bob McCullough & Haiwei Shen	Yes. 1) Used to develop project traffic estimates for corridor studies in rural areas. 2) Used to test alternative improvement scenarios in rural areas. 3) Used to generate external travel forecasts for urban area models. 4) Used to prepare a long-range needs plan for rural roadway improve-ments.	External Model-trips generated .at ST. line based on counts and factors and distribution based on O&D survey. Trip Gen. - FL Stand. "GEN" model executed once for each of 25 MPO areas; & a rural trip gen. process for areas not included in the urban mod., prod.& attractions are aggravated to ST- wide zone system 540 zones Network/Path Bldg - standard TRANPLAN processes. Trip Distribution -TRANPLAN gravity model with estimated friction factors and K fact. Auto Occupancy- Person trips by purpose conv. to vehicle. trips using O&D survey auto occupancy rates.	N/A	Integration of Statewide Models with GIS and other Planning/Policy Databases.	Regional Models: The first step to building a statewide model.

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			Trip Assign.Equil. assignment .of vehicle .trips using TRANPLAN System Evaluation. FL Stand .HEVAI model summarize valid. on &/or analysis statistics. Passenger & Freight trips are combined into vehicle .trips for assign., no transit capabilities			
GA	Carl Spinks	No.		Geogia does not currently have plans to develop a statewide forecasting model.	N/A	N/A
HI	Goro Sulijoadi-kusumo	No statewide models, but have models for each major island/county. All models are intended to facilitate systems balancing approach for communities transportation needs. The ongoing Oahu Model Development project also incorporates a land-use model to increase the State DOT's capabilities in alternatives analysis and evaluating strategies for corridor and regional level scenarios.	TRANPLAN models have been developed for the islands of Oahu, Kauai, Maui, and Hawaii. Oahu is currently going through a model development process incorporating 76Z TAZs and utilizing a customized package developed around MINUTP. A land-use model is also being developed as part of this process which will allow some feedback capabilities with the travel demand model.	No, a statewide forecasting model would have limited uses given that this state is composed of islands. We do, however, have parameters set for each county through a statewide socio-economic model.	What is the relationship between travel demand forecasting and land use planning currently, and where is it moving?	What are the states' experiences in incorporating special generators and non-peak data (i.e. weekend traffic) into the models?
IA	Cizaig Marvick	Iowa does not have a statewide model.		We presently have no plans to develop a model due to (1) no clear need, (2) potential high cost (time and money) (3) lack of data and thus, (4) potentially poor model performance. We continuously reassess these factors and may be interested in statewide modeling should there be a change. We believe any future model might address system level issues such as priorities between highway corridors, freight intermodel	What future issues or policy questions are anticipated that may require statewide produres? There are multi-state models being used on specific corridor purposes (Avenue of the Saints corridor, I-35 Canada to Mexico, NHS System, etc.) Any relationship?	For any model proposed, an issue is the ability of staff to maintain and update the model over the long term. This needs to be considered or evaluated for many of the above issues.

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				issues, long range planning, etc.		
ID	Gary Sanderson	No, it's still under development.		We are in the second year of a three year development schedule for our statewide travel demand forecasting model. We have a consultant agreement with NCATT (National Center for Advanced Transportation Technology) located at Univ. of Idaho. We have competed Phase I, Feasibility Study, and progressing on Phase 2, Model Development. Anticipated completion is December 1999. We have received advice and development. schedules and costs from several other states. Our model will use TRANPLAN, our existing linear referencing system, the gravity model, & Bureau of Census information.	Is there a source or replacement for household O and D study? A traditional O/D study is very expensive. What kind of financial support can be provided on the model development to other states who are just developing or exploring model application to upgrade it to the continuing phase?	
IN	Steve Smith	A Statewide Model using the Transcad software is in the final stages of development under our major corridor study (completion anticipated May 1998). -Development of VMT & VHT measures of major intercity corridor improvements for input into remi & other economic models to determine economic impacts in addition to user benefits. -Needs analysis of state jurisdiction roadway system using FHWA's HERS analysis for capacity expansion project. -Development of a	Our statewide model is being developed by Cambridge Systematics - It is a traditional 4-step model for the development of the base year model/trip table. For future year trip tables development it uses an incremental approach. The model has 14,000 miles of network, 651 internal zones, & 110 external zones/stations. The model has a passenger vehicle & commercial vehicle trip table. The models commercial vehicle trip table is based upon a university research project with Indiana University.		The development of procedures to use statewide. Model based traffic forecasts for project level traffic forecasts. Commodity flow/trucking/ rail issues.	

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		HERS based prioritization index for statewide expansion projects.				
KS	Rick Miller	Not currently. Questions about a very rapidly growing boxed beef industry in the SW corner of the state led to questions about transportation. Around 1992 an agricultural commodity based QRS frieght model was developed for the state. The work is documented in a Midwest Transportation. Center Report entitled: "Microcomputer Transportation Planning Models Used to Develop Key Highway Commodity Flows And to Estimate ESAL Values."	QRS II Networks, ~200 internal zones; 60 external, each commodity (5) had TG&TD procedures, Impedeners? Included tolls, terrain, and speed for assignment. The model was built as proof of concept and had recognizable weaknesses for non-agricultural commodities. It also was weak at the external stations. Overall, it showed a commodity based truck/freight model was possible and potentially useful.	We are considering developing a statewide forecasting model for passenger vehicles. The intent is to use it as a screening tool for programming projects, a mechanism to help with consistency of specific location traffic forecasts, and a tool to help our closely spaced metro areas with external station data. Methodology is assumed to be a Travel Demand Model. Operational data is unknown.	Can/should all areas within a state be effectively analyzed with one tool? Should the tool be tiered? Obviously it already is with Metro and Rural, but are there more (commoner corridor)	How to handle externals particularly with relaxation of the federal speed limit and states selecting different speed limits. Route selection for long trips may now be impacted. This would also be true for heavy commercial tax structures. Truck routes may be influenced by some other state's policies. Is there a good mechanism to handle externals?
KY	Rob Bostrom	Yes. We use it primarily for corridor studies, particularly to determine traffic volumes, VMT & VHT. We then use output with the REMI economic and the STRATBEN Cost Model. We also use it for some traffic forecasts involving new routes or alignments.	-1467 zones; 756 Kentucky zones (parts of 10 states) -28282 links -Auto trip generation: (Home based work, Non-work, External) -Truck trip generation (Internal, External).		Policy issues to explore at conference: -procedures: diversion, future demand, benefit/cost, economic development. -policy questions not able to address with current procedures: freight movement. -procedures justified: corridor studies/new route forecasting. -time & cost to develop procedure: $200,000 but built on an existing model. -time & cost requirements: 1-2 staff people to devote to properly maintain. -relationship between statewide & MPO procedures: no real relationship, goal to develop one. -other procedures used besides travel demand models: trend extrapolation, other models dev. on fly.	-Do economic models such as REMI need to be recalibrated using assignments based on proposed developments, if so how many times should they be recalibrated with new assignments? -Should corridor study refinements (network, calibration) be put in base STM network? Guidelines for doing this. -What is the optimal update period (every 5 years?)?

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					Additional Questions: -Standardization of traffic models. Make them portable between different software packages. -Greater cooperation between states concerning TAZ data maintenance. -Teaching statewide travel demand in University Engineering Courses.	
LA	Coan Bueche	No, other than Historical Projects.		Have given the idea of using statewide (gravity model) travel demand forecasting model some thought, but have no schedule at this time, not certain of issues to be addressed or methods to be employed.	What staffing levels are necessary to develop and maintain a statewide passenger travel demand model? As statewide freight/goods movement model?	What are the hardware and software requirements for statewide multimodal passenger travel demand models for multimodal freight/goods movement models? How have external passenger and freight movements been addressed in statewide models?
ME	Bill Croce	A statewide travel model should be completed by the end of May 1998. The base year 2006 and 2015 are to be delivered. Air quality/emission analyses, alternative analyses, and congestion management issues with further detailing of sub-areas. Growth at system and corridor levels.	The network has over 1500 zones. The zones are comprised of other state zones, MPO zones & Statewide Model zones. The “statewide” portion of the model has about 730 zones. The network has over 26000 links, with over 5000 links attributed to the “statewide” portion of the model. MDOT stresses “Statewide” due to the fact that this data is more readily available & direct comparisons can be made to the statewide portion of the network with known data. Statewide links are coded with nodes, speed, distance, capacity, direction, AADT & estimated Summer ADT as passenger travel forecast analyses. The main effort of the model dev. is to forecast Summer travel vol. We have used extensive recreational bus. data & travel data to develop these Summer trips. MDOT feels that traffic growth is due to the increase in vacation & recreational traffic, not		None	None

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			population & industrially driven as in some St. The zone size is mainly at town level with some of the urban areas (non-MPO areas) have up to 6 zones. Sub area enhancements will be made to the model as site specific traffic studies performed. The trip purposes for the model are; HBW, HBSocial/Rec (Short), HBSocial/Rec (Long), NHB, Other, Trucks. MDOT used the REMI econometric model to forecast population & bus. data used in trip generation. The appropriate regional & local government officials checked this data & provided comments to the MDOT in regards to the forecasted growth.			
MI	Richard Nellett	Yes. Deficiency Identification . Alternative Analysis. Jurisdictional Issues. UMT Change = Revenue State &Substate Plans. Transit Service Alternatives. Support Data to Mangement Systems. Transportation Service Center Analysis.	See Attached.		N/A	N/A
MN	George Cepress	We issue standard forecasting method to forecast traffic for projects throughout the state, however, we do not have a statewide travel demand modal.		A statewide model would be very data intensive and costly to maintain and the errors of the estimate may far exceed the projected travel demand. Cost/benefit value may not be too great. We forecast with historic trend analysis and vehicle classification studies, also making adjustments for unusual socio-economic items.	How does the cost of data collection for a statewide model and its related sensitivity relate to the cost of the project with or without the data? Is utility cost of data recovered with the project benefits?	What happens when the error of the model and data exceeds the expected volumes/traffic of the project?
MO	Fred A. Martin	Currently using historical data to project future trends.	We use historical data to produce growth trends and to predict future traffic. We	We are currently in the process of development of a	What internal resources are required to operate	

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		Traffic prediction and ESALs estimate turning movement projects and road user costs.	have also used origin and destination surveys to supplement the above.	statewide forecasting model (TRANPLAN or equivalent). We hope to have help in developing statewide corridor priorities.	and maintain a statewide model? How are connections made with MPO models that are different?	
NC	Marion R. Poole, Ph.D., P.E., Manager Statewide Planning	Yes, The statewide forecasting model was developed to provide estimates of travel between urban centers and to help assist in defining the NHS system for North Carolina and our State's Intrastate System.	See enclosed Technical Report Number 12.	We have identified a need to develop a more refined and economic sensitive model for statewide travel but have not been able to consistently devote staff time and effort due to other work priorities.		How can statewide models be responsive to changes in economic conditions and cycles? How are long distance, occasional purpose trips which accumulate on a statewide network accounted for in the model?
ND	Duane R. Bentz	No.		No.	None	None
NE	Steve Anderson	Yes. Although Nebraska has a statewide model. It has not been maintained so that it can be used to forecast traffic. The model is used to study special generators on the state highway system, effects of closure of highways for construction and the effect of bypass around smaller communities.	A TRANPLAN model with 945 zones is used. It is currently used to replicate existing total vehicular traffic in the decennial census years. No forecast model is currently maintained. The independent variable to generate traffic is population. The assignment network is primarily the state highway system. The model generates vehicular traffic not freight traffic.	We are considering such a procedure and will identify the resources required.		
NH	Subramanian Sharma, P.E. Traffic Research Engineer	Yes. -Corridor Studies -Bypass Studies -Transit Options -Air Quality Analysis -Congestion Management	The New Hampshire Statewide Travel Model System is implemented using the EMME/s travel modeling software, fax Pro Manager, and Arc/Information Geographic Information System (GIS) software. The NHSTMS is a hour based model system. There are 526 zones (1-439 located in WH.) Most of the zones in forwarding surrounding states, Maine, Vermont & Massachusetts. Model is capable of transit			

STATE	NAME	DOES STATE HAVE TRAVEL DEMAND FORECASTING PROCEDURE? IF YES, ELABORATE ON TYPES OF ISSUES	PROCEDURE DESCRIPTION	IF NO FORECASTING PROCEDURE, ARE YOU GOING TO DEVELOP ONE?	ADDITIONAL POLICY QUESTIONS SUGGESTED TO BE EXPLORED AT CONFERENCE	ADDITIONAL TECHNICAL ISSUES SUGGESTED TO BE EXPLORED AT CONFERENCE
			& highway alignment.			
NJ	Talvin Davis	Yes. The statewide model is used to determine transportation impact of major highway improvements that cross MPO boundaries. It is used to examine statewide issues, the travel patterns, the goods/truck movement & statewide diversion of all trips - EI, IE, & EE.	We have three regional models, representing the three NJ MPOs. These are three forecasting models. The networks & trip tables for these models are weaved/merged together to produce a statewide model for NJ. This is a TRANPLAN assign. Model with 280C zones & contains person trips, vehicle trips & truck trips.		Land Use Models in Forecasting.	
NV	William Hoffman	Yes, we employ travel demand forecasting process. Depending upon the location, (metropolitan, small community or rural) the information is used to determine design and feasibility aspects of Department's current and long range projects.	The statewide process is a combination of metropolitan planning organization models, individual small urban area travel demand models and rural application of growth information for travel demand forecasting. The travel demand models can address the passenger mode through modal split analysis if required. The statewide goods movement model is being developed.	N/A	Geographic Information System Applications in Statewide Travel demand - many areas, states have been reluctant to establish this process due to overwhelming data requirements - is this an answer? What is the best level of application? Route, corridor, community, etc?	Which of the model processes or programs in use now are considered to be most successful?
OH	Mark Byram	NO		Yes, Rural project design, year traffic certification and analysis, major investment studies, evaluation of non-sov modes, project selection, anything else we are asked to do. It should be operational around year 2000-2002. The methods are not yet defined. We expect it may start out as a standard four step travel demand model but may end up as a TRANSIMS type model.	What is the Federal perspective on statewide travel forecasting? What incentives/ rules /funding is planned for future statewide traffic forecasting? How have other states used their models to drive their transportation policies & plans, identify and evaluate transportation demands and alternative solutions?	Use of GIS in developing and maintaining travel demand model network and related data. What methods are in use and planned for future data collection to collect the data that drives the statewide travel demand models? Are states utilizing federal funds to collect HH survey data? Are travel time studies performed regularly? Are there any unique modifications to the regular traffic counting program

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						to accommodate statewide travel modes?
OK	Sam Shehab	NO		NO		
OR	Bill Upton	We are currently developing a statewide model using the Tranus Software. -Effect of land supply on land use and location decisions. -Effect of congestion on land use and location decisions. -Effect of large commercial development on the periphery of the growth boundaries. -Effect of land supply on travel behavior. -Effect of rail investment on highway use. -Effect of changes in the demographic composition of Oregon.	We are developing our model using the program TRANUS from Modelistua in Caracas, Venezuela. It is an integrated land use and transport model. The statewide model was about 140 zones and is used for both passenger and freight. There is also a nested sub-additional state model with 130 zones.			
PA	Thomas A. Kotay	NO.		NO.		
RI	Steven L. Drager	Yes. Rhode Island Statewide Model Air Quality Conformity Analysis Various Individual Project Analysis. Evaluation. of Transportation Improvement Program -Air Quality Conf. Evaluated project on RI TIP for conformity with the 1990 CAAA and ISTEA of 1991. Examined entire State of RI. -Metacolm Avenue. Examined the effects of this project on the county. -East Providence. Used RI St. Model to evaluate the effects within municipality due to proposed roadway	RISM is a multimodel with highway, transit, & HOV-components. It was developed on TransCAD, . GIS software package equipped with analytical procedures for travel demand modeling. With over 1000 traffic analysis zones, RISM is a versatile tool capable of being used for statewide as well as subarea transportation and land use modeling proj. RISM's St. and area data- bases, created from the RIGIS database and the 1990 US Census Tiger Line Files, respectively, including the entire State of RI and adjacent communities in Connecticut and Massachusetts.			

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		improvement . -Washington Bldg. The RI St. Model was used to test the effect of lane restrictions on an interstate hwy & the resulting traffic diversion during peak periods. -Moshassuck Valley Industrial. Hwy. Evaluation, the effect that completion of an industrial highway and resulting land use changes would have on traffic volumes & travel patterns in the immediate area.				
SC	Robert Addy	No - a model is currently under development				
SD	Jeff Brosz Data Inventory	No.		No		
TN	Steve Allen	No.		It is currently being studied. In the past it seemed too costly to develop land use, socio-economic data & once it was developed, it seemed too costly to maintain. It seems more cost effective to forecast from historical trends & collect data as requested. Of the 95 counties in TN, no traffic requests are received for several counties each year.		
TEXAS	Deborah W. Morris, P.E.	No, however, TxDOT has released a Request for Offer, for service to provide "Statewide Analysis Models for Multi-modal Passenger Commodity Flow Freight.." Types of policy and planning issues. Actions within the TX Trans. Plan adopted by the TX Transportation. Commission. These	The procedure will be dev. of a statewide analysis model incorporates both passenger & freight. The model will be built on a PC platform running Windows NT4.0 & operational in the TransCAD 3.0 environment. It will have inputs & outputs portable to & from TRANPLAN for integration with TxDOT's existing urban area models and shall be compatible with ArcInfo & Areview	See prior comments	What considerations has the EPA voiced concerning the possibility of credits based on freight modeling in air quality determinations? In addition to time and costs to develop and maintain statewide forecasting procedures, what staffing requirements	How is the relationship addressed between the zone structure required for a passenger flow model (relatively fine) vs. that required for a commodity flow freight model (typically less detailed)?

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		actions are: Undertaking a commodity origin-destination study for all modes of freight trans. that identifies & compiles data on origins, destinations., & rates prevalent in internal trade. Design & implement a long-term program to survey & doc. freight and passenger trip patterns, especially Intermodel trips, at the state level, & coordinate these with local origin-&-destination studies done by metropolitan plan. org."Survey, describe, & model interstate. & intrastate. passenger travel patterns to identify deficiencies, opportunities. to improve intermodal passenger travel, & actions required to address system deficiencies.	Modes: The freight component shall model trucks, rail, truck/rail & truck/seaport intermodalism. The passenger component shall model cars & rail. Boundaries & Zone Structures: The vendor will evaluate different scenarios & recommend developing a single statewide model, a series of overlapping regional or corridor models, a subarea windowing capability or some combination.		exist or are anticipated? Will existing staff view the statewide model as a tool to expedite their work or an additional burden to maintain, and if so, how will this be accomplished?	
UT	Wayne Jager	Yes. It is used to determine rural highway capacity once projected year of need for improvements. Developers will use FADT in business plans to secure funding.	Population, employment and dwelling projections for counties ad multi-county planning districts are used to develop a growth factor, which is applied to the AADT. Vehicle mix (percent trucks in vehicle stream) is then determined based on current trucks, known development etc.			
VT	Elena Churchill	Yes. The Vermont Statewide Model is relatively new (1996) so we haven't used it extensively yet.. This model was used for a few corridor studies and major developments. It is currently being used to study the traffic impacts of a proposed circumferential highway around Burling.	TRANPLAN Model Passenger and very limited Transit Model. Number of Zones = 622.			Model/GIS Interfaces

State	**Name**	**Does State Have Travel Demand Forecasting Procedure? If Yes, Elaborate on Types of Issues**	**Procedure Description**	**If No Forecasting Procedure, Are You Going To Develop One?**	**Additional Policy Questions Suggested to Be Explored at Conference**	**Additional Technical Issues Suggested to Be Explored at Conference**
WA	Todd Carlson	Yes. Primarily used to identify Highway System deficiencies (mobility only).	See Statewide Transportation Systems Plan Draft Technical Report.	We are currently building the case for the need to forecast passenger and freight for all modes statewide. To date we have a brief conceptual design for a statewide model.		
WIS	Ken Leonard	Yes. 1. Future mobility issues statewide. 2. Modal tradeoffs in corridors. 3. Within metro areas we use the urban model	1. Statewide it is a step down forecast based on a control total. 2. Corridor forecasts are based on a model. 3. Urban models use zones.		What are the costs of these models? Are the models policy sensitive?	

Summary of Question Topics as Taken from Survey

MANAGEMENT / ADMINISTRATIVE ISSUES

1. Staffing - levels and capability
2. Other resources - hardware and software
2. Staff receptiveness
4. Cost, incentives and financial support - internal and external
5. Education and training required
3. Cooperation among adjacent states
7. Standardization and portability of software

FEDERAL REQUIREMENT ISSUES

1. Federal perspective
    1. value
    2. sophistication
    3. cost and funding
4. Reauthorization implications
3. Rules versus quidelines
4. Standards versus acceptable
5. Advocate versus prescribe
6. What is available; published, content?

DATA ISSUES

1. Cost of data collection, processing and maintenance
6. Funding
3. Cost effectiveness of data collection and forecasting
4. Methods of data collection
7. What data needed
    1. household survey
    2. source to replace household survey
    3. travel time surveys
    4. traffic counting programfreight movements
    5. minimum required

FREIGHT

1. Existing model
2. Trucking and rail
8. Light versus heavy vehicles
4. Intermodal
5. Parameters for models
9. Data availability

7. EPA response

GIS

1. Experience
10. Applications
3. Extent of data required
4. Integration with travel models

MODEL APPLICATIONS

1. Policy sensitive models
2. Experience driving policy and plans
11. Applicability at different levels of analysis
    1. corridor
    2. city
    3. regional
    4. multistate corridor
    5. one tool for all areas; tiers
    6. use of statewide forecasts for projects
4. Relative success with different models
5. Application for land use planning
12. Update cycles

TECHNICAL PROCESS

1. Interfacing with MPO models
2. Base statewide model on regional models
13. Potential for simulation procedures
4. Use for land models
5. Service modeling
14. Provide for alternative modes, for both passenger and freight
7. Consider HOV and TDM as alternative modes
8. Integrate demand models with other with other models
15. How to handle trips external to state
10. Special generators
11. Weekend and occasional trips
16. Responsiveness to economic conditions
13. Relative error of forecasts
14. Effects of taxes and speed limits, etc. on route selection
15. Compatibility between travel and air quality models
16. Interface coordination between travel and emission forecasts
17. Zone structure for passenger versus freight
17. Time series versus cross sectional analysis
19. What level of statistical accuracy
20. What tranferability between states

18. What network size, detail
22. Include refinements from corridor analyses

Agenda for the Workshop on Statewide Travel Demand Forecasting
Beckman Center, Irvine California
December 6-8, 1998

SUNDAY, DECEMBER 6

8:30 a.m.
Registration

8:30 - 9:30 a.m.
Breakfast

9:30 a.m. - 12:00 noon
Briefing on FHWA Manual on Forecasting Statewide Passenger Travel
Alan Horowitz

The Manual on Forecasting Statewide Passenger Travel includes four mudules: 1) forecasting statewide passenger travel; 2) specialized methods for forecasting statewide passenger travel; 3) forecasting commodity flows and freight modules; and 4) time series analysis of statewide traffic data.

12:30 - 1:30 p.m.
Luncheon

1:30 - 3:30 p.m.
Overview of Policy Issues in Statewide Travel Demand Forecasting
Neil Pedersen

Welcome
Allan Hendrix

Panelists
Robert Gorman
Charles Howard
Ysela Llort
Lou Lambert
Ken Leonard
Allan Hendrix

3:30 - 4:00 p.m.
Open Discusssion

4:00 p.m.
Break

4:15 - 6:00 p.m.

Workshop 1

Issue Topics:

*Management Issues

*Federal Requirement Issues

*Data Issues

6:00 p.m.

Reception

7:00 p.m.

Dinner

MONDAY, DECEMBER 7

7:30 - 8:30 a.m.

Breakfast

8:30 - 10:00 a.m.

Presentations

A Contrast of Statewide Models for Small, Medium and Large States

Charles C. Crevo

The Evolution of a Statewide Model for New Jersey

Talvin E. Davis

The Evolutionary Process of Statewide Travel Demand Forecasting

Robert McCullough

New Hampshire Statewide Travel Model System

Subramanian Sharma and Robert Lyford

10:00 a.m.

Break

10:15 - 12:00 noon

Workshop 2

Issue Topics

*Freight

*GIS

*Model Applications

12:00 noon - 1:00 p.m.

Luncheon

1:00 - 2:45 p.m.

Presentations

The California Statewide Travel Demand Forecasting Process
R. Leslie Jones
The Rhode Island Statewide Travel Demand Forecasting Model
Sudhir Murthy and Rajesh Salem

Organizational and Institutional Issues in Statewide Forecasting
Richard Nellet
The Washington State Travel Demand Forecasting Decision Process: From Vision to Products
Todd Carlson

2:45 p.m.
Break

3:00 - 5:00 p.m.
Workshop 3
Issue Topics:
*Groups 1 & 2
Issues A - K
*Groups 3 & 4
Issues L - V

TUESDAY, DECEMBER 8

7:30 - 8:30 a.m.
Breakfast

8:30 - 10:00 a.m.
Presentations
The Kentucky Statewide Transportation Focusing Process
Rob Bostrom
Commodity Flow Modeling
William R. Black
The Oregon Statewide Travel Demand Forecasting Process
William Upton
Statewide Passenger Travel Demand Forecasting (Wisconsin)
Bruce Williams

10:00
Break

10:15 - 12:00 noon
Workshop 4
Issue Topics:
*Research Needs; Develop working

statements
*Need/Objective; Anticipated Output;
Funding

12:00 noon - 1:00 p.m.
Luncheon
1:00 - 3:00 p.m.
Reports from Workshops: Findings and Recommendations

3:15 - 4:15 p.m.
Meeting of Conference Steering Committee: Strategy for Publication of Research Results

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