A System of Activity-Based Models for Portland, Oregon

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May 1998

TMIP

Travel Model Improvement Program

Department of Transportation
Federal Highway Administration
Bureau of Transportation Statistics
Federal Transit Administration
Assistant Secretary for Transportation Analysis

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Travel Model Improvement Program

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

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

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

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

This research was funded through the Travel Model Improvement Program.

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

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Federal Highway Administration
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16. Abstract

This report demonstrates that activity-based travel demand models are currently feasible and can replace traditional trip-based travel four-step demand models for urban areas. Travel decisions are part of a broader activity scheduling decision, and requires that we model the demand for activities as well as mobility. The objective of the research was to project emphasized development of a model system that captures the aspects of decision making while remaining applicable in the near term at the level of state and metropolitan planning organizations. The work indicates that activity-based modeling and forecasting is now feasible and can begin to replace the more traditional trip-based forecasting paradigm within MPOs in the United States. Further developments and improvements are possible in model estimation and application procedures. Future advancements in computing processing power will be important in allowing full power of the approach to be applied in practice. This approach will be adapted to serve as an Activity Generator module for the TRANSIMS case study in Portland to be carried out during 1998and 1999.

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A SYSTEM OF ACTIVITY-BASED MODELS FOR PORTLAND, OREGON

May 1998

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Travel Model Improvement Program

Federal Transit Administration

Federal Highway Administration

Office of the Secretary

U.S. Environmental Protection Agency

Executive Summary

Background

This report describes a project carried out by Cambridge Systematics, Inc. in collaboration with Mark Bradley Research and Consulting and Portland Metro. The project was funded by the US Federal Highway Administration as part of the Travel Model Improvement Program (TMIP), and the work was carried out during 1996 and 1997.

The purpose of the project was to demonstrate that activity-based travel demand models are currently feasible and can replace the traditional trip-based four step travel demand model for urban areas. The motivation for activity-based travel models is that travel is derived from the demand for activities. Therefore, travel decisions are part of a broader activity scheduling decision, and this requires that we model the demand for activities as well as mobility. In keeping with the objectives of the TMIP program, the research in this project emphasized development of a model system that captures these aspects of decision making while remaining applicable in the near term at the level of state and metropolitan planning organizations.

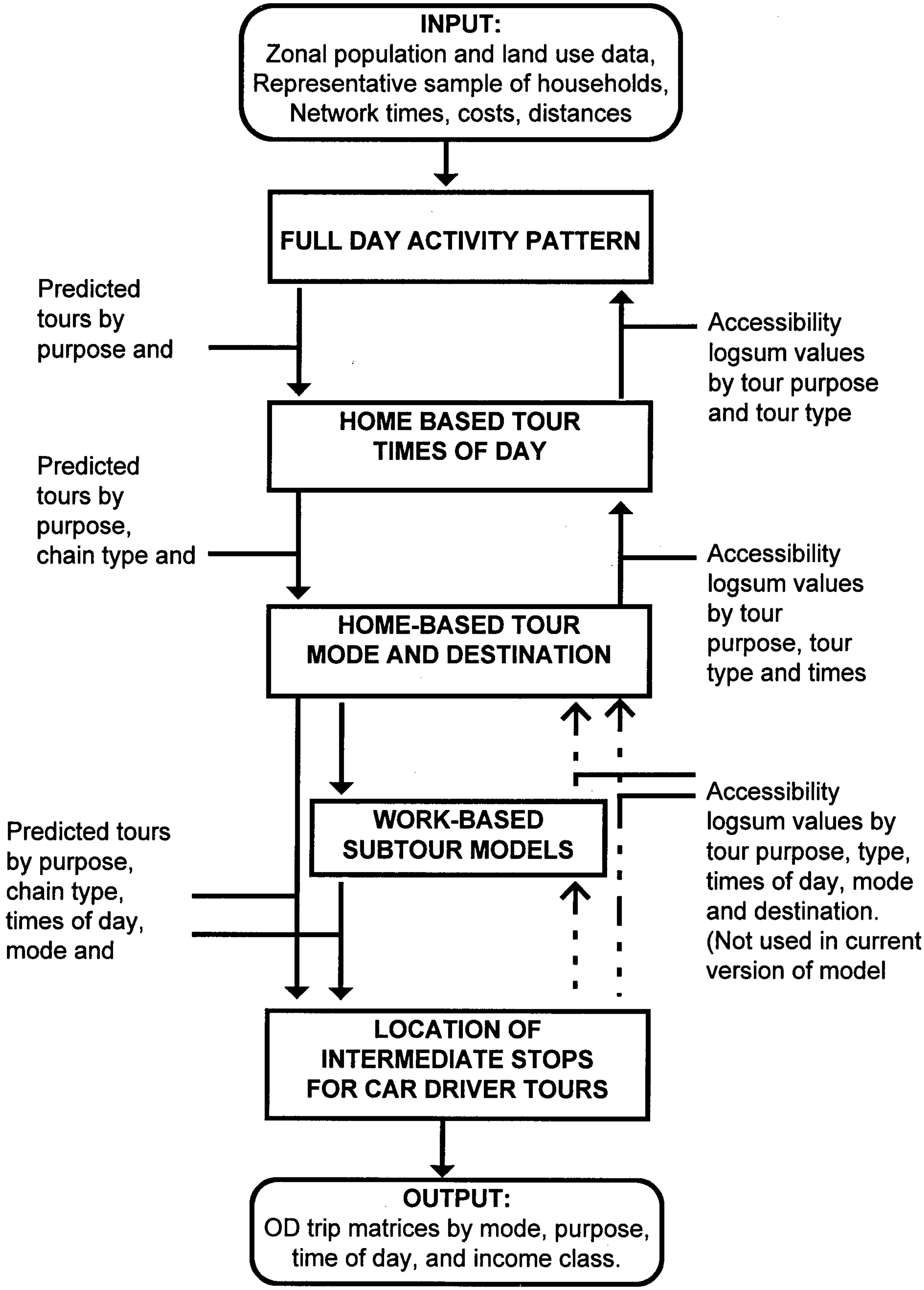
Overview

The activity-based model system described here was developed as an extension of previous research by Bowman (1995) and Ben-Akiva and Bowman (1997) at MIT. The models in the prototype system were estimated using data from a 1994 household travel and activity survey in Portland, Oregon. The model system is designed as a series of disaggregate logit and nested-logit discrete choice models, assuming a hierarchy of the model components. Lower level choices are conditional on decisions at the higher level, and higher level decisions are informed from the lower levels through logsum (accessibility) variables. Figure 1 is a diagram of the model system as currently implemented by Portland Metro. The decisions modeled explicitly in the system are:

Full day activity pattern: Purpose of primary activity: At the highest level of the system is the full day activity pattern model. This model predicts a person's primary activity of the day as either work/school, household maintenance or discretionary, and as either at home or as part of a tour away from home. A tour is defined as a sequence of trip segments that start at home and end at home. A major contribution of this approach is that it includes at-home activities. This feature allows the model to treat the entire range of activities throughout the day, including tradeoffs between in home and out of home activities.

Full day activity pattern: Trip chain type of primary tour: The full day activity pattern model also determines the type for the primary out-of-home trip chain. The tour type is defined by the number and sequence of any intermediate stops made between home and the primary activity. For work tours, this model also determines whether or not there are any work-based "subtours" (trip chains beginning and ending at the workplace) made during the day. It is observed that about half of all trips are made as some part of the home-work-home trip chain. The ability to treat trip chaining explicitly allows these trips to be modeled in a more realistic context.

Figure 1
ACTIVITY-BASED MODEL SYSTEM OVERVIEW



Full day activity pattern: Number, purpose and type of secondary tours: The full day activity pattern model also predicts how many additional "secondary" tours are made during the day. Secondary tours include any trip chains made away from home during the day which do not include the primary activity: for example, a social visit made in the evening after arriving home from work. The model also predicts the main purpose of each secondary tour, and predicts whether intermediate stops are made on the way to and/or from the main destination. Since these tours are predicted simultaneously with the primary tour, the model can capture substitution between making multiple tours from home versus making additional stops during a single tour, for example.

Timing of activities and travel: Once the full day activity pattern is determined, a time of day model predicts the combination of departure time from home and departure time from the primary activity for each tour away from home. The day is broken down into five time periods to distinguish the periods before, during, between and after the AM and PM peaks. By modeling the outbound and return departure times simultaneously, the system can capture "knock on" effects across the day. For example, if a worker departs from home earlier to avoid AM peak congestion, he or she is more likely to be able to leave work earlier in the PM as well.

Choice of mode and primary destination for home-based tours: Once a person's activity pattern is determined in terms of the number, purpose, timing, importance and complexity of tours made across the day, the model system predicts further choices for each of those tours separately. Note that at the tour level, there are separate sets of models depending on purpose (work/school vs. maintenance vs. discretionary). The key model applied at the tour level is a joint destination and mode choice model which depends on the tour purpose and complexity, as well as the road and transit service levels during all segments of the tour. This model estimates the probability that each zone out of a sample of zones will be the primary destination, and that each of nine modes will be the main mode for the tour. The nine possible main modes are drive alone, drive with passenger, auto passenger, LRT with auto access, LRT with walk access, bus with auto access, bus with walk access, walk, and bicycle.

Work-based subtour models: A common type of non-home-based trips is "work-based" trips, which are often part of trip chains which begin and end at the workplace (e.g. going out for lunch). The system contains additional models for such work-based "sub-tours," which are similar to the models for home-based tours. They predict the timing, destination and main mode of any trip chains that begin and end at the primary work place, and are strongly conditional on the timing, mode and destination of the primary tour between home and work.

Choice of locations for intermediate stops: An important feature of this approach is that most trips which are typically pooled together as "non-home-based," such as stops on the way to or from work, can now be modeled in the context of the trip chains of which they form a part. The lowest level model in the system determines the locations of any intermediate destinations visited between home and the primary tour destination, conditional on the main mode and on the location and timing of the primary tour activity. These models are applied for each tour which is predicted to contain intermediate stops. In the current version of the model application, these models are applied at a more aggregate level than the other models, and are applied only for tours made by car.

Application

The study was carried out in parallel with a major congestion pricing study in Portland, a situation which has provided an immediate opportunity to test the activity-based approach in an actual policy application. Given the one-year time frame of the research, it was necessary to make a few simplifications from the original system design, such as applying the lowest level intermediate stop location models at an aggregate level rather than as part of the fully disaggregate sample enumeration. It was possible, however, to keep the overall structure of the system and retain the main innovative features while also creating an application system that can be run by Portland Metro staff on Pentium-based microcomputers. As the application is ongoing at the time of this writing, it is not possible to give any results from that study.

Conclusions

The work so far has indicated that activity-based modeling and forecasting is now feasible and can begin to replace the more traditional trip-based forecasting paradigm within MPOs in the United States. Further developments and improvements are possible both in model estimation and application procedures. Future advances in computing processing power will also be important in allowing the full power of the approach to be applied in practice. There is already a good deal of interest in adapting this approach for use at other MPOs, and in adapting it for other uses such as emissions policy analysis. Also, this approach will be adapted to serve as an Activity Generator module for the TRANSIMS case study in Portland, to be carried out during 1998 and 1999.

Acknowledgments

The main people responsible for the work described in this report are John Bowman and Moshe-Ben-Akiva of MIT and Cambridge Systematics, Mark Bradley as an independent consultant, Tom Rossi and Yoram Shiftan of Cambridge Systematics, and Keith Lawton, Steve Perone, Kyung-Hwa Kim and Dick Walker of Portland Metro. John Bowman of MIT participated as a temporary employee at Cambridge Systematics during the summers of 1996 and 1997. Also contributing through a concurrent congestion pricing project were Randy Pozdena and David Reinke of Eco Northwest, and Greig Harvey, as an independent consultant. Greig passed away during the project, but his legacy of turning state-of-the-art models into practical policy tools has served as both an example and an inspiration.

1. Introduction

This report describes the work done by Cambridge Systematics, Inc. and Mark Bradley Research and Consulting, together with Portland Metro under sponsorship from the Travel Model Improvement Program (TMIP), to demonstrate that activity based modeling is feasible and can replace the traditional trip-based four step travel demand model for urban areas. For this project, an activity based model system was designed based on work done at the Massachusetts Institute of Technology by Bowman (1995) and Ben-Akiva and Bowman (1997). The models were estimated through work both on this project and on a parallel project, the Portland Traffic Relief Options Study (PTROS), a demonstration project into congestion pricing that received both Federal and state funding. Model estimation was done under both projects, while software to apply the models was created and tested under the TROS project.

The confluence of these two projects provides a unique opportunity to immediately test the applicability of the activity-based discrete choice approach. In keeping with the intention of the TMIP program, much of our focus has been on the near-term potential of this approach. The model estimation and application work reported here was done within a time frame of one year and within a fairly modest budget, both indications that the approach can be made applicable at the MPO level.

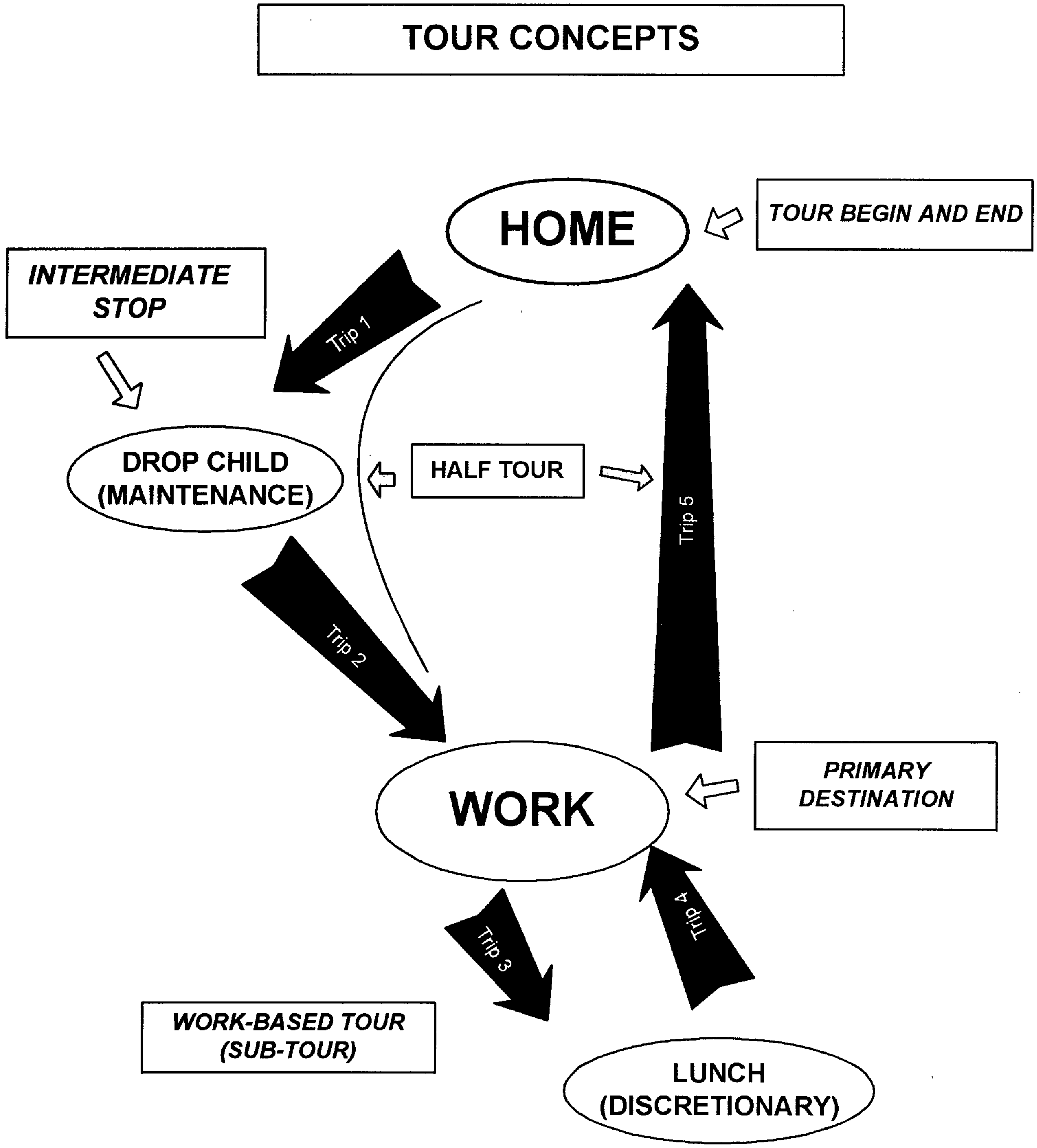
2. Motivation

The motivation for activity based travel models is that travel is derived from the demand for activities. Therefore, travel decisions are part of a broader activity scheduling decision, requiring us to model the demand for activities.

Given the difficulties in modeling the factors underlying the demand for activities and developing an activity based model system, most urban travel models apply some variant of the traditional trip-based four-step modeling approach: trip generation, trip distribution, mode split and trip assignment. The first three components are usually estimated and applied separately for a few trip categories, for example, home based work (HBW), home based other (HBO), and non home based (NHB). In reality, a traveler may try to combine trips of different purposes into "tours." The tour concept is illustrated graphically in Figure 2. The number of tours and the characteristics of each tour an individual makes during a day are derived from his or her demand for activities. In this case the number of tours and their characteristics, including the number of destinations, their spatial distribution, mode of travel, and time of day, are all interrelated.

The need for activity based modeling has been widely discussed in the travel demand literature, but new approaches have generally been limited to academic research. A first step towards activity based models was the introduction of tour-based models, where the unit of travel is defined as the tour from home to one or more destinations and then back home. Activity-based models go a step further by combining the tours in a day, plus any key at-home activities, into a full-day activity pattern. The development of tour based and activity based modeling has taken place in the Netherlands, resulting in practical tour based model systems operating in, among other places, the Zuidvleugel region of the Netherlands (Daly, van Zwam and van der Valk, 1983), and the Dutch National Model (Gunn, van der Hoorn and Daly, 1987). More recent tour based model systems have been developed for Stockholm (Algers et al, 1995) for Salerno, Italy (Cascetta, Nuzzolo, and Velardi, 1993) and for the Italian Transportation System (Cascetta and Biggiero, 1997). In the U.S. tour based models were developed for Boise, Idaho (Shiftan, 1995) and for the New-Hampshire statewide model. (Rossi and Shiftan, 1997).

Figure 2


TOUR CONCEPTS
HOME
TOUR BEGIN AND END
INTERMEDIATE STOP
Trip 1
DROP CHILD (MAINTENANCE)
HALF TOUR
Trip 5
Trip 2
WORK
PRIMARY DESTINATION
Trip 3
Trip 4
WORK-BASED TOUR (SUB-TOUR)
LUNCH (DISCRETIONARY)

The New Hampshire statewide travel model system was developed by Cambridge Systematics for the New Hampshire Department of Transportation (NHDOT) and consists of the same components as the Boise system with the addition of a mode choice component to the tour-based model system. 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.

The Boise and the New-Hampshire models were developed using an econometric utility approach. In this approach the decision maker considers all feasible alternatives, or uses a simple search rule (heuristic) which results in a large choice set. Most of the model is devoted to the complex representation of a utility-based multi-dimensional choice set, and no iteration occurs between search and choice. An alternative approach of hybrid simulation was used by RDC (1995) to develop the Activity-Mobility Simulator (AMOS) including a prototype model which has been tested in the Washington metropolitan area. Hybrid simulation models focus most of their attention on the choice set generation, employing a complex search heuristic which yields a very small choice set. A very simple utility or satisfaction based model is used to represent the choice from this set, and the process may involve iteration between search and choice.

The current Portland effort is similar to the Boise and New-Hampshire approach but goes beyond them in its scope towards a complete activity-based model system. This is due to the greater resources available for model development, to the existence of a good geographic information system and a recent household activity survey including at-home activities, to the experience gained from the Boise model, the New Hampshire model, and, most importantly, to the earlier work undertaken by Bowman and Ben-Akiva at MIT. The model structure described in the following section is a direct extension of the MIT work, also taking advantage of the practical experience in applying complex tour-based models which team members have gained at Cambridge Systematics and Hague Consulting Group.

3. The Structure of the Activity-Based Model System

This section describes the overall model structure. An ideal activity based model system includes full information on the chain of activities each person in the household is involved in throughout the day. This information includes time of day, duration, activity type, location, mode of travel, and travel time for each activity. The model structure designed for this project tried to get as close as possible to such an ideal model system, but at the same time to consider application issues so that the system could be implemented immediately by Portland Metro.

The initial model system design was based on previous and ongoing research by Bowman and Ben-Akiva at MIT. A memo describing the initial design in detail is included as Appendix A to this report. While that full design remains a goal for this line of research, parts of it were deemed as too ambitious for the scope of this project and for application by Portland Metro given current technology and resources. Therefore the model system that was actually estimated and applied required some amendments from the original design, although the main advantages of activity-based modeling were retained. Further research needed to meet the original design requirements is discussed in the final chapter of this report, and is outlined in more detail in a memo included as Appendix D.

The remainder of this chapter describes the model system as currently implemented.

3.1. Tour Concepts

Figure 2 illustrates the tour and related concepts that are important in understanding the model structure. A tour is defined as a sequence of trip segments that start at home and end at home. Each tour can have number of stops, and stops are classified by three purposes: subsistence (work or school), maintenance, and discretionary. Section 4 of Appendix A describes how each of the possible activity purposes is classified to one of these three main purposes. Each tour has a primary destination. For tours that include a stop for work that exceed a threshold duration, the work is the primary destination of the tour. For other tours a set of rules based on a combination of hierarchy and duration of activities determine the primary destination. Section 3 of Appendix A gives details of how the primary destination of a tour is determined.

The portion of the tour from home to the primary destination is called a half tour, and the portion of the tour from the primary destination to home is the other half of the tour. All stops other than the primary destinations are called intermediate stops. One or more activities may take place at each stop location, so the duration of a stop can be quite long, although it is generally less than the time spent at the primary destination. Subsistence tours may have a work-based (or school-based) sub-tour. A work based tour is defined as a sequence of trip segments that start at work and end at work. For example, a person leaving work for lunch and coming back to the office is making a work-based sub-tour.

3.2. The Overall Model Structure

Figure 1, included in the Executive Summary above, shows the overall structure of the activity-based model system. The model system is designed as a system of disaggregate logit and nested-logit models assuming a hierarchy of the model components. Lower level choices are conditional on decisions at the higher level, and higher level decisions are informed from lower level through logsum (accessibility) variables.

Table 1 shows the five main types of models currently included in the system, as well as the types of variables included in each of the model types. The models are disaggregate in that they include demographic and socioeconomic descriptor variables that can vary for each household and person in the sample. Residence area land use is also included in the models at the traffic zone (TAZ) level. Destination land use variables and network times and costs for car and transit are used in the Mode and Destination models and the Intermediate Stop Location models. These variables are not used directly in the Times of Day or Activity Pattern models, but their influence is captured through the "accessibility logsum" variables, which represent the expected utility across all possible modes and destinations in the lower level models.

Note that the models for Work-Based Sub-tours and Intermediate Stop Locations use aggregate categorical variables (income class and home-based tour mode and times of day). Also note that none of the higher level models use accessibility logsums from these two lowest levels. This departure from the original system design was made so that these two types of models could be applied at a more aggregate level, making it feasible to apply the entire model system using current Pentium-based microcomputers.

Table 1: Model Types and Variable Types

Model / Variable Types	Household descriptors	Person descriptors	Residence land use	Destination land use	Network times, costs	Accessibility logsums
Full-Day Activity Pattern (Tours by Purpose, Type)	✓	✓	✓			✓
Home-based Tour Times of Day	✓	✓	✓			✓
Home-based Tour Mode and Destination	✓	✓	✓	✓	✓	
Work-based Subtour Mode and Destination	✓*	✓*		✓	✓	
Intermediate Stop Location for Car Driver Tours	✓*	✓*	✓	✓	✓	

*: these are included only as aggregate categories in the current model system

The following sections describe the data source for model estimation, and then each of the model types in turn.

3.3 The Household Activity and Travel Survey Data

In 1994, a large-scale household survey was carried out in Portland and the surrounding counties. Background data was collected at the household level and person level, and then each person in the household completed a two day diary listing <u>major in-home activities, plus all travel made during the days</u>. The survey contained roughly 5,000 households, giving more than 10,000 persons and 20,000 person-days of travel and activities. All activities were geocoded with over a 95% success rate for addresses within the current Metro study area.

A number of stated preference experiments were also carried out in conjunction with the household survey. For this study, the most relevant experiment was one which looked at mode choice, time of day choice, route choice and travel frequency in response to changes in travel times, fuel costs, transit fares, and, most importantly, hypothetical tolls introduced on major roads.

In order to use the survey data in model estimation, it was necessary to perform the following steps:

- merge together corresponding household, person, activity, and location data,
- classify the activity and travel sequences into tours and day-long activity patterns,
- draw samples of alternative destinations for the mode and destination choice models and intermediate stop location models,
- attach zonal land use data to tour origins and alternative destinations/stop locations,
- attach zone-to-zone car and transit times, costs and distances to all possible tour origin/destination pairs

These procedures and the relevant data files are documented in detail in a memo included here as Appendix B. The rules for classifying activity chains into tours and activity patterns and for drawing samples of alternative destinations generally followed the original system design in Appendix A, but a few revisions were necessary, and these are documented in Appendix B.

Appendix B also contains a number of tables that summarize the resulting tour and activity pattern data files.

In this study, the data preparation was a fairly time-consuming process, involving a number of iterations as methods were improved and anomalies in the data were identified. As further studies of this sort are undertaken, these data processing procedures can become more standardized and available to other practitioners.

3.4. The Full Day Activity Pattern Model

The highest level of the model system is the full day activity pattern model, an extension of earlier work reported by Ben-Akiva and Bowman (1997). The basic behavioral unit for this model is a person-day. In both estimation and application we have limited the sample to persons aged 16 and over, and limited the days to weekdays (Monday to Friday). We know the basic socio-demographic characteristics of each person and his/her household, as well as the zone (TAZ) in which the person lives. We also know the numbers of drivers and vehicles in the household.

Figure 3 shows the 114 full day activity pattern alternatives specified in this model. The model determines the person's primary activity of the day as either subsistence (work or school), maintenance and discretionary, and as either at home or on tour. A key feature of the model is that it includes at-home activities. This allows the model to predict the entire day's activity pattern, including tradeoffs between at home and on tour activities.

The primary daily activity is one of six alternatives:

1. Subsistence (work or school) at home
2. Subsistence (work or school) on tour
3. Maintenance (shopping, personal business, etc.) at home
4. Maintenance (shopping, personal business, etc.) on tour
5. Discretionary (social, recreation, entertainment, etc.) at home
6. Discretionary (social, recreation, entertainment, etc.) at tour

(Note that in this study, we only included people aged 16 and over. If children were included, it would be necessary to treat school separately from work).

If the primary activity is out of home, the full day activity model also determines the trip chain type for that tour. There are eight possible types for work/school tours and four possible types for maintenance and discretionary tours. The trip chain type is defined by the number and sequence of the stops in the tour. The alternatives that apply for all tour types are:

1. simple tour (no intermediate activities)
2. one or more intermediate activities on the way from home to the primary destination
3. one or more intermediate activities on the way from the primary destination to home
4. intermediate activities in both directions.

The four additional types that apply for work/school tours are:

1. simple tour plus a work-based sub-tour (intermediate tour beginning and ending at work or school)
2. intermediate activity on way to primary destination, plus work-based sub-tour
3. intermediate activity on way back home, plus work-based sub-tour
4. intermediate activities in both directions plus work-based sub-tour

Simultaneously with primary activity type and primary tour type, the full day activity model predicts the number and purposes of secondary tours. There are six alternatives:

1. No secondary tours
2. One secondary tour for work or maintenance
3. One secondary tour for discretionary purpose
4. Two or more secondary tours for work or maintenance
5. Two or more secondary tours for discretionary purpose
6. Two or more secondary tours: at least one for work or maintenance and at least one for discretionary purposes.

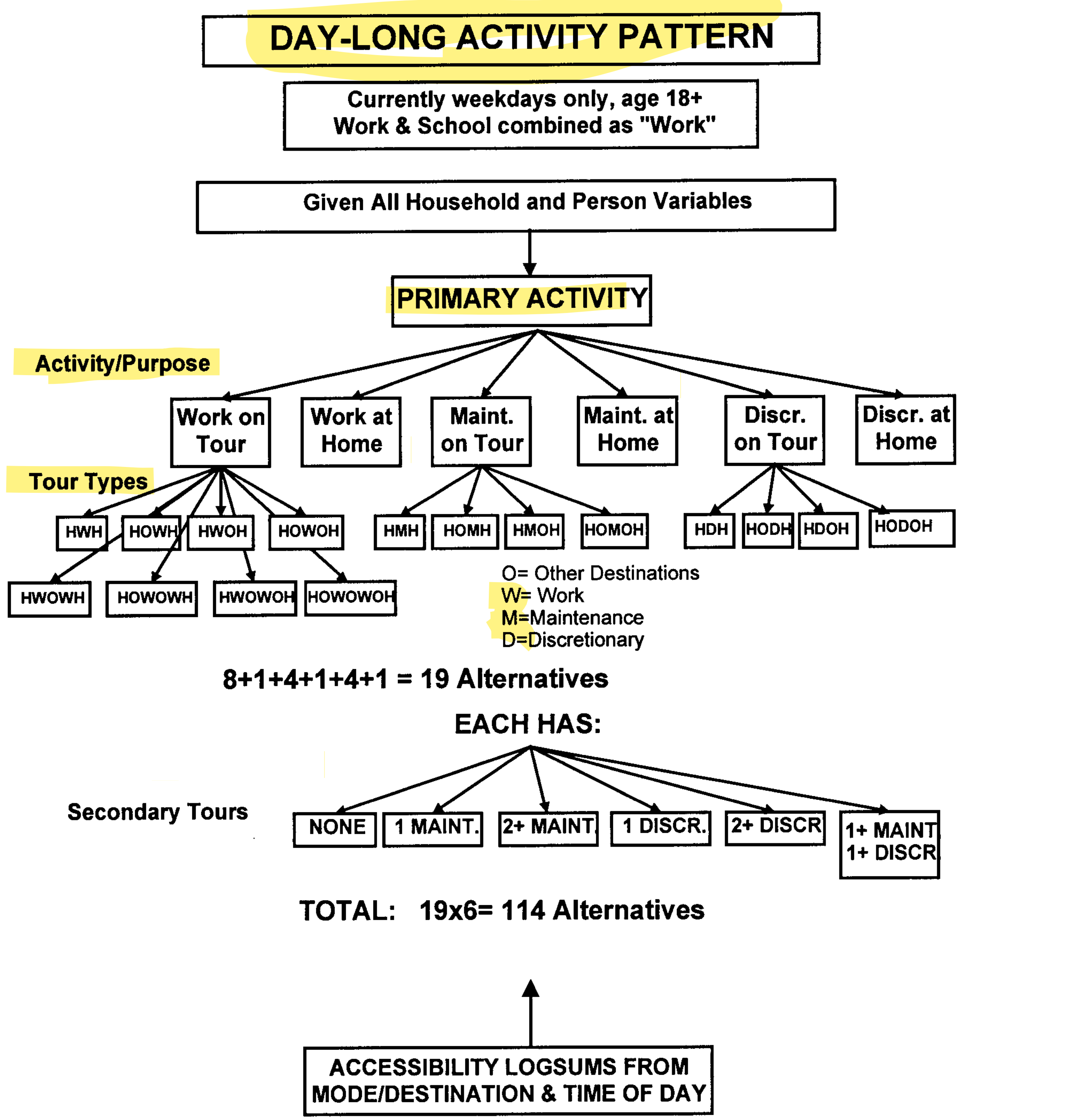
Since not all of the tour types apply to all of the primary activity types, there are 8+1+4+4+1+1 = 19 possible combinations of primary activity/tour types Each of the possible secondary tour patterns are possible for all primary activity/tour types, so the model has a total of 19 x 6 = 114 alternatives, as shown by Figure 3.

The model is based on person and household characteristics, as well as logsums from the lower level mode/destination choice models. The model was estimated using nested and non-nested structures, with nesting giving no significant improvement. The model estimation results are given in Appendix C, Table 1.

In applying the models, the 114 choice probabilities are combined to predict the number of tours made during the day by 3 purposes and 12 types. For work/school, there are only 8 possible tour types, as listed above. For maintenance and discretionary, there are 12 types, as listed below:

(1) primary tour, no stops
(2) primary tour, stop on way to primary destination
(3) primary tour, stop and way back from primary destination

Figure 3



DAY-LONG ACTIVITY PATTERN
Currently weekdays only, age 18+
Work & School combined as "Work"
Given All Household and Person Variables
PRIMARY ACTIVITY
Activity/Purpose
Work on Tour
Work at Home
Maint. on Tour
Maint. at Home
Discr. on Tour
Discr. at Home
Tour Types
HWH
HOWH
HWOH
HOWOH
HWOWH
HOWOWH
HWOWOH
HOWOWOH
HMH
HOMH
HMOH
HOMOH
HDH
HODH
HDOH
HODOH
O= Other Destinations
W= Work
M=Maintenance
D=Discretionary
8+1+4+1+4+1 = 19 Alternatives
EACH HAS:
Secondary Tours
NONE
1 MAINT.
2+ MAINT
1 DISCR.
2+ DISCR
1+ MAINT
1+ DISCR
TOTAL: 19x6= 114 Alternatives
ACCESSIBILITY LOGSUMS FROM
MODE/DESTINATION & TIME OF DAY

(4) primary tour, stops in both directions
(5) secondary tour, no stops, no work tour in pattern
(6) secondary tour, stop on way to primary destination, no work tour in pattern
(7) secondary tour, stop and way back from primary destination, no work tour in pattern
(8) secondary tour, stops in both directions, no work tour in pattern
(9) secondary tour, no stops, work tour in pattern
(10) secondary tour, stop on way to primary destination, work tour in pattern
(11) secondary tour, stop and way back from primary destination, work tour in pattern
(12) secondary tour, stops in both directions, work tour in pattern

For secondary tours, we distinguish whether or not the primary activity is a work tour because this is an important variable in the time-of-day models.
For secondary tours, instead of using a logit choice models to determine tour type, we use fixed values for the tour type probabilities based on the survey sample distribution, as follows:

Tour-type distributions applied for secondary tours

Secondary Tour Type: Full day pattern includes:	Maintenance Work tour %	Maintenance No work tour %	Discretionary Work tour %	Discretionary No work tour %
No stops	70.4	74.2	84.0	86.4
Stop before	12.9	11.7	7.0	6.7
Stop after	11.9	11.0	6.3	4.1
Stop both ways	4.8	3.1	2.8	2.8

Also, some of the secondary tour alternatives do not exactly describe the number of secondary tours, so again we use average values from the survey sample in applying the models:

Average number of secondary tours applied for modeled alternatives

Secondary Tour Type: Full day pattern includes:	Maintenance Work tour	Maintenance No work tour	Discretionary Work tour	Discretionary No work tour
no secondary tours	0	0	0	0
1 maintenance tour	1.0	1.0	0	0
1 discretionary tour	0	0	1.0	1.0
2+ maintenance tours	2.115	2.325	0	0
2+ discretionary tours	0	0	2.000	2.066
1+ both purposes	1.215	1.316	1.060	1.146

The tables show that secondary maintenance tours are more likely to include intermediate stops than are secondary discretionary tours, and that there are several cases of people making more than two secondary maintenance tours - particularly when there is no work tour made during the day.

3.5. The Home-based Tour Time of Day Models

Once the full day activity pattern is determined in terms of the number, purpose and trip chain type of all tours during the day, the time of day model is designed to determine the sequencing and duration of these tours and the out-of-home activities that comprise them. In the current application, we only distinguish between five different time periods:

1. EA	Early	3:00 am to 6:59 am
2. AM	AM Peak	7:00 am to 9:29 am
3. MD	Midday	9:30 am to 3:59 pm
4. PM	PM Peak	4:00 pm to 6:59 pm
5. LA	Late	7:00 pm to 2:59 am

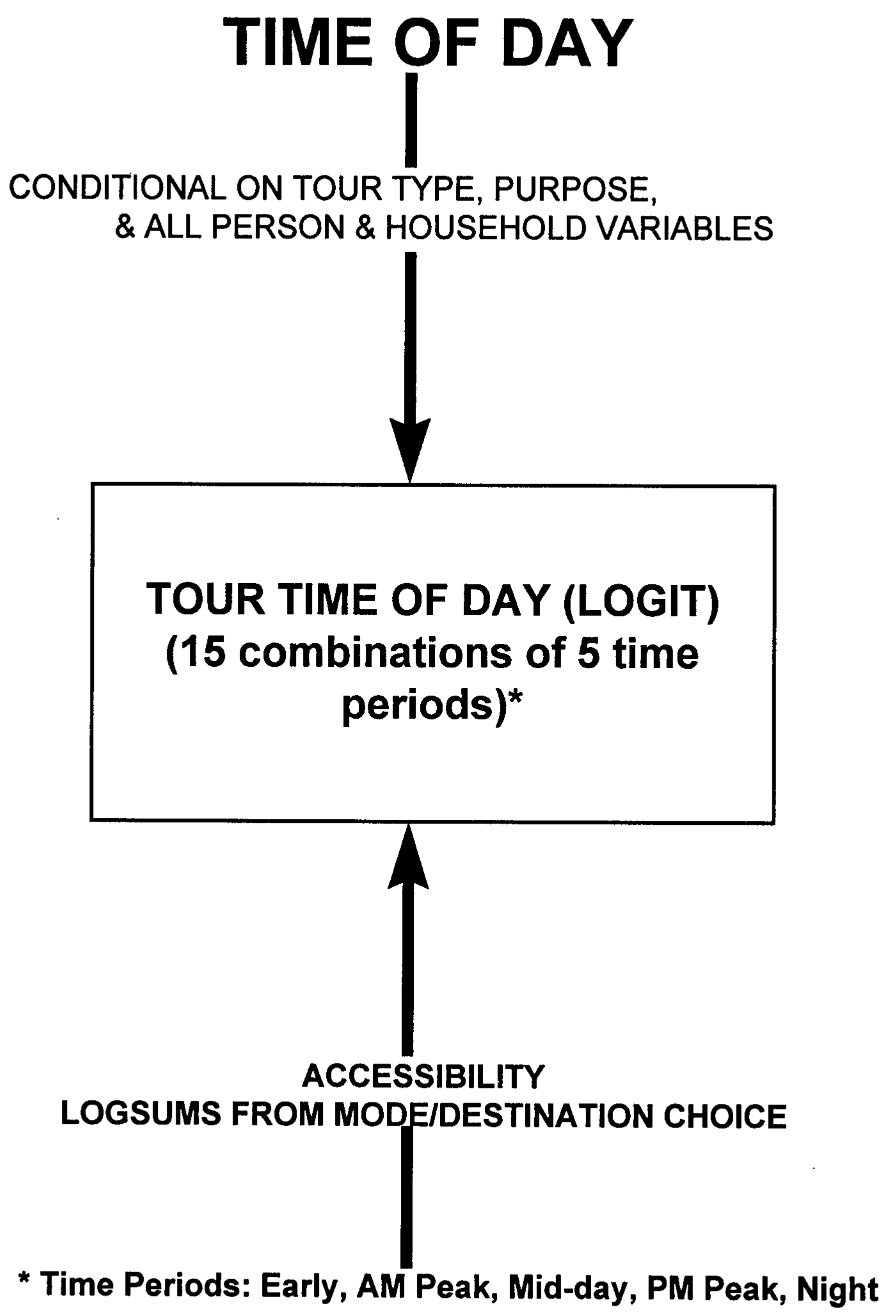
The time of day model structure is summarized in Figure 4. For each tour, the model predicts the combination of departure time from home and departure time from the primary activity. Given there are five time of day periods, there can be twenty five combinations of start and end periods. However, all pairs extending overnight were eliminated in application resulting in fifteen possible combinations, as shown below. In the current version of the model system, all intermediate activities occurring within a half tour are all assigned to the same time period.

(1) EA-EA	(2) EA-AM	(3) EA-MD	(4) EA-PM	(5) EA-LA
	(6) AM-AM	(7) AM-MD	(8) AM-PM	(9) AM-LA
		(10) MD-MD	(11) MD-PM	(12) MD-LA
			(13) PM-PM	(14) PM-LA
				(15) LA-LA

Currently, we have estimated three separate time of day models, one for work/school tours, a second for maintenance tours, and a third for discretionary tours. Various person and household variables were used as independent variables, as well as logsums from the lower level mode/destination choice models. Tour purpose and tour type were also used as variables, meaning that the time-of-day models are applied conditionally on the results of the full day activity pattern model. These models take into account whether or not there are intermediate activities on the half tours, whether it is a primary tour or a secondary tour, and whether or not a work/school tour is also made during the day. The estimation results are shown in Appendix C, Tables 2 and 3.

Note that time of day is one of the most difficult aspects to include in full detail in the activity-based approach. This is partially due to the lack of variation in network time and cost data across times of day, but is mainly due to the fact that the number of possible combinations of activity sequences and start and end times for all activities across the day is immense, particularly if we move to shorter time periods such as one hour time slices. In this study, we have chosen a practical approach which gets at the timing of the key activities in relation to the key time periods in the day. There is still a great deal of scope for improving this aspect of the approach, as discussed in the final chapter and Appendix D. In particular, one could specify a larger number of time periods across the day, perhaps in combination with a sampling of alternatives approach to limit the number of alternatives. One could also increase the range of variables included, adding variables such as occupation type and schedule flexibility indicators.

Figure 4



3.6. The Home-based Tour Primary Destination and Mode Choice Models

Once the full day activity pattern is determined in terms of number, purpose, hierarchy, trip chain type, and times of day of each tour, the model system predicts the primary mode and destination for each tour. As shown in Figure 5, the model predicts the probability that each zone out of a sample of 22 zones will be the primary tour destination, and that each of 9 possible modes will be the main mode of the tour. So, in the joint model there are 22 x 9 = 198 mode/destination alternatives. The 9 possible main modes are:

1. Auto drive alone
2. Auto drive with passenger
3. Auto passenger
4. MAX (light rail) with auto access
5. MAX (light rail) with walk access
6. Bus with auto access
7. Bus with walk access
8. Bicycle
9. Walk only

The primary mode of the tour is determined by the combination of the modes for the two half tours, and the mode for the half tour is determined by the combination of the modes for the different trip segments. The rules to assign the mode of the tour based on the mode of the different trip segments are detailed in Appendix A Section 2. Therefore the primary mode of the tour may actually represent a group of different modes on the trip segments that make up a tour. (This occurs in about 3% of cases in the Portland survey data, with the most common combination being auto drive alone in one direction and drive with passenger in the other direction.).

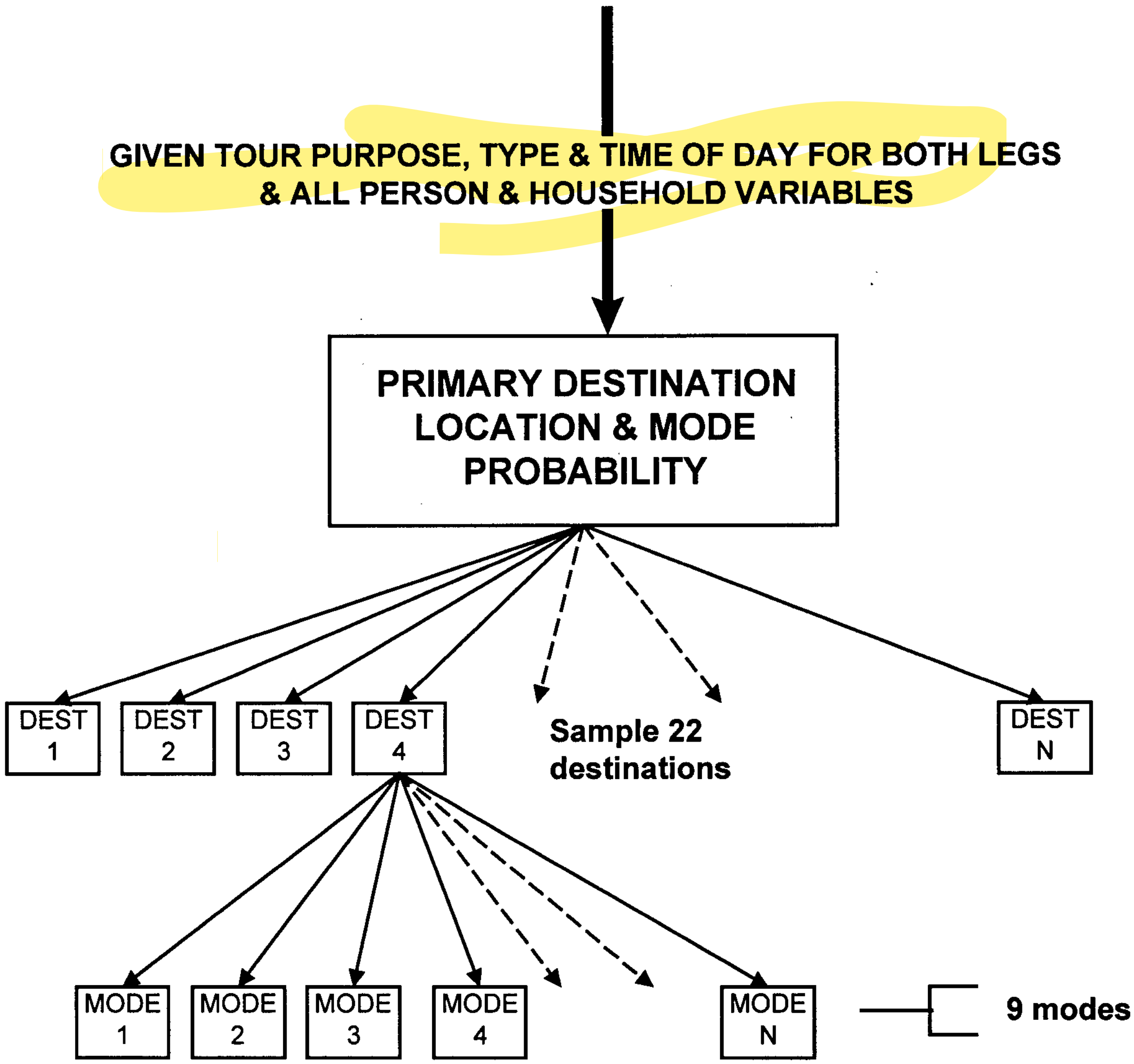
For each observed tour used in estimating these models, 21 possible destination zones were drawn from the full set of 1244 zones using a stratified sampling approach. The strata were set up to try to match the actual distribution of destinations in terms of distance and employment, as follows:

(1)	the residence zone
(2-5)	4 zones sampled from a distance less than D1
(6-9)	4 zones sampled from a distance between D1 and D2 and employment < S1
(10-13)	4 zones sampled from a distance between D1 and D2 and employment > S1
(14-17)	4 zones sampled from a distance greater than D2 and employment < S2
(18-21)	4 zones sampled from a distance greater than D2 and employment > S2

where: D1 = the 20th percentile distance of all actual tour destinations for the purpose
D2 = the 60th percentile distance of all actual tour destinations for the purpose
S1,S2 = the median "size" of all actual tour destinations in the distance band,
(size = total employment for work/school,
retail+service employment for maintenance, and
retail+service employment + households for discretionary)

Figure 5

PRIMARY DESTINATION & MAIN MODE CHOICE



198 choices per tour

This is disaggregate, by tour taken from the sample of households from each zone.

In plainer words, all possible destination zones around each origin were classified into 3 distance bands, and the zones in the outer 2 distance bands were classified according to high or low employment levels. This effectively classifies all zones into 5 "bins," and 4 zones were sampled randomly from each bin. The distance bands and employment cutoffs were set so that the distributions of the sampled zones by distance and employment would match the distributions for the actual chosen zones as closely as possible. The origin zone was always included in the sample as well, giving a total of 21 alternatives.

The probability of sampling each of the 21 zones is calculated and used in model estimation to correct for the sampling procedure (see Ben-Akiva and Lerman 1985). This procedure has been shown to produce consistent estimates, while keeping the number of choice alternatives manageable for model estimation and application.

The mode/destination models use household and person data as well as network distance, time and cost data. In the course of extensive testing, it was found that the Revealed Preference (RP) data would not support estimation of reasonable coefficients for both the time and cost variables for any of the tour purposes. This is probably due to the fact that both parking costs and traffic congestion are fairly low in Portland (at least at the level of definition in the data), meaning that both car costs and car travel times are strongly related to distance and thus correlate highly with each other. Another possible explanation is that there is very low transit usage in Portland, and those who do use transit may be basing their choice on factors other than travel time and cost.

For these reasons, a decision was made to constrict the values of travel time to be equal to those estimated from the concurrent Stated Preference (SP) survey. Another attractive feature of the SP data is that it looked directly at reactions to congestion pricing - an important policy measure to be analyzed with the model and which does not exist in Portland presently. The SP-based values of time were estimated separately for home-work trips and home-other trips, and were estimated for three different income classes. The values are shown in Table 4 in Appendix C. The variation is greater between income classes than it is between purposes, particularly for the work trips.

The SP-based values of time were used to calculate "generalized time" for the car and transit modes (the total time and cost utility divided by the car drive alone time coefficient), which was used as a variable in the mode/destination choice models shown below in Appendix C - Table 5. In each of the three models, a function was estimated that contained linear, quadratic and cubic terms for the generalized time. The results are highly significant, with the same general shape in all the models. The function is slightly S-shaped, with disutility rising sharply at first, then leveling off a bit, and then rising more sharply again at very high travel times. This function gives a reasonable match to the actual distribution of tour distances in the data for all modes.

The other mode-specific variables in the models are mostly related to age, gender and household type. The car availability variables are very strong, particularly for the car driver and transit alternatives.

At this level of the application system, probabilities are generated for 3 tour purposes x 8 tour types x 15 time of day combinations x 21 destinations x 9 modes, which is almost 70,000 elemental alternatives. Because of this large size and resulting limitations on computer run time, the lower level models for intermediate stop location, and work-based tour mode/destination described below were not made part of the sample enumeration system. Those models are applied in a separate more aggregate zone-to-zone context, with no logsum feedback to the higher level models.

3.7. The Work-based Sub-tour Models

The large majority of work-based sub tours are simple tours with no intermediate stops, with both half-tours made during the midday hours. Therefore, we did not estimate separate models to predict the time of day and complexity of these sub-tours, but just apply fixed fractions based on the shares observed in the survey data. As one would expect, the time of day fractions are strongly conditional on the times of day the home to work tour begins and ends.

This still leaves us to predict the mode and destination of the work-based sub-tours, as shown in Figure 6. The mode-destination choice model is very similar to the models for home-based tours described above, except that now the choices are strongly dependent on the mode used to go between home and work. In particular, the mode to work determines whether or not a car is available for any work-based tours made during the day. The estimation results are shown in Appendix C, Table 6.

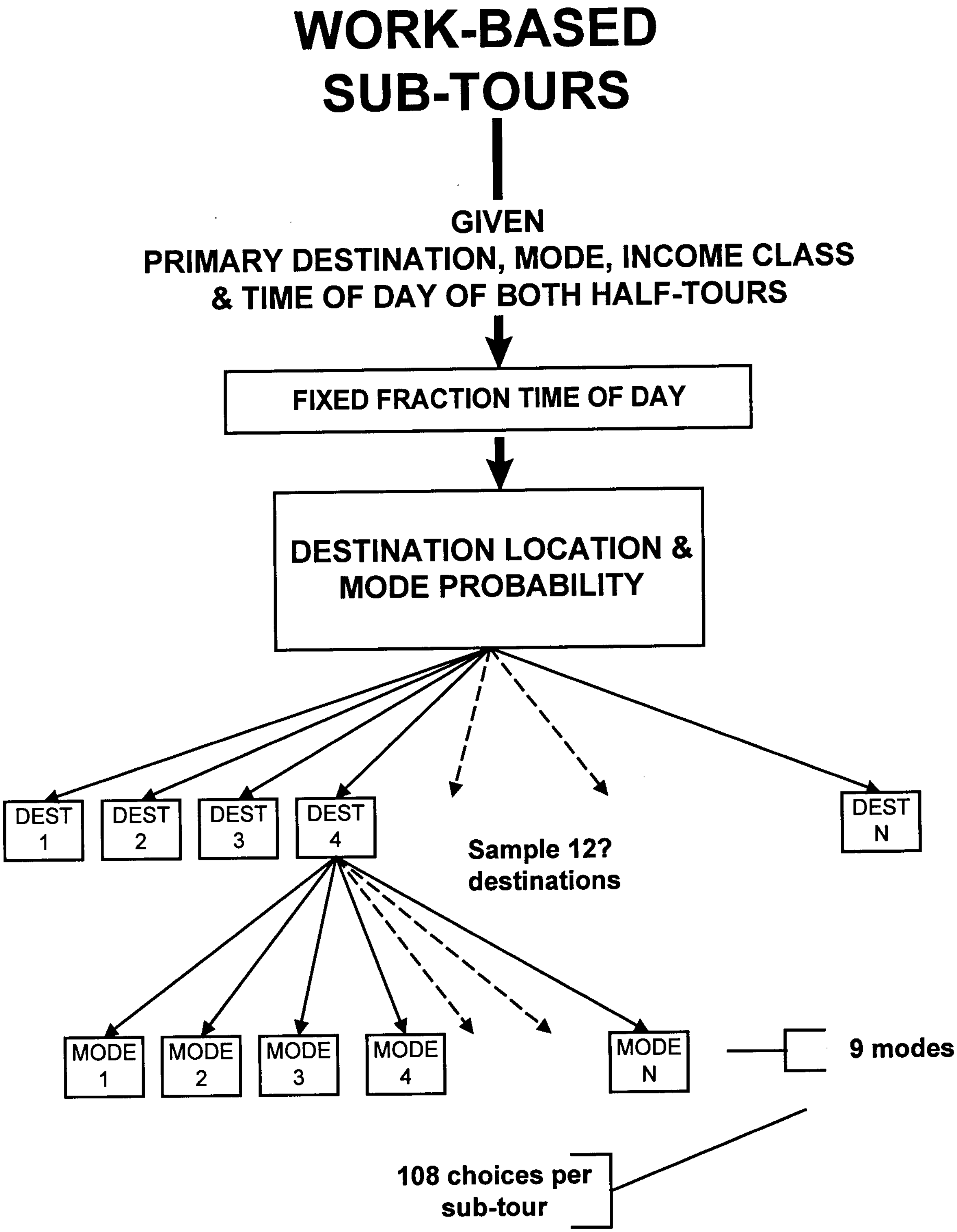
3.8. The Intermediate Stop Location Models

The "lowest" level model in the system determines the location for each intermediate activity made during a given half tour. Figure 7 shows the structure of this model. It is analogous to the structure of the mode/destination models described above, except that now the mode is fixed to be the same as the mode used to make the half tour (switching modes during a half tour is not considered).

Another aspect of this model is that the possible locations are sampled using distance bands, as before, but now the relevant distance is the extra distance required to make the stop relative to making no stop at all between the tour origin and primary destination. The estimation results, shown in Appendix C, Table 7, are for two separate models - one for stops made during work-related tours, and the other for stops made during non-work-related tours. Both models show the same S-shaped impedance function as already seen for the mode/destination choice models in earlier sections.

There are three aspects to the handling of intermediate stops that are not as complete as one would ideally want. First, we only treat a maximum of one intermediate activity in each half-tour direction. Second, we currently only apply this model for car driver tours, and not for transit tours (in the survey data, intermediate stops are more common for car tours than for transit tours). Third, and most important, we apply the intermediate stop models on an aggregate zone-to-zone level, and do not use the logsums from these models in the higher level tour models. This simplification is necessary to retain computational feasibility for the system as a whole. Even with these approximations, the explicit treatment of the majority of intermediate stops is an improvement over most tour-based sample enumeration systems reported elsewhere.

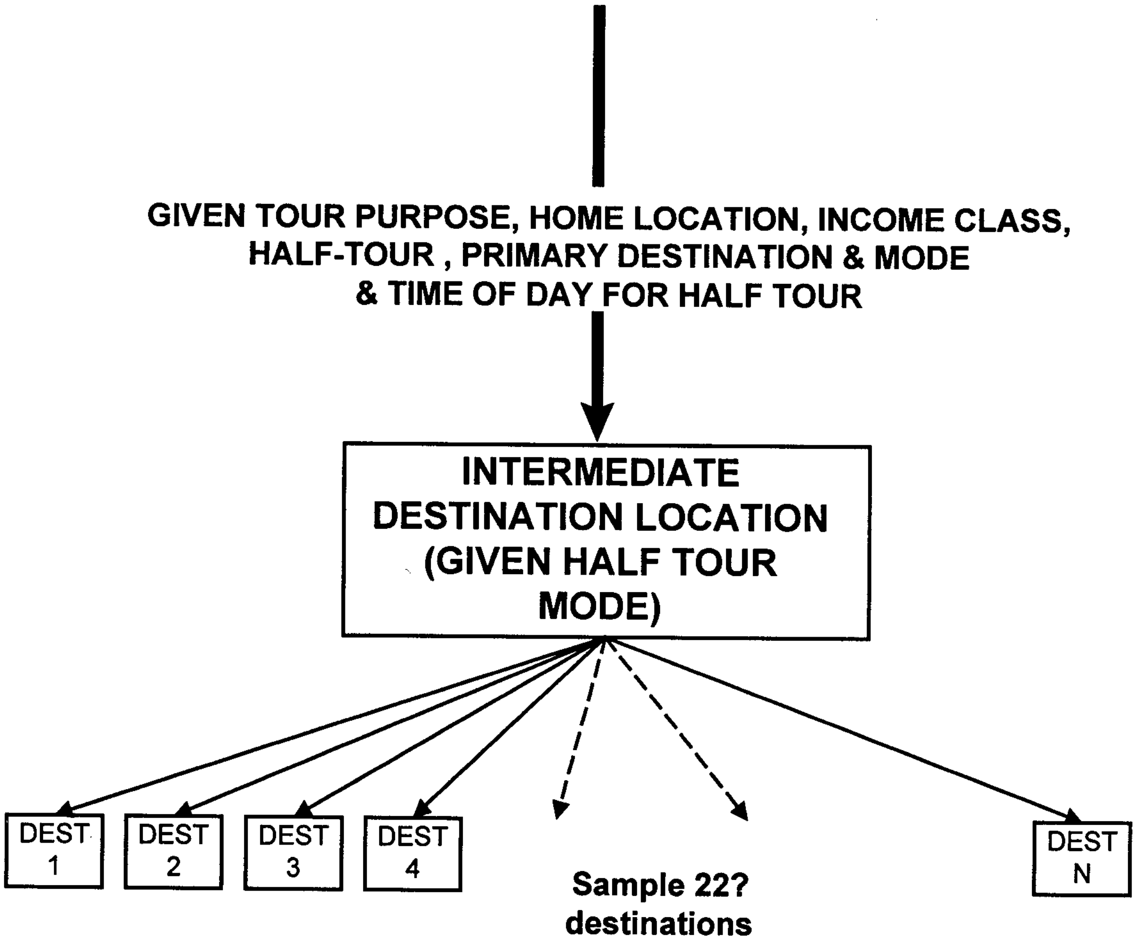
Figure 6



Note: This model is aggregate initially, applied by work zone.

Figure 7

LOCATION CHOICE FOR INTERMEDIATE STOPS



Note: Initial application will be as an aggregate model for all half tours between each zone to zone pair. Later applications will be disaggregate. Applied separately to each half tour

4. Application of the Models

4.1. Current application

At the time of writing this report, the model system is being implemented at Portland Metro to provide forecasts for a study of possible congestion pricing policy initiatives. Figure 8 illustrates how the activity-based model system fits within the larger forecasting system. The models we have discussed thus far form one "layer" of the structure which is located second from the bottom of the diagram. The top layers above this involve:

1. preparation of input data for both the base case and policy cases
2. generation of a synthetic sample of households for each forecast year/ demographic scenario
3. use of an auto ownership model to replace the PUMS-based number of vehicles with a more policy sensitive measure.

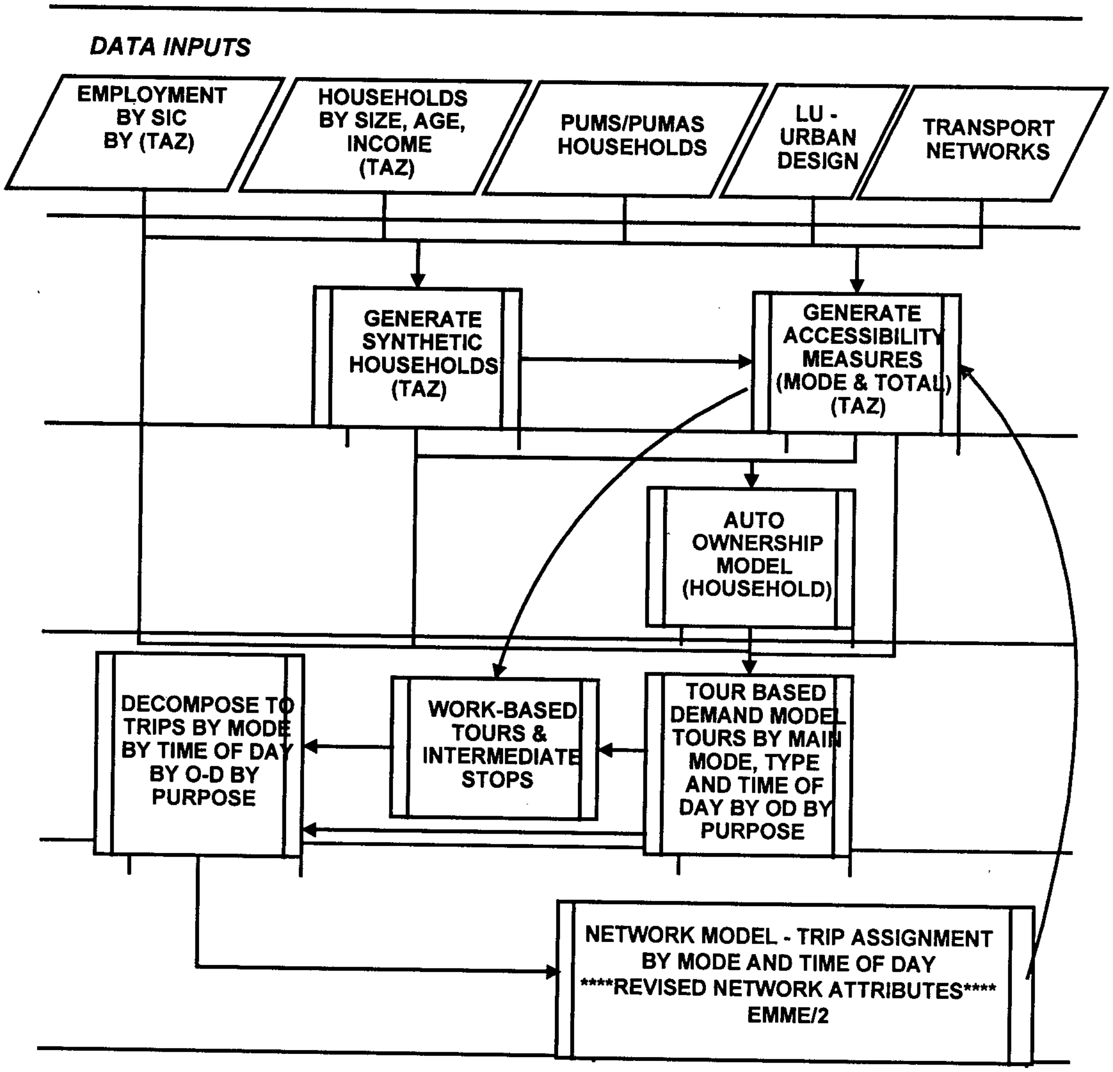
The bottom layer involves assignment of the trip matrices for car and transit trips to the relevant networks. Ideally, the loaded network travel times and accessibilities that result from the assignment procedure are fed back into the car ownership model and into the activity-based models, and the entire system is iterated in this manner until the network travel time attributes are consistent in all of the component models.

Use of the system for road pricing policies involves additional considerations for consistency between different components. Using multi-user class assignment with different values of time in each class, the assignment procedure will assign a fraction of users to the tolled network links and the rest of the users to alternative routes with no tolls. In the mode/destination choice models, we want to use the probability-weighted travel time and cost faced by each person, and this will be a function of that person's probabilities of taking the tolled route versus the non-tolled route, multiplied by the respective travel times and costs on those routes . We have worked out a procedure to approximate this route choice probability within the activity-based model system, and thus retain as much consistency as possible with the assignment model. Even so, we still need to iterate on all components of the entire system to ensure that all travel times and costs are consistent.

Another practical issue is the calibration of the models to existing traffic counts, etc. In theory, this procedure can be done in the same way as for a more traditional trip-based system. In practice, it may take MPOs some time to get used to the new trip purpose definitions, etc., and to develop new calibration procedures. In cases where existing base trip matrices have already been developed and validated, a pivot point procedure can be used to retain the policy sensitivity of the new models while matching the base case forecasts of the old models. Such a pivot procedure is being implemented at Portland Metro.

Figure 8

MODEL SYSTEM OVERVIEW



4.2. Illustrative results

Although no applications results for the entire model system are available at the time of writing this report, it may be useful to show some results from applying simple policy measures to the survey data used for model application. The results in this section are taken from the simultaneous application of the full day activity pattern model, the home-based tour time of day models and the home-based tour mode/destination choice models to the household survey data. The application used the same disaggregate sample enumeration procedure that is used in the full model system. What is not included in this example are the models for work-based tours and intermediate stops, the route choice assignment procedure, and the expansion of the sample to the larger Portland area population. Because route choice tends to be the decision that is most sensitive to shifts in car times and costs, we can expect that the policy effects for the system as a whole will be much larger than the effects shown in this example. The most interesting results to focus on here are the relative policy effects on mode choice, trip distance, time of day choice, and activity participation.

Table 2 below contains a few selected results for the application exercise. More complete results are given in Tables 8 to 11 of Appendix C. Results are given for three policies, each with respect to the base case 1994 road and transit networks. For the first policy, a 10% increase in all car travel times, the results show a mode choice elasticity for car drive alone tours of -0.13, and for drive alone tour distance of -0.36. This indicates that the destination choice element is more sensitive than the mode choice element for this policy. (Clearly, this must be interpreted as a longer-term elasticity, since people cannot easily change their work or school destinations in the short term.). For maintenance and discretionary tours, the car drive alone tour and distance elasticities with respect to travel time appear higher than for work/school, with values around -0.30 and -0.65 respectively. For all tour purposes, the effects on car drive alone tours are about the same for all periods of the day.

For the first policy, the decrease in the number of total tours across all modes and all times of day is about -0.2% for work/school, -1.0% for maintenance and -0.3% for discretionary. This indicates the activity suppression effects of the policy, which are predicted via the full day activity pattern model. As one would expect, this effect is much smaller than the mode choice or destination choice effects. The fraction of tours suppressed is about the same during all of the periods of the day.

The second policy simulates a 100% increase in car fuel and operating costs, from 8 cents per mile in the base case to 16 cents per mile in the policy case. The implied elasticities for car drive alone in this case are about -0.06 and -0.15 for work/school tours and mileage, and about -0.10 and -0.21 for both maintenance and discretionary tours and mileage. Again, there are similar effects during all periods of the day. A difference with respect to the travel time policy, which can be seen in the more complete tables in Appendix C, is that increasing car costs causes an increase in multiple occupant car tours, whereas increasing car travel times causes a decrease in all types of car tours.

The third policy simulates a toll charged only during the AM peak and PM peak periods, which has the effect of doubling the car fuel and operating costs during those periods (i.e. it is equivalent to the second policy, but applied only during the peaks).

Table 2: Selected results for model application example

Policy description:	10 % increase in all travel time by auto		100% increase in all variable costs by auto		100% increase in auto variable. costs during peak	
Subsistence (work/school) tours	% chg Tours	% chg Miles	% chg Tours	% chg Miles	% chg Tours	% chg Miles
All modes						
- All times of day	-0.2	-2.7	-0.8	-9.4	-0.6	-5.5
- AM peak	-0.3	-2.9	-0.6	-9.0	-1.6	-8.6
- Midday	-0.2	-2.6	-1.1	-9.8	+0.8	-1.2
- PM peak	-0.2	-2.8	-0.6	-9.0	-1.8	-9.1
- Off-peak	-0.1	-2.3	-1.2	-10.1	+1.6	+0.6
Single occupant auto						
- All times of day	-1.3	-3.6	-5.8	-14.6	-3.5	-8.5
- AM peak	-1.4	-4.0	-5.8	-14.6	-5.9	-13.1
- Midday	-1.2	-3.3	-6.2	-15.0	-0.4	-2.5
- PM peak	-1.4	-3.9	-5.6	-14.4	-6.1	-13.6
- Off-peak	-1.0	-2.9	-5.9	-14.5	+1.0	0.0
Maintenance tours	% chg Tours	% chg Miles	% chg Tours	% chg Miles	% chg Tours	% chg Miles
All modes						
- All times of day	-1.0	-5.0	-2.3	-14.2	0.0	-2.1
- AM peak	-1.0	-5.2	-2.0	-13.6	-1.7	-8.0
- Midday	-0.7	-4.6	-1.6	-13.7	+0.8	0.0
- PM peak	-1.4	-5.5	-2.9	-14.3	-1.6	-6.6
- Off-peak	-1.6	-5.3	-4.0	-15.9	+0.5	+0.5
Single occupant auto						
- All times of day	-2.8	-6.5	-8.7	-21.5	-1.2	-3.6
- AM peak	-2.5	-6.6	-6.9	-19.3	-4.2	-11.0
- Midday	-2.5	-6.2	-8.2	-21.4	+0.3	-0.7
- PM peak	-3.3	-7.2	-9.6	-21.9	-4.5	-10.2
- Off-peak	-3.4	-6.8	-10.7	-23.5	+0.4	+0.4
Discretionary tours	% chg Tours	% chg Miles	% chg Tours	% chg Miles	% chg Tours	% chg Miles
All modes						
- All times of day	-0.3	-4.4	-0.6	-13.3	+0.2	-1.2
- AM peak	-0.2	-4.3	-0.2	-11.9	-1.4	-7.8
- Midday	-0.2	-4.3	-0.3	-13.2	+0.6	-0.8
- PM peak	-0.3	-4.6	-0.5	-12.9	-0.3	-2.9
- Off-peak	-0.3	-4.5	-0.9	-14.0	+0.6	+0.7
Single occupant auto						
- All times of day	-3.1	-6.5	-10.7	-23.1	-1.3	-3.2
- AM peak	-2.5	-6.4	-7.9	-20.4	-5.5	-12.5
- Midday	-2.9	-6.4	-10.0	-22.6	-0.6	-2.2
- PM peak	-3.3	-6.7	-11.1	-23.3	-3.1	-6.4
- Off-peak	-3.2	-6.4	-11.9	-24.3	+0.6	+0.6

For the last policy, Table 2 shows that there is also some shift of tours out of the peak periods into the midday and off-peak periods. To offset this change, some tours that previously had one half tour in one of the peak periods and the other half tour outside the peak may now switch modes or destinations or be suppressed altogether. For work/school car driver tours, we see that the net effect from these two offsetting changes is negative in the midday period (-0.4%) and positive in the early and late off-peak periods (+1.0%). The results for maintenance and discretionary tours are similar to those for work/school. Using the tour-based approach with time-of-day sensitivity allows the models to capture such complex shifts.

There are also offsetting changes predicted by the full day activity pattern model. When some peak period activities are suppressed, this allows other activities to be substituted during the midday and off-peak periods when travel costs have not increased. These new activities in the off-peak periods tend to be non-work activities, many of which would have otherwise been made as intermediate stops on a work tour. For maintenance, these types of changes cancel each other out (net effect of 0), while for discretionary there is even a slight increase in the total number of tours made (+0.2%), although the distance traveled while making those tours has decreased slightly. Table 8 in Appendix C provides more detail as to which types of tours are made. For discretionary tours, for example, the 0.2% increase arises from an increase in the number of primary tours which more than offsets a decrease in the number of secondary tours made after work/school tours. Although these changes are not large in this example, they illustrate the range of realistic policy effects added by adopting the activity based modeling approach.

4.3. Future applications

The key limitation for the current activity-based model system is simply one of computer processing time and, to a lesser degree, memory and disk space. As these continue to improve over time, the models can be improved accordingly. The most important improvements are discussed next in the final chapter.

One particular application that should be of great interest is as part of the TRANSIMS model system being developed at Los Alamos as another stream of the TMIP research program. That stream has the longer-term, more ambitious goal of doing away with the spatial and temporal approximations used in the modeling process, such as zones, time periods, samples of households, and so forth. The final TRANSIMS test-bed application is now getting underway in Portland, and the activity-based approach described in this report will be tested as a means of generating household activity patterns within the TRANSIMS framework.

While the TRANSIMS approach is exciting for the longer term, we believe that this approach has a great deal of potential in the near term. As applications are carried out in Portland and, we hope, other interested MPOs and agencies, the benefits of the approach will be seen in terms of more realistic and responsive forecasts.

5. Conclusions and Recommendations

This project goes a substantial way towards demonstrating that Activity Based Modeling is feasible and can replace the traditional trip-based four step process for MPOs in the United States. While the model structure had to be simplified from its original design to fit current Metro computing capabilities and the scope of this project, this should not be a constraint much longer as computing resources continue to become cheaper and faster.

While this application represents a major improvements over both current practice by MPOs in the United States and over the previous tour based models developed, there is still some ways to go towards achieving a full activity based model system. Possible first steps for future work will be to complete the current application to match the original design more closely, as described in Appendix D. The most important features to improve in order to implement the original design are:

- **Time of day of the primary activity.** In the current application the time of day of the primary activity is modeled given the tour type. There is a need to test the level of time of day choice in the model system hierarchy, and to test if time of day should be part of the daily activity pattern as was originally designed. It is hypothesized that perhaps time of day of the primary activity should be at a higher level than the tour type and should include accessibility linkage from the tour type, and thus that the tour type should be modeled given the primary activity time. Increasing the number of time periods considered in the model is another possible improvement, perhaps in combination with a sampling of alternatives approach, such as was used for destination choice.

- **Intermediate stop model.** In the current version, secondary stops are modeled and applied in an aggregate fashion. Also, it is assumed that time period for the secondary stop is the same as the period leaving home for stops on the way to the primary destination, and is the same as the period leaving the primary destination for stops on the way back to home. Disaggregate secondary stop models should ideally be incorporated in the model system to determine the time and location of all intermediate stops.

- **Work sub-tour model.** In the current version, this model is also applied in an aggregate manner. Disaggregate models determining the mode, destination, and time of day of work-based sub-tours could be implemented.

- **Time and space availability constraints** should ideally be implemented to account for dependencies between activities. For example the timing of the primary activity should constrain the times available for secondary tours. To make such improvements meaningful, it will probably be necessary to define the time periods more precisely (e.g. moving to time slices of one hour or shorter).

- **A more precise zone system.** The current application uses the existing Metro's traffic analysis system of 1244 zones. The original design call for a one acre grid cell system. Metro's current GIS system can identify the spatial variables for such a grid based system, allowing a more accurate description of spatial variables and spatial dependency between activities. This is especially important for walk and bike trips, as well as accessibility to transit. Alternatively, we can consider using street segments instead of grid cells to define locations, as is currently being done in the TRANSIMS Portland test application.

Other design improvements that are not part of the original design for this project include mainly the incorporation of long term decisions including principal work place, residential location and other long-term household activity pattern:

- **Condition the models on principal workplace**. In the current version the work destination is modeled given the daily activity pattern including timing of the primary activity, tour type and secondary tours. However, work location is a longer term decision and should appear high in the model system hierarchy. For shorter term forecasting, tour type and timing should be conditioned on the "fixed" work destination. It is suggested to add a primary work location model high in the system hierarchy with accessibility variables from the tour models. The work destination at its current place in the model system can remain in addition to the principal work place for the daily work place. This model can be a nested model, binary at the upper level with the alternatives of going to the principal work place or going to an alternative work place, with a destination choice model at the lower level for the case of going to an alternate work place.

- **Residential choice** is another long term decision that should appear at a high level of the model system. The order of the residential location versus the primary work location should be tested. This is the subject of ongoing Ph.D. research at MIT.

- Other long-term household activity pattern decisions may include: purchasing of a transit monthly pass, daycare arrangement for small children, and school location for children.

Other possible improvements involve the level of detail of the models:

- **Time of day** still needs significant improvement to account for the details of the daily activity pattern. The coarse definition of five time of day periods does not allow us to accurately identify the duration and sequence of activities and the time span between trips (important considerations for peak spreading policies and air quality forecasting). Methods to improve time of day modeling should be investigated, including more time of day periods (possibly with sampling of alternatives), and/or modeling time of day as a continuous variable.

- **More activity purposes.** The aggregation of all tour into three purposes does not allow us to account for the different characteristics of tours with different purposes. At the minimum school tours should be separated from work tours, but other disaggregation of tour purposes should also be investigated, such as separating pick up and drop off passengers from other maintenance purposes.

- **Trip segment mode choice.** The current version assigns one mode for the whole tour. Models that predict the mode for the half-tour given the tour mode and then predict the trip segment mode given the half-tour mode could be implemented.

- **Interactions between household members.** Currently, each adult in the household is treated separately, with no explicit joint decision-making. Such interactions should eventually be included, at least at the uppermost levels predicting lifestyle and activity pattern decisions.

- **Separate models for children's activities and for weekend activities**: To be comprehensive, the models should simulate activities and travel for children under 16 as well. These should be modeled as conditional on the activities of the adults in the household. Separate models for weekend days should also be included, perhaps with fewer purpose classifications and details than are used for weekday travel.

- **Explicit models of transitions over time.** All of the models are currently static in nature. Effort should be made to collect and use panel data to make the models of longer-term lifestyle decisions more explicit in representing transitions in choices over time.

Final important areas for further research include:

- **Microsimulation application framework**: Many of the changes mentioned above would add considerably to the number of alternatives and levels of hierarchy that would need to be included in the model. It is doubtful that all of these changes could be incorporated fully within the disaggregate nested logit sample enumeration framework. An alternative is to shift to a stochastic (Monte Carlo) microsimulation framework which simulates a single discrete activity pattern in full detail for each individual. This approach is now being developed and tested in the framework of the TRANSIMS Portland case study. The approach retains the structure and information from the nested logit models while calculating probabilities going "up the tree," but simulates single choices with additional details while coming "back down the tree."

- **Sensitivity testing**: Regardless of application framework, the sensitivity of such activity-based models needs to be tested more fully in order to understand their strengths and potential weaknesses. This would include testing in response to:

    - various types of exogenous inputs
    - random perturbations
    - model mis-specification
    - choice set mis-specification
    - variations in application sample size and choice set size

    Some testing of this sort will occur naturally in the course of application, but more structured testing efforts should be undertaken as well.

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TECHNICAL APPENDICES TO FINAL REPORT

A System of Activity-Based Models for Portland, Oregon

A Demonstration Project for the

FHWA Travel Model Improvement Program (TMIP)

May, 1998

Appendix A: Activity Based Model System for Portland Metro: Preliminary Model System Design

Memo by John Bowman

This document represents the design of the Portland activity based travel demand model system, as of mid-August, 1996, replacing draft 2 which was distributed on or around July 10, 1996. Sections 8 and 9 are new. Minor changes in old sections are shown in boldface type. The following sections are included:

1	Daily Activity Schedule Hierarchy	Shows the explicitly modeled dimensions of the daily activity schedule and the hierarchy which relates them
2	Daily Activity Schedule Definition of Alternatives	Defines the alternatives for each dimension of the hierarchy.
3	Interpreting the Survey Data	Provides rules for translating observed daily schedules into the model hierarchy, providing additional definition of the dimensions of the daily schedule.
4	Definitions of Activity Purposes	Translates the survey activity codes into the three activity purpose categories of work, maintenance and discretionary.
5	Assigning Mode	Provides logic for assigning the principal mode of any tour in the daily activity schedule.
6	Sampling of Alternatives	Explains the stratified importance sampling scheme and procedures for sampling destination alternatives.
7	Availability of Alternatives	Lists the criteria for evaluating the availability of alternatives in each dimension of the daily activity schedule.
8	Handling the Enriched Sample	Specifies the dimensions of the model system which require special estimation procedures, the special procedures required, and the weighting factors which should be used.
9	Primary work tour explanatory variables	This section defines variables which may be important in the various models which comprise the work tour.

Section 1: Daily Activity Schedule Hierarchy

Daily Activity Pattern
Primary activity (purpose, at home vs. on tour, timing)
  Primary tour type
    Secondary tours (number and purpose)

Primary Tour
Work tour mode and destination
  Before work stop (**timing**, destination)
  Midwork stop (timing, mode, destination)
  After work stop (timing, destination)
Nonwork tour mode and destination
  secondary stop (sequence, timing, destination)
    tertiary stop (sequence, timing, destination)

Secondary Tours
Work and maintenance tours (timing, mode, destination)
Discretionary tours (timing, mode, destination)

Notes:

1. The entire daily schedule is conditioned on residential location, auto ownership and workforce participation, which are all assumed to be a long term lifestyle and mobility choice, as in the MTC and tour-based model systems. **However, it is not conditioned on a principal workplace.**

2. Indentation indicates conditionality, including the use of expected utility measures from indented choice dimensions.

3. The Daily Activity Pattern (DAP) alternative set is enhanced from the Ben-Akiva and Bowman prototype to include stop sequence in the primary tour.

4. The DAP model includes logsums directly from the primary tour and secondary tour models. The rationale for this change from the prototype is that expected utility from primary and secondary tours directly affect the choice of daily activity pattern. The primary tour model does not condition the secondary tour models. The important aspects of the primary tour which condition secondary tour choices are included explicitly in the choice of daily activity pattern.

5. The primary work tour model has been enhanced from the prototype to explicitly model secondary activities occurring before, during and after work. The primary work tour mode and destination choice includes up to 3 logsums, one for each of the before, mid and after work stops.

6. The primary nonwork tour has been enhanced to explicitly model secondary and tertiary stops. Participation in these secondary and tertiary stops is determined as a part of the daily activity pattern.

Section 2: Daily Activity Schedule Definition of Alternatives

Dimension	Alternatives	Definition/Notes/Issues
Daily Activity Pattern		
Primary activity	Work at home Work on tour Maintenance at home Maintenance on tour Discretionary at home Discretionary on tour	See the attached section on interpreting the survey data for detailed interpretation of the meaning of these alternatives.
Primary activity timing begin and complete times (home activity) -or- departure time from home and departure time from primary activity(tour activity)	1. AM peak to AM peak 2. AM peak to midday 3. AM Peak to PM peak 4. AM peak to night 5. midday to midday 6. midday to PM peak 7. midday to night 8. midday to AM peak 9. PM peak to PM peak 10. PM peak to night 11. PM peak to AM peak 12. PM peak to midday 13. night to night 14. night to AM peak 15. night to midday 16. night to PM peak	AM peak is 6:30 am -8:59 am midday is 9 am - 3:59 pm PM peak is 4 pm - 6:59 pm night is 7 pm - 6:29 am We will combine with the most similar alternative any time period alternative which occurs in less than 1% of the sample of primary activities.
Primary tour type	Work tour types: HWH HWOH HOWH HOWOH HWOWH HWOWOH HOWOWH HOWOWOH Maintenance tour types: HMH HMHo HMHoo+ Discretionary tour types: HDH HDHo HDHoo+	Home indicates presence at home location. One W indicates primary work activity away from home. O indicates activities for any purpose at one or more locations away from home (except can be home in case of WOW). M indicates primary maintenance activity away from home. o indicates 1 additional stop for any purpose somewhere on the tour. oo+ indicates 2 or more additional stops for any purpose somewhere on the tour. D indicates primary discretionary activity away from home. See the attached section on the interpretation of the data set for detailed interpretation of the meaning of the alternatives.
Number and purpose of secondary tours	0 M D MM+ DD+ MD+	No secondary tours 1 tour for work or maintenance 1 tour for discretionary purpose 2 or more tours for work or maintenance 2 or more tours for discretionary purposes 2 or more tours: at least 1 for work or maintenance and at least 1 for discretionary purposes.

Section 2: Daily Activity Schedule Definition of Alternatives (continued)

Dimension	Alternatives	Definition/Notes/Issues
Primary Work Tour		
Mode and destination	Modes: Drive alone (DA) Drive with passenger (DP) Auto passenger (PA) MAX with auto access (MA) MAX with walk access (MW) Bus with auto access (BA) Bus with walk access (BW) Walk (WA) Bicycle (BI) **Destinations:** **1-acre grid cells**	Principal mode for a tour or subtour. This is based on the principal mode used for each of the two half-tours (journey to destination and journey from destination), excluding from consideration modes used for subtours (of the tour or subtour being considered). **The mode alternative will be defined by the two half-tour modes in a few cases which occur frequently in the data.** See the attached section on the assignment of modes for detailed interpretation of these alternatives.
Before work timing --departure time from before-work activity location	**AM peak midday PM peak night**	**We will combine with the most similar alternative any time period alternative which occurs in less than 1% of the sample of before work stops.**
Before work destination		
Midwork timing --departure time from work --departure time from midwork activity location	same as primary activity timing	See the attached section on interpreting the survey data for detailed interpretation of these alternatives.
Midwork mode and destination	modes are the same as primary work tour mode	
After work timing --departure time from after-work activity location	AM peak midday PM peak night	We will combine with the most similar alternative any time period alternative which occurs in less than 1% of the sample of after work stops.
After work destination		

Section 2: Daily Activity Schedule Definition of Alternatives (continued)

Dimension	Alternatives	Definition/Notes/Issues
Primary Nonwork Tour		
Mode and destination	same as primary work tour mode	
Secondary sequence	before primary activity after primary activity	
Secondary timing --departure time from secondary activity location	same as after work timing	
Secondary destination		
Tertiary sequence	relative to primary and secondary stops: before between after	
Tertiary timing --departure time from tertiary activity location	same as after work timing	
Tertiary destination		
Secondary Tour		
Timing --departure time from home departure time from primary activity location	same as primary activity timing	
Mode and destination	same as primary work tour mode	

Section 3: Interpreting the Survey Data

These rules explain how to interpret the survey data set in terms of the model system design, assigning all the attributes which together define the daily schedule.
Assign each reported activity to one daily schedule.

I. Assign a purpose of work (W), maintenance (M), or discretionary (D) to every activity, using the attached definition of activity purposes.

II. Determine if the daily activity pattern is work on tour, work at home or non-work.
   A. **Calculate the total reported duration of work activities conducted away from home, and call this total the work on tour duration.**
   B. Add the total reported duration of work activities conducted at home to the work on tour duration. Call this the work duration.
   C. Using the results of a) and b) for the entire sample, generate histograms of work duration and work on tour duration. For the work (alternatively, work on tour) histogram choose a threshold which is as large as possible without interpreting as nonwork (alternatively, work at home) very many patterns which include work activity (alternatively, work on tour). **A threshold of 60 minutes was chosen for work on tour (MAB, actproc3.doc).**
   D. If the work duration exceeds the work threshold, assign the pattern as work; else assign it as non-work. For work patterns, if the work on tour exceeds the work on tour threshold, assign it as work on tour; else assign it as work at home **and assign as the primary activity the at home W activity with the greatest duration.**

III. For work on tour patterns, define the primary tour, and the work-based subtour if applicable.
   A. Assign as the primary work destination the work destination within the daily pattern which is visited the largest number of times. If this number of visits is shared by 2 or more destinations, assign as primary the one with the largest total work duration.
   B. If the primary work destination is visited more than once in the daily activity pattern, assign a pattern which includes WOW.
   C. For patterns with WOW, include in the primary tour workday the 2 work stops with longest duration at the primary work location, and, for patterns with 3 or more stops at the primary location, any additional stops which occur at the primary work location without an intervening trip home. Also include in the workday any stops which occur between these workday work activities.
   D. Assign as the departure time from home the last departure time from home prior to the arrival at the first of the workday's stops at the primary work location. Use as the departure time from work the departure time from the last of the workday's stops at the primary workplace. Assign the tour mode using the attached rule for assigning modes, using the half tour which begins at the assigned departure time from home, and the half tour which begins at the assigned departure time from work.
   E. For WOW patterns use, as the explicitly modeled subtour, the subtour which includes the destination which is farthest from the work location. Use the departure time from work on the subtour and the departure time from the destination as the departure times of the subtour. Assign the mode using the attached rule for assigning modes, using the tour defined by the assigned departure times.
   F. If destinations are visited after the workday, before the return home, then assign a pattern which includes WOH. If more than 1 destination is visited on the way home, assign as the destination the location which has the longest distance on the WOH path. Assign as the departure time from the after work stop, the departure time from this location.
   G. If destinations are visited before the workday, after the departure from home on the work tour, then assign a pattern which includes HOW. If more than 1 destination is visited on the way to work, assign as the destination the location which has the longest distance on the HOW path. **Assign as the departure time from the before work stop, the departure time from this location.**

IV. Determine the purpose of all tours other than primary work tours. Sum together the activity duration of W and M activities, and sum separately the duration of D activities. Use the following priority table to assign each of the sums to a priority category. **(Analysis of the sample data may lead to the adjustment of the thresholds in the table.)** Assign the purpose of the tour as M if the W/M sum is higher priority than the D sum; else assign a purpose of D.

Priority	Purpose	Duration
1	W/M	over 2
2	D	over 4
3	W/M	1-2
4	D	2-4
5	W/M	under 1
6	D	under 2

V. For non-work patterns, determine whether the pattern is maintenance on tour (MT), discretionary on tour (DT), maintenance at home (MH) or discretionary at home (DH).

A. Examine nonwork patterns to establish thresholds for MT, DT and MH patterns.

1. Generate a histogram of the M tour of longest duration in each nonwork pattern, and select an M on tour threshold which excludes tours of the shorter durations. Use as duration the elapsed time between departure from home and arrival at home.
2. Generate a histogram of the D tour of longest duration among nonwork patterns lacking an M tour which exceeds the M threshold. Select a D on tour threshold which excludes tours of the shorter durations.
3. Generate a histogram of the total at-home W/M duration among nonwork patterns lacking an M or D tour which exceeds the M, or D respectively, threshold. Select an M at home threshold which excludes patterns with shorter W/M durations.

B. Using the thresholds, assign each nonwork pattern a pattern of MT, DT MH or DH, as follows:
If there is an M tour that exceeds the M on tour duration threshold, then call the pattern MT, and assign the M tour with longest W+M duration as the primary tour.
Else, if there is a D tour which exceeds the D on tour duration threshold, then call the pattern DT, and assign the D tour with longest D duration as the primary tour.
Else, if the total W+M time at home exceeds the M at home threshold, then call the pattern MH, and assign as the primary activity the W or M activity with the greatest duration.
Else, call the pattern DH, and assign as the primary activity the D activity with the greatest duration.

VI. For primary non-work tours, define the tour.

A. Assign the primary tour type using the number of stops which occur on the tour.

B. Assign as the primary destination the highest duration activity of the tour's purpose. Assign as departure times the departure time from home and the departure time from the primary destination. Assign the tour mode using the attached rule for assigning modes, using the tour defined by the assigned departure times.

C. Assign as the secondary destination the destination with the longest distance along the path from home to the secondary destination and on to the primary destination. Assign the secondary sequence as before or after the primary stop, and assign the departure time from the secondary stop.

D. Assign as the tertiary destination the destination with the longest distance along the path from the preceding higher priority stop (or home) to the tertiary destination and on to the following higher priority stop (or home). Assign the tertiary sequence as before, between or after, and assign the departure time from the tertiary stop.

VII. For primary at home patterns, define the begin and end times corresponding to the reported begin and end times of the activity of longest duration with purpose (W/M or D) which matches the pattern purpose.

VIII. For every daily schedule assign the number and purpose of secondary tours by counting the non-primary tours of each purpose.

IX. Define each secondary tour. Assign the primary destination as the **stop with the longest duration of activities** which match the tour purpose (W/M or D). Assign the departure time from home and the departure time from the primary destination. Assign the tour mode using the attached rule for assigning mode.

Section 4: Definition of Activity Purposes

W	Work, work related and school
M	Maintenance (business of HH or individual. Could be called business)
D	Discretionary (activities engaged in for pleasure, recreation, or refreshment. Could be called recreation)

Where the survey responses are interpreted as follows:

Survey Description	Survey Code	Model Purpose	Model Code
Meals	11	D	3
Work	12	W	1
Work-related	13	W	1
Shopping (general)	14	M	2
Shopping (major)	15	M	2
Personal services	16	M	2
Medical care	17	M	2
Professional services	18	M	2
Household or personal business	19	M	2
Household maintenance	20	M	2
Household obligations	21	M	2
Pick-Up/Drop-Off passengers	22	M	2
Visiting	31	D	3
Casual entertaining	32	D	3
Formal entertaining	33	D	3
School	41	W	1
Culture	42	D	3
Religion/Civil Services	43	D	3
Civic	44	D	3
Volunteer work	45	D	3
Amusements (at-home)	51	D	3
Amusements (out-of-home)	52	D	3
Hobbies	53	D	3
Exercise/Athletics	54	D	3
Rest and relaxation	55	D	3
Spectator athletic events	56	D	3
Incidental trip	90	D	3
Tag along trip	91	D	3

Section 5: Assigning Mode

Introduction

In the model system we are explicitly modeling the mode for tours. The tour mode is based on the mode used for each of the two half-tours (journey to destination and journey from destination), excluding from consideration modes used for subtours (of the tour or subtour being considered), but including modes used for detours on the journey to or from the destination.

We are modeling tour mode for primary work tours, work-based subtours, primary non-work tours and secondary tours.

Terminology

Trip Mode (M)	The mode used for the travel from one activity location to the next activity location
Half-tour mode (HTM)	The principal mode used among all trips on the journey from the tour origin to its primary destination, or on the return journey from the primary destination to the tour origin.
Half-tour mode set (HTMS)	The list of trip modes used on a half-tour
Tour mode set (TMS)	The two half-tour modes associated with a tour
Tour mode (TM)	The principal mode of the tour

Mode alternatives

DA	Auto drive alone
DP	Auto drive with passenger
PA	Auto passenger
MA	MAX with auto access
MW	MAX with walk access
BA	Bus with auto access
BW	Bus with walk access
WA	Walk
BI	Bicycle
OT	Other

Assignment Rules

Trip mode (M)

```
CASE (Got to activity by...)
        Private vehicle (7)
                IF driver
                THEN  IF 1 person in vehicle                                   M =  DA
                      ELSE                                                          DP
                ELSE                                                                PA
        MAX (6)
                IF trip ends at home
                THEN  IF got from stop to destination by walk                       MW
                      ELSE                                                          MA
                ELSE  IF got to stop by walk                                        MW
                      ELSE                                                          MA
        Public bus (5)
                IF trip ends at home
                THEN  IF got from stop to destination by walk                       BW
                      ELSE                                                          BA
                ELSE  IF got to stop by walk                                        BW
                      ELSE                                                          BA
        Bicycle (3)                                                                 BI
        Walk (2)                                                                    WA
        Anything else                                                               OT
```

Half-tour mode (HTM)

```
IF HTMS includes MA                                                          HTM =  MA
ELSE  IF HTMS includes BA                                                           BA
      ELSE  IF HTMS includes MW
            THEN  IF HTMS includes DA, DP or PA                                     MA
                  ELSE                                                              MW
            ELSE  IF HTMS includes BW
                  THEN  IF HTMS includes DA, DP or PA                               BA
                        ELSE                                                        BW
                  ELSE  IF more than 60% of half tour distance is DP and PA
                        THEN  IF HTMS includes DP                                   DP
                              ELSE                                                  PA
                        ELSE  IF HTMS includes DA                                   DA
                              ELSE  IF HTMS includes BI                             BI
                                    ELSE  IF HTMS includes only WA                  WA
                                          ELSE                                      OT
```

Tour mode

```
IF TMS includes DA                                                            TM =  DA
ELSE  IF TMS includes DP                                                            DP
      ELSE  IF TMS includes BI                                                      BI
            ELSE  IF TMS includes WA                                                WA
                  ELSE  IF TMS includes MA                                          MA
                        ELSE  IF TMS includes BA                                    BA
                              ELSE  IF    TMS includes MW                           MW
                                    ELSE  IF TMS includes BW                        BW
                                          ELSE  IF TMS includes PA                  PA
                                                ELSE                                OT
```

Section 6: Sampling of Alternatives

We are sampling destination alternatives because of the large number of destination alternatives. **We will draw 101 alternatives** for each modeled destination choice in the daily activity schedule. **The first alternative is a special destination, drawn with probability 1.** For the remaining 100 alternatives, 20 (unchosen) destinations will be drawn at random from each of 5 strata. The definition of the strata will be similar for the various destination choices in the daily activity schedule, but will vary slightly, as explained below.

Initial estimation sample. Although we will draw 101 alternatives for each destination choice, we will initially calculate the attributes of the alternatives for only 25 or 50 of the alternatives, so that computation does not excessively delay the beginning of model estimation. We expect initial model estimation to validate our sampling scheme or indicate the need to change the scheme or use more of the alternatives from the sample.

Chosen alternative. We will keep the chosen alternative in addition to the drawn sample. When we use the sample for estimation we will substitute the chosen alternative for one of the drawn alternatives in its stratum. This will enable us to use any subsample of the drawn sample for estimation purposes.

Logsums. When we calculate logsums for higher level models we will need to draw a sample of lower level alternatives for each upper level alternative which requires a logsum. This will dramatically increase the data, logic and computation requirements of the sampling procedure. Since we have elected to use bottom up development, we will draw these larger samples as we need them when we move up the hierarchy in model estimation. For now, we are only defining the samples required for the lower level models, and the upper level models if we want to estimate without calculating the logsums.

Availability. For the sake of simplicity, we will ignore other dimensions of the daily activity schedule, namely mode and time-of-day, when we draw the sample. We will use only **distance and** a measure of the available activity opportunities at the destination zone to eliminate unavailable alternatives at the time of sampling. However, when we use the sample in a particular situation, we will need to take into consideration not only the destination, but also the mode and time of day, in assessing the availability of each alternative, as described in section 7 below.

Sampling fractions. During model estimation we will need to use the stratum sampling fraction to adjust the utility function of each alternative. For each observation in the data set, we need to calculate and store the number of available alternatives in the stratum, n_{gp} . We will also need the number of available alternatives drawn from the stratum, n_{gs} , but we should be able to infer this from the sample itself when we select the subsample for estimation. The stratum sampling fraction, denoted q_g, equals n_{gs}/n_{gp}. When the sample is used in a situation where the particular mode or timing make some of the sample unavailable, the sampling fraction will remain the same, because we will estimate that the population and the sample have the same proportion of unavailable alternatives.

Basic stratification scheme. The stratification is based on distance and the size of the destination zone, as follows:

Stratum	Number drawn	Description
0	1	**special zone drawn with probability 1**
		(this and the chosen alternative must not be drawn from the 5 strata)
1	20	zones within the 1st distance threshold
		zones between the 1st and 2nd distance thresholds
2	20	with size larger than the size threshold
3	20	with size smaller than the size threshold
		zones outside the 2nd distance threshold
4	20	with size larger than the size threshold
5	20	with size smaller than the size threshold

Variations of the scheme

The special zone, distance thresholds, measure of size, and size threshold, all of which define the strata, depend on the type of destination choice. The following variations exist:

Type of destination choice

Specific characteristics of the stratification scheme

Primary destination of tours
includes the following tour types: primary work, primary maintenance, primary discretionary, secondary maintenance (includes work), secondary discretionary, and work-based subtour

special zone: **work tours--principal workplace**
work-based subtours--home zone
other--none

distance measure: the distance from the origin of the tour to the destination of the tour.

distance threshold: a circle with the center at the origin.

the 1st distance threshold is the 20th percentile of the origin to destination distance among tours of the same type in the sample

The 2nd threshold is the 60th percentile of the origin to destination distance among tours of the same type in the sample

size measure: work tours--total employment in the destination zone

maintenance tours--retail and service employment in the destination zone

discretionary tours--destination zone's proportion of the retail and service employment in the region, plus the destination zone's proportion of the households in the region

work-based subtours--retail and service employment in the destination zone

size threshold: median destination size among tours of the same type in the sample

availability:
1. size >=1
2. **dist<max(dist), where max(dist) is the maximum distance among tours of the same type in the sample**

Secondary destinations of tours (i.e., detours, which don't begin and end at the same location)

special zone: work zone for work tours, none for nonwork tours

distance measure: the distance from the origin of the detour, to the intermediate destination of the detour, and on to the ultimate destination.

distance threshold: an ellipse with the centers at the origin and the ultimate destination.

the 1st distance threshold is the 20th percentile of the distance among destinations of the same type in the sample [i.e., one of (a)before work, (b)after work, and (c)secondary or tertiary on nonwork tour

The 2nd distance threshold is the 60th percentile of the distance among destinations of the same type in the sample

size measure: retail and service employment in the intermediate destination zone

size threshold: median destination size among destinations of the same type in the sample

availability:
1. size >=1 OR #households >=1
2. **dist<max(dist)**

Section 7: Availability of Alternatives

The probability expression in a logit model uses only the utilities of the available alternatives. Thus, for model estimation and application, the availability of all alternatives must be determined for every observation in the sample. The estimation data files must therefore include an availability code for every alternative. For example, in a mode and destination choice model, if we are estimating the model with 10 modes and 25 sampled destinations, we need an availability code for each of the 250 mode-destination alternatives. The following table describes the criteria which will be used to determine availability for each dimension of the model hierarchy.

Dimension	Availability constraints
Daily Activity Pattern	
Primary activity	Work availability: employed or primary activity is work
Primary activity timing begin and complete times (home activity), or departure time from home and departure time from primary activity(tour activity)	No constraints exist on the combination of begin and complete times, although we assume that any combination represents a time span of less than 24 hours.
Primary tour type	
Number and purpose of secondary tours	
Primary Work Tour	
Mode and destination	**Activity opportunity criterion.** employment in destination zone >=1 **Time and space criterion.** The question here is whether a particular combination of time-of-day, mode and destination are available for a person's activity, given their prior commitment to be at location A at time A before the activity and at location B at time B after the activity. The availability criterion is based on Hägerstrand's time-space prism which implies that a particular time-mode-dest combination is only available if the person can get to the chosen activity destination and back between times A and B using the chosen mode. To implement this criterion we consider a time-mode-dest alternative available only if the travel time is less than the maximum travel time observed in the sample for a 'similar' activity, denoted max(TT). Similar activities are defined as those which share the same tour priority and purpose, activity type/priority within tour (e.g. before work stop or secondary nonwork stop), and departure times (DT and DF). The "observed" travel time, used in determining max(TT), is calculated as the direct travel time from location A to the destination and on to location B, using the mode selected by the traveler. Thus, the time and space criterion is: TT < max(TT) The use of this criterion requires the generation of tables of the values of max(TT) for all activity purposes and priorities explicitly included in the model system hierarchy. **Auto availability for auto driver modes**: HH autos per driver > 0 and person is 16 yrs or older.

Section 7: Availability of Alternatives (continued)

Dimension	Availability constraints
Primary Work Tour (continued)	
Before work timing **--departure time from before-work activity location**	**bounded by departure time from home and departure time from work**
Before work destination	**Activity opportunity criterion.** retail and service employment in destination zone >=1 or # households in destination zone >=1 **Time and space criterion:** TT < max(TT) We are not sampling for each time-of-day alternative. Therefore, for evaluating availability we will base max(TT) on all before-work stops in the sample which are explicitly modeled.
Midwork timing --departure time from work --departure time from midwork activity location	bounded by departure time from home and departure time from work
Midwork mode and destination	**Activity opportunity criterion.** retail and service employment in destination zone >=1 or # households in destination zone >=1 **Time and space criterion:** TT < max(TT) We are not sampling for each time-of-day alternative. Therefore, for evaluating availability we will base max(TT) on all midwork stops in the sample which are explicitly modeled.
After work timing --departure time from after-work activity location	bounded by departure time from work and departure time to work (assumed to be the same tomorrow as it was today, so the person must return home in time to go to work)
After work destination	**Activity opportunity criterion.** retail and service employment in destination zone >=1 or # households in destination zone >=1 **Time and space criterion:** TT < max(TT) We are not sampling for each time-of-day alternative. Therefore, for evaluating availability we will base max(TT) on all after-work stops in the sample which are explicitly modeled.

Section 7: Availability of Alternatives (continued)

Primary Nonwork Tour

Mode and destination	**Activity opportunity criterion.** retail and service employment in destination zone >=1 or # households in destination zone >=1 **Time and space criterion:** TT < max(TT)
Secondary sequence	
Secondary timing --departure time from secondary activity location	Cannot include time periods completely spanned by the primary activity. This activity can occur before the primary activity, with 'departure from' occurring in the same time period as the departure to the primary activity. It can also occur after the primary activity, with 'departure from' occurring no earlier than the departure from the primary activity, and as late as the next day's departure to the primary activity (assumed to be the same as today's primary activity)
Secondary destination	**Activity opportunity criterion.** retail and service employment in destination zone >=1 or # households in destination zone >=1 **Time and space criterion:** TT < max(TT) Max(TT) based on all explicitly modeled secondary stops on primary nonwork tours in the sample.
Tertiary sequence	
Tertiary timing --departure time from tertiary activity location	cannot include time periods completely spanned by either the primary activity or the secondary activity. This is the same logic as for the secondary activity, except it has to deal with two unavailable time periods
Tertiary destination	**Activity opportunity criterion.** retail and service employment in destination zone >=1 or # households in destination zone >=1 **Time and space criterion:** TT < max(TT) Max(TT) based on all explicitly modeled tertiary stops on primary nonwork tours in the sample.

Secondary Tour

Timing --departure time from home --departure time from primary activity location	cannot include time periods completely spanned by the primary tour (or at-home activity): Departure from home and departure from activity location must be during or "after" the last 'departure from' of the primary tour, and during or "before" the first 'departure to' of the primary tour. We are unable to enforce time constraints across multiple secondary tours because we are not conditioning these tours upon one another
Mode and destination	**Activity opportunity criterion.** retail and service employment in destination zone >=1 or # households in destination zone >=1 **Time and space criterion:** TT < max(TT) Since we are not sampling for different secondary tour timing alternatives we use as our time constraint max(TT) among the sample of secondary tours which share the same primary activity timing, number and purpose of secondary tours, and secondary tour mode.

Section 8: Handling the Enriched Sample

The diary survey includes observations drawn from the households of individuals who were intercepted at park and ride lots in the metropolitan area. The intercept surveys occurred at six lots in various locations of the region, serving bus and/or MAX transit lines. Some members of the enrichment sample were intercepted while waiting for their transit vehicle during the A.M. peak period. Others were sampled from a list of all license plates collected in the park and ride lot on a certain day. In both cases, the survey collected activity and travel information from the entire household of the interceptee, during two days when the respondent might not have used park and ride. Thus, the enrichment survey is not a pure choice based sample. In fact, most of the observed trips from the enriched sample were not by MAX or bus. Nevertheless, the sample was designed to include people who were more likely than average to use park and ride, because one member of their household either boarded or parked at a park and ride station. That is, a systematic attempt was made to achieve a distribution of choices in the sample which was different than the distribution of choices in the population. The systematic method was based on choice dimensions which we are modeling. We need special estimation procedures to overcome bias this introduces.

The choice of a daily activity schedule involves multiple dimensions of choice. The question arises whether the distributions of all dimensions of the daily schedule choice are altered by the enriched sample. For any such dimension, special estimation procedures are required if model estimation includes the enriched data. If the distribution of choices in a dimension was not altered by the enrichment, or if the observations from the enrichment sample are excluded for model estimation, then the model can use regular estimation methods. Following is a list of the dimensions of the daily activity schedule and a discussion of the way the enriched sample alters (or does not alter) the distribution of each dimension.

1. Daily activity pattern--primary activity location (home vs. tour): The sample includes households where the intercepted individual was on a tour. This person was therefore more likely than average to have a primary activity on tour on the survey day.

2. Daily activity pattern--primary tour type, and number and purpose of secondary tours. The use of MA or BA modes is probably correlated with particular primary tour types and the choice of secondary tours. Thus, we must also assume the sample enrichment alters the distribution of these choices as well.

3. Tour mode--In most cases one tour mode for the intercepted person was MA or BA. This could be primary or secondary, and for any purpose. Given the probable use of MA or BA on the recruitment day, the probability of MA or BA for some tour is greater on the survey day, at least for the intercepted person.

4. Tour destination--The primary destination of the intercepted person was probably in the corridor served by the park and ride lot. Again, this increases the probability of certain destinations among the enriched sample.

5. Tour time of day--In many cases the intercept sampling captured people traveling at restricted times of the day. If their pattern is repetitive, then the distribution of time of day is also altered.

6. Secondary stops--All dimensions of secondary stops are conditioned by the choices for the daily pattern and the primary stops on the tours. The sampling alters the conditioning choices, but these are exogenous in the secondary stop models. The sample enrichment is very unlikely to have altered the distribution of secondary choices. For example, given that a person living at a particular location chose to use MA on a primary work tour to a particular downtown location, the distribution of their before work destination is the same, whether or not they were in the intercept group or the population at large.

This analysis suggests that all dimensions of the daily schedule except for decisions about specific secondary stops on tours should use estimation methods for endogenously stratified samples arising from sample enrichment. One of two estimation methods can be used:

1. If the model is MNL, then ESML with a utility adjustment term can be used.

2. If the model is a simultaneously estimated nested logit (NL) it requires WESML.

Alternatively, any dimension can be estimated without special procedures if the sample enrichment data is excluded. This may be desirable for dimensions which are only indirectly related to the goals of the sample enrichment. In such cases the extra complexity (ESML and WESML) and loss off statistical efficiency (WESML) may more than offset additional information provided by the additional observations.

We suggest the following procedures for the various dimensions of the model system. They amount to using the sample enrichment data with accompanying special procedures only for mode and primary destination choices on all tours. The secondary stop models can use the extra data without special procedures:

	Model	Use park and ride data?	Procedure	Reason
1	Primary activity (purpose, at home vs. on tour, timing)	No	ESML without adjustments (MNL or NL)	Enrichment data does not provide enough special information related to underused transit alternatives. The issue here is whether including more patterns in which MA and BA were chosen would improve the estimation of the logsum parameter enough to warrant the extra complexity and loss of overall efficiency associated with a weighting procedure.
2	Primary tour type, and number and purpose of secondary tours	No	ESML **without** adjustments (MNL or NL)	Ditto.
3	Primary work tour mode and destination	Yes	ESML **with** adjustments (MNL) or WESML(NL)	We are directly modeling mode choice parameters.
4	Primary nonwork tour mode and destination	Yes	ESML **with** adjustments (MNL) or WESML(NL)	We are directly modeling mode choice parameters.
5	Secondary tour timing	No	ESML **without** adjustments (MNL or NL)	Enrichment data does not provide enough special information related to underused transit alternatives.
6	Secondary tour mode and destination	Yes	ESML **with** adjustments (MNL) or WESML(NL)	We are directly modeling mode choice parameters.
7	Secondary stops on primary tours	Yes	ESML **without** adjustments.	Stratification is exogenous for these dimensions, and including extra observations from transit tours may add important information.

ESML with adjustment terms and WESML require us to identify distinct choice-based strata of the population which, because of the sample enrichment, were sampled at rates which differ from their rates in the population. In WESML the observations from these strata are weighted. In ESML the utility functions of these observations are adjusted. In both cases the factors are distinct for each stratum, and can be calculated from the sample.

We now describe the stratification, and proceed to specify the calculation of required factors.

In the mode and destination models, which require the special procedures, the stratification is in three dimensions: geographic area of residence, mode, and geographic area of destination. We partition the region geographically into 7 residential areas, one served by each of the six park and ride lot sites, and one which is not served by any park and ride lots. This dimension of the stratification is needed because the enriched samples served limited geographic areas. We group the 10 modeled modes into 3 aggregate modes: MAX, bus and all other. This dimension of the stratification is needed because the enriched sample includes only bus and MAX modes, and mode is a choice dimension. For each of the 6 park and ride sites we partition the region into 2 destination areas, one which is served by the transit system from the lot, and one which is not. This dimension of the stratification is needed because the enriched sample includes only destinations in the area served by the park and ride lot, and destination is a choice dimension. Each stratum is characterized by one residential area, one aggregate mode and one destination area. In subsequent references we call each residential area a stratum, including all associated modes and destinations. We call the combination of a particular aggregate mode and a particular destination area a substratum when it is associated with a particular residential area.

The calculations use the following notation:

1. k index representing any one of the 7 residential area strata. For 6 of these strata it also refers to the park and ride lot serving the stratum.
2. t index representing any one of the mode-destination substrata.
3.
4. notation related to counts from the samples:

	Unenriched exogenously stratified sample		Lot k sample	
Stratum	Number of observations	Number that chose substratum t	Number of observations	Number that chose substratum t
k	N_k	N_{kt}	N^k	N^k_t

1. x_n the number of persons in the population which are represented by observation n in the unenriched exogenously stratified sample
2.
3. W_{kt} The proportion, among the **population** residing in area k, which chose an alternative in substratum t. This is unobservable. We will use as an estimator the proportion among the unenriched sample, after expansion to represent the population: $W_{kt} = \frac{\sum_{n \in \text{substratum } kt} x_n}{\sum_{j \in \text{stratum } k} x_j}$, for all k, t. (If this weight is zero because no observation were drawn from a stratum, then another estimate must be supplied, such as the proportion in the entire region which chose the mode and destination area of substratum kt)
4.
5. H_{kt} The proportion, among the **sample** residing in area k, which chose an alternative in substratum t: $H_{kt} = \frac{N_{kt} + N^k_t}{N_k + N^k}$, for all k, t

In model estimation, each alternative i available for observation n is associated with exactly one stratum kt, the stratum with matching attributes.

WESML weights each observation n by the value $\left(\frac{W_{kt}}{H_{kt}}\right)_{in}$, where i is the alternative **chosen** by n.

ESML with adjustment adds to the utility function of **each** alternative the following term: $\ln\left(\frac{H_{kt}}{W_{kt}}\right)_{in}$

Section 9: Primary Work Tour Explanatory Variables

This section defines variables which may be important in the various models which comprise the work tour.

Tour Mode and Destination

Mode constants

Attributes of motorized modes (DA, DP, PA, MA, MW, BA, BW)
(these attributes are for a direct round trip at the chosen times)

1. 1. Time related variables
 2. a. walk distance on pedestrian portion of path
 3. b. auto time, MA&BA
 4. c. in vehicle time of main mode
 5. d. wait time, M&B
 6. e. total distance (for use in weighting: e.g. a/g, a/(log g), d/g, d/(log g)
 7. f. household income (for use in weighting: e.g. time*(log f)
8. 2. cost [or cost/(hh income) or cost/(log hh income)]
9. 3. Service quality and reliability variables
 10. a. standard deviation of wait time, M&B
 11. b. availability of continuous pedestrian right-of-way on pedestrian portion of path, MA, MW, BA, BW (e.g. sidewalks and, for high volume cross streets, crossing provisions) (alternatively, use minimum of PEF along the path)

Attributes of non-motorized modes (WA, BI)

1. 1. availability of continuous right-of-way along path
 2. a. pedestrian right-of-way, WA
 (e.g. sidewalks and, for high volume cross streets, crossing provisions) (alternatively, use minimum of PEF along the path)
 3. b. bicycle right of way for unskilled cyclists, BI
 presence of one of the following everywhere along path:
 4. (1) separated path
 5. (2) designated lane
 6. (3) posted speed limit of 30 mph or less
 7. (4) traffic volumes under xx
 8. (alternatively, generate and use minimum BIF along the path)
9. 2. distance related variables
 10. a. path length
 11. b. crow flight distance (to use in generating a measure of circuity by relating path length and crow-flight distance)
12. 3. wait time at crosswalks, WA
13. 4. Grade related variables
 14. a. maximum grade along path (alternatively, maximum elevation change from one zone to the next along the path)
 15. b. total positive elevation change along path (measure zone to zone elevation changes and sum those which are positive)

16. c. number of zone transitions along path with elevation changes in certain ranges:
    17. (1) total number of zone transitions
    [for use in calculating proportions, e.g. (5)/(1)]
    18. (2) number with elevation change < 0 ft
    19. (3) number with elevation change between 0 and x_1 feet
    20. (4) number with elevation change between x_1 and x_2 feet
    21. (5) number with elevation change over x_2 feet (most important)
    22. (better to use path length with grade between x_1 and x_2%, but I suspect this is harder to get.)

Locational and other alternative attributes

1. 1. proportion of time spent in activity [PTA] (see attached definition)
2. 2. Attraction of surrounding area
   (consider mode specific variables, with various distance thresholds)
   3. a. employment in and around destination zone
   4. b. retail and service employment in and very near destination zone (esp. M&B)
   5. c. pedestrian environment factor [PEF] in and very near work zone (esp. M, B, WA)
6. 3. Area type dummies (e.g. CDB)

Decision-maker characteristics

1. 1. autos per driver, DA, DP, PA, MA, BA
2. 2. income (mode specific, use base case so all coefficients are positive)
3. 3. age and age categories
4. 4. Characteristics modeled in the daily activity pattern (e.g. dummies for tours with stops before and/or after work (mode specific, use base case so all coefficients are positive))
5. 5. Include in the estimation data file other characteristics which might be useful in market segmentation of parameters, e.g. household type, role in household, employment status, occupation, industry
6. 5. We can't use transit incentives or subsidized parking (from the survey) as variables because they have opposite effects, and the survey question confounds the response.

Size and logsum variables

1. 1. Size: employment in zone (specific to CBD and non-CBD categories)
2. 2. expected utility from before work stops
3. 3. expected utility from midwork stops
4. 4. expected utility from after work stops

Proportion of Time Spent in Activity (PTA)

Traditionally, travel time and cost have been the most important variables in travel demand models. However, activity based travel theory says that travel demand is derived from the demand for activities. Therefore, we expect some activity based explanatory variables with positive coefficients to be just as important in the utility function of schedule alternatives as the travel time and cost variables. One potentially important measure of the utility of an activity, given the activity purpose, is the amount of time spent in the activity relative to the amount of time spent getting to and from the activity. We expect alternatives with a higher proportion of time spent in the activity to yield higher utility. The idea is that people prefer activity alternatives in which they spend more time on the activity itself and less time in travel to and from the activity location.

Since the daily activity schedule model explicitly represents the priority, sequence and timing of activities, it is possible, for any explicitly modeled activity in the schedule, to generate and use in the demand model (mode, destination, timing) an estimate of the proportion of time spent in the activity (PTA). We must define this variable in terms of exogenous variables and choice variables of higher priority dimensions of the daily activity schedule. An important limitation of the model design is that we model departure times, but not the activity time itself, and the time categories are very coarsely defined. We therefore need an estimate of the activity time. We can use the average reported activity time in the sample among activities of the same priority, purpose and departure times, if we believe this will be the same under (changed) forecast conditions. This might be a bad assumption, since we might expect changes in the transport system to change the proportion of time spent in activities. Nevertheless, the information gained from using actual reported durations in the sample probably exceeds the problems introduced by this estimation procedure.

The PTA measure requires, in addition to the activity time, the time spent in travel. The amount of time which is of concern is the incremental travel time required to introduce the activity into the schedule. Therefore, the travel time equals the travel time from the preceding activity of higher priority (or home, if this is the first activity in the tour) to the activity location, plus the travel time from the activity location to the following activity of higher priority (or home if this is the last activity on the tour), minus the travel time for movement directly from the preceding to the following activity.

Restating the measure notationally, we have:

$$PTA = AAT/(AAT + TT+TF-TD)$$

where TT is the travel time required to get to the chosen destination via the chosen mode during the chosen time period of departure to the activity (DT)

TF is the travel time required to get from the chosen destination via the chosen mode during the chosen time period of departure from the activity (DF)

TD is the travel time required to get directly from the preceding to the following activity locations via the chosen mode during the time period of departure from the activity (DF)

AAT is the average activity time (end time minus begin time) in the sample among activities with the same tour purpose (W, M or D) the same activity purpose category, the same priority, and the same sequence relative to higher priority activities in the tour (e.g. before work stop, or secondary stop following primary stop on NW tours).

The use of this measure requires the generation of tables of the values of AAT from the sample, for use in calculating PTA.

Correlation of this variable with travel time may prevent the use of both variables in the model.

Primary Work Tour--Before work timing

Constants

1. 1. Time of departure from home (base case)
2. 2. First time period after departure from home
3. 3. Second and third time periods after departure from home

Decision-maker characteristics

The constants may be specific to certain types of persons, characterized by gender, age category, marital status, household type, and presence of children (under 6, and 6-15) in the household.

Size variable

Duration of time period

Primary Work Tour--Before work destination

Attributes of chosen mode

Use the variables listed for the primary work tour mode and destination model. In this case these are incremental attributes. Add the values for the two legs of the journey, and subtract the values for the direct home-to-work trip.

Locational and other alternative attributes

1. 1. Use the variables listed for the primary work tour mode and destination model.
2. 2. Destination constants

3. a. home zone
4. b. work destination
5. 3. Minimum of (a) the distance of the destination from the home zone, and (b) the distance of the destination from the work zone.
   We expect preference for locations near H or W location. Thus, the sign of this parameter would be negative. The effect might be nonlinear.
6. 4. A measure of the deviation from a straight path encountered in moving from origin to destination and on to the subsequent destination. Specifically, we use the cosine of half the angle generated by the path from origin to destination and on to subsequent destination. This measure ranges from 0 for a straight path (180°, i.e. cos 90° = 0) to 1 for a path which doubles back on itself (0°, i.e. cos 0° = 1). We expect a preference for a straight path, with disutility for deviation from a straight path. Thus the sign of the coefficient would be negative. The effect might be nonlinear.

Decision-maker characteristics

1. There may be gender, age, or home location differences

Size variable

1. Retail and service employment in zone

Primary Work Tour--Midwork timing

Constants

We have little information to explain timing choice except timing of the primary work tour. One approach is to estimate a full set of alternative specific midwork timing constants for each primary work tour timing alternative, essentially a separate model for each primary work tour timing alternative. The number of parameters would be large. A variation, which reduces the number of parameters, would estimate two parameters for each primary tour timing alternative by defining (1)the most likely time as the base, plus (2) a group of less likely alternatives, and (3) a group of very unlikely alternatives. Alternatively, we could define one full set of alternative specific constants (regardless of primary work tour timing), with the midday time period as the base. Then for each primary work tour timing alternative, add an additional constant for the midwork tour timing which is most likely. I prefer the first approach because it should more accurately predict lower probability alternatives.

Size variable

Duration of time period

Primary Work Tour--Midwork mode and destination

Destination constants

1. 1. primary tour destination (this may be multiplied by some measure of the attractiveness of the work zone as a nonwork destination, such as log retail/service employment)
2. 2. home zone (or 1/(distance to home zone) to reflect declining advantage of home destination as distance grows)

Mode constants

1. 1. a full set of J-1 constants
2. 2. For each mode, a constant which takes the value one if the mode matches the mode chosen for the tour. This captures the tendency to use the same mode for the midwork subtour as for the work tour.

Attributes of modes

Use the variables listed for the primary work tour mode and destination model.

Locational and other alternative attributes

Use the variables listed for the primary work tour mode and destination model.

Decision-maker characteristics

There may be gender, age, or additional work location characteristics of importance

Size variable

1. Retail and service employment in zone

Primary Work Tour--After work timing

Similar to before work timing

Primary Work Tour--After work destination

Attributes of chosen mode

Same as before work destination: Use the variables listed for the primary work tour mode and destination model. In this case these are incremental attributes. Add the values for the two legs of the journey, and subtract the values for the direct home-to-work trip.

Locational and other alternative attributes

1. 1. Use the variables listed for the before work destination model.
2. 2. Recreational attraction (number of opportunities or employment) of surrounding area (consider mode specific variables, with various distance thresholds)

Decision-maker characteristics

1. There may be gender, age, or home location differences

Size variables

1. 1. Retail and service employment in zone
2. 2. Some measure of recreation opportunities in the zone

Appendix B: Results of Processing Activity Data into Tours and Activity Patterns:

Memo by Mark Bradley

This memo and the two attachments document the processing of the Portland area activity survey data files into records of (a) home-based and work-based tours and (b) summaries of day-long activity patterns. The tour file will be the basis of mode, destination and time-of-day modeling for both the TMIP Activity Model Demonstration Project and the METRO TROS Congestion Pricing Project. The day-long activity pattern file will be the basis for the full day activity pattern model.

Some initial processing of the data needed to be done to the activity data before tour formation processing could be done.

(1) The raw files provide by Metro were:

ALLHH.DAT	household-level survey data
ALLPER.DAT	person-level survey data
ALLACT.DAT	activity-level survey diary data
ACTLOC.DAT	the x and y coordinates and TAZ numbers of all activity diary locations

These contain all records from both the Portland and Vancouver samples, although they are not always sorted in the same order.

(2) SPSS for Windows was used to sort and merge the raw data files:

First, the SPSS commands in RAWCONV.SPS were used to sort the raw household, person and activity data files by the appropriate ID's and write out three intermediate (.SAV) files in SPSS format.

Second, the SPSS commands in ACTLOC.SPS were used to sort the ACTLOC.DAT file by household, person and activity ID's and write out an intermediate (.SAV) file in SPSS format.

Third, the SPSS commands in ACTMRG5.SPS were used to merge information from the four intermediate files together by matching on the appropriate ID's. The output was to an ASCII file, ALLACT3.DAT. One record was written per activity, which included all relevant activity, person, household and location data for that activity. The number of activity records for each person-day was calculated and written to each record. There are 176,468 records in the file. About 13% have a missing value for the TAZ location - usually because they are outside the zone system area.

(3) The Pascal program ACTPRO10.PAS was used to screen out illogical data, form tours, and classify day-long activity patterns. The input file is ALLACT3.DAT and the output ASCII files are:

TOURS10.DAT	tour records
PATTRN10 DAT	day-long pattern records

This program generally follows the procedures and definitions in John Bowman's design memos, but some changes were made. Attachment 1 of this memo contains revised versions of sections 3, 4 and 5 of the latest design memo.

Attachment 2 of this memo contains summary tables of the data. For TOURS10.DAT, the tables show the breakdown of the sample along several variables for each type of tour - home-based work/school, work/school-based, home-based maintenance and home-based discretionary. For PATTRN10.DAT, the tables show the breakdown of the sample for each of the six main activity pattern types - work on tour, work at home, maintenance on tour, maintenance at home, discretionary on tour, and discretionary at home. The tables are restricted to .those cases that are used in model estimation - weekday observations for those aged 16+ with valid TAZ location data.

(4) Pascal program SAMPDEST.PAS was used to draw a sample of destinations for each tour record. The destinations were sampled as follows:

Stratum	# Zones	Work/School	Work Based	Maintenance	Discretionary	Intermediate
1	1 or 2	Residence zone	Work zone	Residence zone	Residence zone	Residence zone Tour dest zone
2	4	Dist < 5.58	Dist < 1.52	Dist < 2.77	Dist < 3.26	Dist < 0.14
3	4	Dist 5.58-15.88 Size>=1959.	Dist 1.52-6.54 Size>=670.	Dist 2.77-8.30 Size>=536.	Dist 3.26-9.38 Size>=1227.	Dist 0.14-2.94 Size>=496
4	4	Dist 5.59-15.88 Size<1959.	Dist 1.52-6.54 Size<670.	Dist 2.77-8.30 Size<536.	Dist 3.26-9.38 Size<1227.	Dist 0.14-2.94 Size<496.
5	4	Dist 15.89-92.58 Size>=2573	Dist 6.55-56.46 Size>=331	Dist 8.31-87.22 Size>=740	Dist 9.39-62.38 Size>=967	Dist 2.95-60.52 Size>=495
6	4	Dist 15.89-92.58 Size<2573	Dist 6.55-56.46 Size<331	Dist 8.31-87.22 Size<740	Dist 9.39-62.38 Size<967	Dist 2.95-60.52 Size<495

For the four tour types, the "Dist" variable is the round-trip road network distance between the residence (or work) zone and the sampled zone. For intermediate stops, the "Dist" variable is the extra one-way road network distance from the origin to the sampled stop and then on to the destination, relative to the distance from the origin to the destination.

The "Size" variable is defined as:

Work/school : total employment in the zone.
Discretionary : retail plus service employment plus households in the zone.
Otherwise: : retail plus service employment in the zone.

After all 1244 zones were assigned to the strata, the indicated number of zones was selected at random without replacement. In the event that there were less than 4 zones in a stratum, the number drawn from stratum 6 was increased to give a total set of 21 sampled zones (22 for intermediate stops). The sampling weight for a stratum is the number of zones in the stratum divided by the number drawn from stratum.

Finally, for model estimation, the actually chosen destination zone is always included in the sample, substituting for one of the randomly selected zones in its stratum.

For each of the 21 or 22 destinations in the sample, the following variables are added to the estimation data sets:

Zone land use variables (from TAZDATA2.BIN):

taz ,	{Zone number }
tothh ,	{Total Households }
totemp ,	{Total Employment }
totret ,	{Total Retail Employment }
totser ,	{Total Service Employment }
totacr ,	{Total Acres }
recacr ,	{Total Recreational Acres }
ltpkg ,	{Long Term Parking Cost }
stpkg ,	{Short Term Parking Cost }
mixqm ,	{Mixed Used Measure w/i Quarter Mile }
mixhm ,	{Mixed Used Measure w/i Half Mile }
hhhm ,	{Total Households w/i Half Mile }
hhqm ,	{Total Households w/i Quarter Mile }
emphm ,	{Total Employment w/i Half Mile }
empqm ,	{Total Employment w/i Quarter Mile }
rethm ,	{Total Retail Employment w/i Half Mile }
retqm ,	{Total Retail Employment w/i Quarter Mile }
walktim ,	{GIS Based Centroid Walk Time }
empwalk ,	{Avg walk time from Emp, min }
hhwalk ,	{Avg walk time from HH, min }
tot30t ,	{Emp. Access w/i 30 minutes w/transit }
localint,	{Number of local intersections }
avgps ,	{Average Parcel Size }
opempcov,	{Off-Peak Emp. Transit Coverage }
ophhcov ,	{Off-Peak HH Transit Coverage }
pkempcov,	{Peak Emp. Transit Coverage }
pkhhcov ,	{Peak HH Transit Coverage }

Round trip network level of service variables (from TAZ2TAZ1.BIN, TAZ2TAZ2.BIN)

tdist ,	{road network distance, miles }
autoiv ,	{auto invehicle time ,min }
busiv ,	{bus invehicle time , min }
buswait ,	{bus total wait time , min }
buswalk ,	{bus total walk time , min }
busbrd ,	{bus total boardings }
busfare ,	{bus transit fare , cents }
maxiv ,	{LRT invehicle time , min }
maxwait ,	{LRT total wait time , min }
maxwalk ,	{LRT total walk time , min }
maxbrd ,	{LRT total boardings }
maxfare ,	{LRT transit fare , cents }
pkrdiv ,	{P&R invehicle time , min }
pkrdwait,	{P&R total wait time , min }
pkrdwalk,	{P&R total walk time , min }
pkrdbrd ,	{P&R total boardings }
pkrdfare,	{P&R transit fare , cents }
pkrdauiv,	{P&R auto in-veh time , min }
pkrdtaz ,	{P&R lot zone number }
pkrdtyp ,	{P&R transit type -bus or LRT }

Various Pascal code files contain procedures which were used for data preparation. This same code will be used in model application to maintain consistency. The files are:

ZONEPROC.PAS	Process zonal land use and level of service data files and arrays
TOURPROC.PAS	Process input tour and pattern data files and variables
SAMPPROC.PAS	Set destination sampling strata and draw random samples

A number of additional programs were set up during the course of calculating logsums and preparing estimation data sets for the upper level models:

MDESAPP1.PAS	Apply mode/destination models to estimation data sets, check results
MDESAPP2.PAS	Apply mode/destination models to tour and zonal data, check results
MDESAPP3.PAS	Apply mode/destination models to tours and zonal data for all time of day combinations, calculate logsums, write time of day estimation data sets.
MTODAPP1.PAS	Apply time of day models to estimation data sets, check results
MTODAPP2.PAS	Apply mode/destination and time of day models to tour and zonal data, check results, calculate elasticities
MTODAPP3.PAS	Apply mode/destination and time of day models to pattern and zonal data, for all tour types, time of day combinations, calculate logsums, write activity pattern model estimation data set
PATTAPP1.PAS	Apply pattern model to estimation data set, check results
PATTAPP2.PAS	Apply mode/destination, time of day and pattern models to pattern and zonal data, check results, calculate elasticities
PATTAPP3.PAS	Apply mode/destination, time of day and pattern models to pattern and zonal data, check results, calculate elasticities
WBASAPP1.PAS	Apply work-based mode/destination model to estimation data set, check results
STOPAPP1.PAS	Apply intermediate stop location models to estimation data sets, check results

These programs use additional code files that can be reused in model application:

COEFPROC.PAS	Routines to read in estimated coefficients from Alogit F12 files.
MDESMAPP.PAS	Application of home-based tour mode/destination models
TODMAPP.PAS	Application of home-based tour time of day models
WBASMAPP.PAS	Application of work-based subtour mode/destination model
STOPMAPP.PAS	Application of intermediate stop location models
PATTMAPP.PAS	Application of the full day activity pattern model

The model estimation results and the use of these models in forecasting will be documented in a separate memo.

Attachment 1: Revised sections from Model System Design, Draft 3: J. Bowman 8/9/96

Section 3: Interpreting the Survey Data

These rules explain how to interpret the survey data set in terms of the model system design, assigning all the attributes which together define the daily schedule.

I. Assign each reported activity to one daily schedule (household/person/survey day).

II. Assign a purpose of W, M or D to every activity, using the attached definition of activity purposes (see Section 4).

III. Determine if the daily activity pattern is work on tour, work at home or non-work.
   A. Calculate the total reported duration of work activities conducted away from home, and call this total the work on tour duration.
   B. Add the total reported duration of work activities conducted at home to the work on tour duration. Call this the work duration.
   C. If the work duration during the day exceeds **120 minutes**, assign the pattern as work; else assign it as non-work. For work patterns, if the work on tour exceeds **60 minutes** assign it as work on tour; else assign it as work at home and assign as the primary activity the at home W activity with the greatest duration.

IV. For work on tour patterns, define the primary work tour, and any work-based subtours.
   A. Assign as the primary work location the out-of-home work destination within the daily pattern which is visited the largest number of times. If this number of visits is shared by 2 or more destinations, assign as primary location the one with the largest total work duration.
   B. If the primary work location is visited more than once in the daily activity pattern, include in the primary work tour the 2 work stops with longest duration at the primary work location. For patterns with 3 or more stops at the primary work location, include any additional stops at the primary work location which occur without an intervening trip home.
   C. Assign as the departure time from home the last departure time from home prior to the arrival at the first of the tour's stops at the primary work location. Use as the departure time from work the departure time from the last of the tour's stops at the primary work location.
   D. Identify any work-based subtours which depart from and return to the primary work location during the primary work tour. Assign the destination which is farthest from the work location as the primary destination of the subtour. Use the departure time from the work location and the departure time from the location of this primary destination as the departure times of the subtour.

V. Identify and define any home-based tours other than the primary work tour (if applicable):
   A. For each tour identified, sum together the activity duration of all out-of-home W and M activities during the tour, and sum separately the duration of all out-of-home D activities during the tour. Use the following priority table to assign each of the sums to a priority category. Assign the purpose of the tour as M if the W/M sum is higher priority than the D sum; else assign a purpose of D.

Priority	Purpose	Duration category	
1	M	W+M	= 120+ minutes
2	D	D	= 240+ minutes
3	M	W+M	= 60-119 minutes
4	D	D	= 120-239 minutes
5	M	W+M	= 1-59 minutes
6	D	D	= 1-119 minutes

   B. For any home-based non-work tours identified, assign as the primary destination the highest duration activity of the tour's purpose (M or W activities for M tours, D activities for D tours). Assign as departure times the departure time from home and the departure time from the primary destination location.

VI. For all tours which have been identified (home based work tours, work-based subtours, and home-based non-work tours):

A. Assign the main mode for the tour using the attached rules for assigning modes (see Section 5), using the half tour which begins at the assigned departure time from home (work for work-based tours), and the half tour which begins at the assigned primary destination.

B. Identify any intermediate destinations visited during the half-tour from home (work for work-based tours) to the primary destination. If more than 1 such destination is visited, assign as the "main" intermediate destination the location which deviates farthest from the straight line between home (or work) and the destination. Assign the departure time from this location as the departure time from the intermediate stop.

C. In the same way, identify any intermediate destinations visited during the half-tour from the primary destination back to home (to work for work-based tours). If more than 1 such destination is visited, assign as the "main" intermediate destination the location which deviates farthest from the straight line between the destination and home (or work). Assign the departure time from this location as the departure time from the intermediate stop.

VII. For non-work daily patterns, determine whether the pattern is maintenance on tour (MT), discretionary on tour (DT), maintenance at home (MH) or discretionary at home (DH).

A. For each non-work tour, calculate the total tour duration the elapsed time between departure from home and arrival at home

B. If there is an M tour with a total duration of **60 minutes or more**, then call the pattern MT, and assign the M tour with longest total duration as the primary tour of the day.

C. Else, if there is a D tour with a total duration of **60 minutes or more**, then call the pattern DT, and assign the D tour with longest total duration as the primary tour of the day.

D. Else, if the total duration during the day of at-home W+M activities is **120 minutes or more**, then call the pattern MH, and assign the at-home W or M activity with the greatest duration as the primary activity of the day.

E. Else, if the total duration during the day of at-home D activities is **120 minutes or more**, then call the pattern DH, and assign the at-home D activity with the greatest duration as the primary activity of the day of the day.

F. Else, assign the pattern as **non-valid** (insufficient activities reported).

VIII. For every daily schedule define the remaining aspects of the daily pattern:

A. For primary on tour patterns, define the primary tour type depending on the number of intermediate stops on the way to and from the primary destination, and, for work tours, on the number of work-based subtours. Define the primary activity timing based on the departure time from home and the departure time from the primary destination.

B. For primary at home patterns, define the primary activity timing based on the reported begin and end times of the primary activity of the day.

C. Designate any home-based tours which are not the primary tour of the day as "secondary tours". Classify the pattern according to the number and purpose of secondary tours by counting the non-primary tours of each purpose.

Section 4: Definition of Activity Purposes

W Work, work related and school
M Maintenance (business of HH or individual)
D Discretionary (activities engaged in for pleasure, recreation, or refreshment)
Where the survey responses are interpreted as follows:

Survey Description	Survey Code	Model Purpose	Model Code
Meals	11	D	3
Work	12	W	1
Work-related	13	W	1
Shopping (general)	14	M	2
Shopping (major)	15	M	2
Personal services	16	M	2
Medical care	17	M	2
Professional services	18	M	2
Household or personal business	19	M	2
Household maintenance	20	M	2
Household obligations	21	M	2
Pick-Up/Drop-Off passengers	22	M	2
Visiting	31	D	3
Casual entertaining	32	D	3
Formal entertaining	33	D	3
School	41	W	1
Culture	42	D	3
Religion/Civil Services	43	D	3
Civic	44	D	3
Volunteer work	45	D	3
Amusements (at-home)	51	D	3
Amusements (out-of-home)	52	D	3
Hobbies	53	D	3
Exercise/Athletics	54	D	3
Rest and relaxation	55	D	3
Spectator athletic events	56	D	3
Incidental trip	90	D	3
Tag along trip	91	D	3

Section 5: Assigning Mode

Introduction

In the model system we are explicitly modeling the mode for tours. The tour mode is based on the mode used for each of the two half-tours (journey to destination and journey from destination), excluding from consideration modes used for subtours (of the tour or subtour being considered), but including modes used for detours on the journey to or from the destination.

We are modeling tour mode for primary work tours, work-based subtours, primary non-work tours and secondary tours.

Terminology

Trip Mode (M)	The mode used for the travel from one activity location to the next activity location
Half-tour mode (HTM)	The principal mode used among all trips on the journey from the tour origin to its primary destination, or on the return journey from the primary destination to the tour origin.
Half-tour mode set (HTMS)	The list of trip modes used on a half-tour
Tour mode set (TMS)	The two half-tour modes associated with a tour
Tour mode (TM)	The principal mode of the tour

Mode alternatives

DA	Auto drive alone
DP	Auto drive with passenger
PA	Auto passenger
MA	MAX with auto access
MW	MAX with walk access
BA	Bus with auto access
BW	Bus with walk access
WA	Walk
BI	Bicycle
OT	Other

Mode Assignment Rules

Trip mode (M)

CASE (Got to activity by...)				
Private vehicle (7)				
	IF driver			
	THEN	IF 1 person in vehicle	M =	DA
		ELSE		DP
	ELSE			PA
MAX (6)				
	IF trip ends at home			
	THEN	IF got from stop to destination by walk		MW
		ELSE		MA
	ELSE	IF got to stop by walk		MW
		ELSE		MA
Public bus (5)				
	IF trip ends at home			
	THEN	IF got from stop to destination by walk		BW
		ELSE		BA
	ELSE	IF got to stop by walk		BW
		ELSE		BA
Bicycle (3)				BI
Walk (2)				WA
Anything else				OT

Half-tour mode (HTM)

IF HTMS includes MA — HTM = MA
ELSE IF HTMS includes BA — BA
- ELSE IF HTMS includes MW
  - THEN IF HTMS includes DA, DP or PA — MA
    - ELSE — MW
  - ELSE IF HTMS includes BW
    - THEN IF HTMS includes DA, DP or PA — BA
      - ELSE — BW
    - ELSE IF more than 60% of half tour car travel time is DP and PA
      - THEN IF HTMS includes DP — DP
        - ELSE — PA
      - ELSE IF HTMS includes DA — DA
        - ELSE IF HTMS includes BI — BI
          - ELSE IF HTMS includes only WA — WA
            - ELSE — OT

Tour mode

IF TMS includes DA — TM = DA
ELSE IF TMS includes DP — DP
- ELSE IF TMS includes BI — BI
  - ELSE IF TMS includes WA — WA
    - ELSE IF TMS includes MA — MA
      - ELSE IF TMS includes BA — BA
        - ELSE IF TMS includes MW — MW
          - ELSE IF TMS includes BW — BW
            - ELSE IF TMS includes PA — PA
              - ELSE — OT

Attachment 2: Tables based on analysis of tour and daily pattern data files

Summary of TOURS10.DAT

Variable	Mean	Std Dev	Minimum	Maximum	Valid N	Label
SAMPNO	304344.01	136306.74	200009.0	508184.0	18224	Household number
PERSNO	1.63	.92	1.00	9.00	18224	Person number
DAYNO	1.48	.50	1.00	2.00	18224	Diary day number
DAYOFWK	3.09	1.43	1.00	5.00	18224	Diary day of the week
NACTS	7.44	2.83	2.00	26.00	18224	Number of activities on diary d
PATTERN	1.81	1.16	1.00	7.00	18224	Main daily pattern type
TOURTYPE	2.30	1.19	1.00	4.00	18224	Tour purpose category
PRIMARY	1.41	.49	1.00	2.00	18224	Primary tour of day?
SUBSTDUR	191.29	240.38	.00	1192.00	18224	Tour subsistence duration
MAINTDUR	25.36	52.35	.00	685.00	18224	Tour maintenance duration
DISCRDUR	52.85	94.80	.00	945.00	18224	Tour discretionary duration
ORIGXCO	7654762.5	31819.50	7489745	7761543	18224	Origin X coordinate
ORIGYCO	691607.20	36772.51	520046.0	823034.0	18224	Origin Y coordinate
ORIGTAZ	671.69	395.36	1.00	1244.00	18224	Origin zone
DESTXCO	7651514.1	28937.08	7498130	7752585	18224	Destination X coordinate
DESTYCO	689041.88	31853.50	541524.0	833556.0	18224	Destination Y coordinate
DESTTAZ	601.89	407.95	1.00	1244.00	18224	Destination zone
DISTANCE	25041.60	24429.53	2.00	268740.0	18224	XY crow-fly distance
PRIMEACT	3.48	2.50	1.00	24.00	18224	Primary activity number
PRACTCOD	20.10	13.64	11.00	91.00	18224	Primary activity purpose
PRACTDUR	199.59	181.98	1.00	719.00	18224	Primary activity duration
HLFMODE1	2.22	2.18	.00	10.00	18224	Main mode for trip to dest.
HLFMODE2	2.62	2.57	.00	12.00	18224	Main mode for trip to orig
MAINMODE	2.28	2.32	1.00	9.00	18224	Main mode for tour
LEAVORIG	2.10	2.46	.00	23.00	18224	Leave origin activity number
ARRVDEST	3.35	2.52	1.00	24.00	18224	Arrive at dest. activity number
LEAVDEST	3.70	2.44	1.00	24.00	18224	Leave dest. activity number
ARRVORIG	5.09	2.50	2.00	25.00	18224	Arrive at origin activity number
LEAVOTIM	1129.98	454.49	.00	2945.00	18224	Departure time from origin
LEAVOPER	2.81	1.02	1.00	5.00	18224	Departure period from origin
LEAVDTIM	1598.74	374.54	323.00	3900.00	18224	Departure time from dest.
LEAVDPER	3.72	.85	1.00	5.00	18224	Departure period from dest.
TIMECOMB	9.72	3.13	1.00	15.00	18224	Time period combination
TOTDURAT	329.81	258.98	.00	1440.00	18224	Total duration away from origin
TOURSDUR	.08	.30	.00	4.00	18224	Work-based tours from destination
CHAINTYP	1.89	1.43	1.00	8.00	18224	Type of trip chaining
STOPSBEF	.24	.63	.00	9.00	18224	Stops made on trip to dest.
STOPBACT	.49	1.47	.00	22.00	18224	Stop before activity number
STOPBCOD	23.04	14.66	11.00	91.00	2860	Stop before activity purpose
STOPBDUR	43.50	58.39	1.00	450.00	2856	Stop before activity duration
STOPBXCO	7652888.4	32385.43	7174200	7944743	2860	Stop before X coordinate
STOPBYCO	689993.27	42451.60	-564142	826904.0	2860	Stop before Y coordinate
STOPBTAZ	640.28	401.34	-1.00	1244.00	2860	
STOPBTIM	1206.76	393.10	313.00	2335.00	2860	Stop before departure time
STOPBPER	3.00	.86	1.00	5.00	2860	Stop before departure period
STOPBCOM	8.87	3.09	1.00	15.00	2860	Stop before time combination
STOPSAFT	.36	.79	.00	12.00	18224	Stops made on trip to origin
STOPAACT	1.02	2.21	.00	17.00	18224	Stop after activity number
STOPACOD	22.57	15.09	11.00	91.00	3988	Stop after activity purpose
STOPADUR	49.93	59.08	1.00	585.00	3984	Stop after activity duration
STOPAXCO	7653818.3	29108.90	7482127	7774316	3988	Stop after X coordinate
STOPAYCO	689763.06	38762.92	-528056	814939.0	3988	Stop after Y coordinate
STOPATAZ	634.55	401.17	-1.00	1244.00	3988	
STOPATIM	1657.70	331.62	535.00	3650.00	3988	Stop after departure time
STOPAPER	3.85	.79	1.00	5.00	3988	Stop after departure period

STOPACOM	11.77	2.03	1.00	15.00	3988	Stop after time combination
HHSIZE	2.75	1.33	1.00	9.00	18224	Total household size
HHCHU5	.16	.45	.00	4.00	18224	HH children under age 5
HHC511	.28	.64	.00	4.00	18224	HH children age 5-11
HH1217	.28	.62	.00	5.00	18224	HH children age 12-17
HHADLT	2.03	.72	.00	7.00	18224	HH adults 18+
HHFULL	1.38	.92	.00	6.00	18224	HH employed full time
HHPART	.14	.39	.00	3.00	18224	HH employed part time
HHDLIC	1.99	.79	.00	7.00	18224	HH drivers licenses
NMVEH	2.06	.99	.00	8.00	18224	HH vehicles owned
INCOME	10.09	3.60	1.00	14.00	18224	HH annual income
GENDER	1.53	.50	1.00	2.00	18224	Gender
AGE	4.41	1.72	1.00	9.00	18224	Age
DRLIC	1.05	.24	1.00	3.00	18224	Drivers license status
EMPLOY	2.87	2.53	1.00	9.00	18224	Employment status

PATTERN Main daily pattern type by TOURTYPE Tour purpose category

TOURTYPE Page 1 of 1

PATTERN	Count / Col Pct	primary work tou 1.00	work-bas ed tour 2.00	maintena nce tour 3.00	discreti onary to 4.00	Row Total
work on tour	1.00	7443	1392	1522	1279	11636
		100.0	100.0	25.9	36.4	63.8
work at home	2.00			364	154	518
				6.2	4.4	2.8
mainten. on tour	3.00			3492	839	4331
				59.4	23.9	23.8
discret. on tour	4.00			181	1224	1405
				3.1	34.8	7.7
mainten. at home	5.00			237	12	249
				4.0	.3	1.4
discret. at home	6.00			73	5	78
				1.2	.1	.4
none long enough	7.00			7		7
				.1		.0
	Column Total	7443	1392	5876	3513	18224
		40.8	7.6	32.2	19.3	100.0

Number of Missing Observations: 0

PRIMARY Primary tour of day? by TOURTYPE Tour purpose category

TOURTYPE — Page 1 of 1

PRIMARY	Count / Col Pct	primary work tou 1.00	work-based tour 2.00	maintenance tour 3.00	discretionary to 4.00	Row Total
primary	1.00	7443		2410	928	10781
		100.0		41.0	26.4	59.2
secondary	2.00		1392	3466	2585	7443
			100.0	59.0	73.6	40.8
	Column Total	7443	1392	5876	3513	18224
		40.8	7.6	32.2	19.3	100.0

Number of Missing Observations: 0

DAYNO Diary day number by TOURTYPE Tour purpose category

TOURTYPE — Page 1 of 1

DAYNO	Count / Col Pct	primary work tou 1.00	work-based tour 2.00	maintenance tour 3.00	discretionary to 4.00	Row Total
	1.00	3775	751	3151	1807	9484
		50.7	54.0	53.6	51.4	52.0
	2.00	3668	641	2725	1706	8740
		49.3	46.0	46.4	48.6	48.0
	Column Total	7443	1392	5876	3513	18224
		40.8	7.6	32.2	19.3	100.0

Number of Missing Observations: 0

DAYOFWK Diary day of the week by TOURTYPE Tour purpose category

TOURTYPE Page 1 of 1

DAYOFWK	Count / Col Pct	primary work tou 1.00	work-based tour 2.00	maintenance tour 3.00	discretionary to 4.00	Row Total
Monday	1.00	1408	261	1170	579	3418
		18.9	18.8	19.9	16.5	18.8
Tuesday	2.00	1458	264	1103	612	3437
		19.6	19.0	18.8	17.4	18.9
Wednesday	3.00	1468	268	1057	657	3450
		19.7	19.3	18.0	18.7	18.9
Thursday	4.00	1558	290	1213	783	3844
		20.9	20.8	20.6	22.3	21.1
Friday	5.00	1551	309	1333	882	4075
		20.8	22.2	22.7	25.1	22.4
	Column Total	7443	1392	5876	3513	18224
		40.8	7.6	32.2	19.3	100.0

Number of Missing Observations: 0

NACTS Number of activities on diary day by TOURTYPE Tour purpose category

TOURTYPE Page 1 of 1

NACTS	Count / Col Pct	primary work tou 1.00	work-based tour 2.00	maintenance tour 3.00	discretionary to 4.00	Row Total
2.00	Count	145		22	17	184
	Col Pct	1.9		.4	.5	1.0
3.00	Count	530	2	63	50	645
	Col Pct	7.1	.1	1.1	1.4	3.5
4.00	Count	1056	56	168	263	1543
	Col Pct	14.2	4.0	2.9	7.5	8.5
5.00	Count	1282	146	378	361	2167
	Col Pct	17.2	10.5	6.4	10.3	11.9
6.00	Count	1535	313	736	588	3172
	Col Pct	20.6	22.5	12.5	16.7	17.4
7.00	Count	1041	260	693	536	2530
	Col Pct	14.0	18.7	11.8	15.3	13.9
8.00	Count	800	237	851	490	2378
	Col Pct	10.7	17.0	14.5	13.9	13.0
9.00	Count	501	159	850	432	1942
	Col Pct	6.7	11.4	14.5	12.3	10.7
10.00	Count	256	98	636	313	1303
	Col Pct	3.4	7.0	10.8	8.9	7.1
11.00	Count	141	48	490	174	853
	Col Pct	1.9	3.4	8.3	5.0	4.7
12.00	Count	74	41	362	122	599
	Col Pct	1.0	2.9	6.2	3.5	3.3
13.00	Count	35	16	197	69	317
	Col Pct	.5	1.1	3.4	2.0	1.7
14.00	Count	25	9	146	31	211
	Col Pct	.3	.6	2.5	.9	1.2
15.00	Count	11	2	106	29	148
	Col Pct	.1	.1	1.8	.8	.8
16.00	Count	5	2	59	15	81
	Col Pct	.1	.1	1.0	.4	.4
17.00	Count	2		53	9	64
	Col Pct	.0		.9	.3	.4
18.00	Count	2	2	35	8	47
	Col Pct	.0	.1	.6	.2	.3
19.00	Count	1	1	9	3	14
	Col Pct	.0	.1	.2	.1	.1
21.00	Count			10	1	11

				.2	.0	.1
23.00		1 .0				1 .0
24.00				5 .1	1 .0	6 .0
25.00				2 .0	1 .0	3 .0
26.00				5 .1		5 .0
Column Total		7443 40.8	1392 7.6	5876 32.2	3513 19.3	18224 100.0

Number of Missing Observations: 0

PRACTCOD Primary activity purpose by TOURTYPE Tour purpose category

TOURTYPE Page 1 of 1

PRACTCOD	Count Col Pct	primary work tou 1.00	work-based tour 2.00	maintenance tour 3.00	discretionary to 4.00	Row Total
Meals	11.00		771 55.4		815 23.2	1586 8.7
Work	12.00	6486 87.1	58 4.2	173 2.9		6717 36.9
Work-related	13.00	207 2.8	143 10.3	131 2.2		481 2.6
Shopping (genera	14.00		103 7.4	2887 49.1		2990 16.4
Shopping (major)	15.00		4 .3	59 1.0		63 .3
Personal service	16.00		12 .9	284 4.8		296 1.6
Medical care	17.00		23 1.7	455 7.7		478 2.6
Professional ser	18.00		1 .1	55 .9		56 .3
Personal busines	19.00		55 4.0	375 6.4		430 2.4
Household mainte	20.00		19 1.4	97 1.7		116 .6
Household obliga	21.00		7 .5	227 3.9		234 1.3
Pick-Up/Drop-Off	22.00		30 2.2	1037 17.6		1067 5.9

31.00		17		648	665
Visiting		1.2		18.4	3.6
32.00				61	61
Casual entertain				1.7	.3
33.00		3		39	42
Formal entertain		.2		1.1	.2
41.00	750	14	96		860
School	10.1	1.0	1.6		4.7
42.00				103	103
Culture				2.9	.6
43.00		6		192	198
Religion/Civil S		.4		5.5	1.1
44.00		4		224	228
Civic		.3		6.4	1.3
45.00				77	77
Volunteer work				2.2	.4
51.00		14		12	26
Amusements (at-h		1.0		.3	.1
52.00		11		580	591
Amusements (out-		.8		16.5	3.2
53.00		3		60	63
Hobbies		.2		1.7	.3
54.00		18		513	531
Exercise/Athleti		1.3		14.6	2.9
55.00		64		46	110
Rest and relaxat		4.6		1.3	.6
56.00				93	93
Spectator events				2.6	.5
90.00		12		34	46
Incidental trip		.9		1.0	.3
91.00				16	16
Tag along trip				.5	.1
Column	7443	1392	5876	3513	18224
Total	40.8	7.6	32.2	19.3	100.0

Number of Missing Observations: 0

MAINMODE Main mode for tour by TOURTYPE Tour purpose category

TOURTYPE Page 1 of 1

MAINMODE (Count / Col Pct)	primary work tou 1.00	work-based tour 2.00	maintenance tour 3.00	discretionary to 4.00	Row Total
1.00 Car driver alone	5619 75.5	817 58.7	3200 54.5	1354 38.5	10990 60.3
2.00 Car drive w/pass	302 4.1	89 6.4	1433 24.4	943 26.8	2767 15.2
3.00 Car passenger	450 6.0	90 6.5	775 13.2	754 21.5	2069 11.4
4.00 MAX-walk access	58 .8	6 .4	11 .2	7 .2	82 .4
5.00 MAX-other access	39 .5			2 .1	41 .2
6.00 Bus-walk access	403 5.4	16 1.1	83 1.4	50 1.4	552 3.0
7.00 Bus-other access	177 2.4	1 .1	9 .2	12 .3	199 1.1
8.00 Bicycle	99 1.3	10 .7	40 .7	36 1.0	185 1.0
9.00 Walk	296 4.0	363 26.1	325 5.5	355 10.1	1339 7.3
Column Total	7443 40.8	1392 7.6	5876 32.2	3513 19.3	18224 100.0

Number of Missing Observations: 0

LEAVOPER Departure period from origin by TOURTYPE Tour purpose category

TOURTYPE Page 1 of 1

LEAVOPER	Count / Col Pct	primary work tou 1.00	work-bas ed tour 2.00	maintena nce tour 3.00	discreti onary to 4.00	Row Total
	1.00	1242	26	93	62	1423
Early	3-6:29am	16.7	1.9	1.6	1.8	7.8
	2.00	4834	91	768	344	6037
AM peak	6:30-9am	64.9	6.5	13.1	9.8	33.1
	3.00	1159	1221	3186	1040	6606
Midday	9am -4pm	15.6	87.7	54.2	29.6	36.2
	4.00	149	43	1298	1429	2919
PM peak	4pm -7pm	2.0	3.1	22.1	40.7	16.0
	5.00	59	11	531	638	1239
Night	7pm-2:59	.8	.8	9.0	18.2	6.8
	Column Total	7443	1392	5876	3513	18224
		40.8	7.6	32.2	19.3	100.0

Number of Missing Observations: 0

LEAVDPER Departure period from dest. by TOURTYPE Tour purpose category

TOURTYPE Page 1 of 1

LEAVDPER	Count / Col Pct	primary work tou 1.00	work-bas ed tour 2.00	maintena nce tour 3.00	discreti onary to 4.00	Row Total
	1.00	78		42	8	128
Early	3-6:29am	1.0		.7	.2	.7
	2.00	43	18	354	71	486
AM peak	6:30-9am	.6	1.3	6.0	2.0	2.7
	3.00	2531	1181	2960	970	7642
Midday	9am -4pm	34.0	84.8	50.4	27.6	41.9
	4.00	3955	124	1399	550	6028
PM peak	4pm -7pm	53.1	8.9	23.8	15.7	33.1
	5.00	836	69	1121	1914	3940
Night	7pm-2:59	11.2	5.0	19.1	54.5	21.6
	Column Total	7443	1392	5876	3513	18224
		40.8	7.6	32.2	19.3	100.0

Number of Missing Observations: 0

TIMECOMB Time period combination by TOURTYPE Tour purpose category

TIMECOMB (Count / Col Pct)	TOURTYPE primary work tou 1.00	work-bas ed tour 2.00	maintena nce tour 3.00	discreti onary to 4.00	Row Total
1.00 Early -Early	38		42	8	88
	.5		.7	.2	.5
2.00 Early -AM peak	34	4	29	31	98
	.5	.3	.5	.9	.5
3.00 Early -Midday	670	3	8	13	694
	9.0	.2	.1	.4	3.8
4.00 Early -PM peak	459	17	10	3	489
	6.2	1.2	.2	.1	2.7
5.00 Early -Night	41	2	4	7	54
	.6	.1	.1	.2	.3
6.00 AM peak-AM peak	5	14	325	40	384
	.1	1.0	5.5	1.1	2.1
7.00 AM peak-Midday	1553	41	412	248	2254
	20.9	2.9	7.0	7.1	12.4
8.00 AM peak-PM peak	3066	12	24	44	3146
	41.2	.9	.4	1.3	17.3
9.00 AM peak-Night	210	24	7	12	253
	2.8	1.7	.1	.3	1.4
10.00 Midday -Midday	306	1137	2536	708	4687
	4.1	81.7	43.2	20.2	25.7
11.00 Midday -PM peak	421	71	608	256	1356
	5.7	5.1	10.3	7.3	7.4
12.00 Midday -Night	432	13	42	76	563
	5.8	.9	.7	2.2	3.1
13.00 PM peak-PM peak	21	24	752	244	1041
	.3	1.7	12.8	6.9	5.7
14.00 PM peak-Night	128	19	546	1185	1878
	1.7	1.4	9.3	33.7	10.3
15.00 Night -Night	59	11	531	638	1239
	.8	.8	9.0	18.2	6.8
Column Total	7443	1392	5876	3513	18224
	40.8	7.6	32.2	19.3	100.0

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Number of Missing Observations: 0

TOURSDUR Work-based tours from destination by TOURTYPE Tour purpose category

TOURTYPE Page 1 of 1

TOURSDUR (Count / Col Pct)	primary work tou 1.00	work-based tour 2.00	maintenance tour 3.00	discretionary to 4.00	Row Total
.00	6047 81.2	1392 100.0	5876 100.0	3513 100.0	16828 92.3
1.00	1306 17.5				1306 7.2
2.00	77 1.0				77 .4
3.00	11 .1				11 .1
4.00	2 .0				2 .0
Column Total	7443 40.8	1392 7.6	5876 32.2	3513 19.3	18224 100.0

Number of Missing Observations: 0

STOPSBEF Stops made on trip to dest. by TOURTYPE Tour purpose category

TOURTYPE Page 1 of 1

STOPSBEF	Count / Col Pct	primary work tou 1.00	work-based tour 2.00	maintenance tour 3.00	discretionary to 4.00	Row Total
	.00	6207 83.4	1229 88.3	4545 77.3	3126 89.0	15107 82.9
	1.00	942 12.7	124 8.9	939 16.0	280 8.0	2285 12.5
	2.00	204 2.7	27 1.9	262 4.5	72 2.0	565 3.1
	3.00	61 .8	11 .8	76 1.3	21 .6	169 .9
	4.00	21 .3		28 .5	10 .3	59 .3
	5.00	6 .1	1 .1	16 .3	2 .1	25 .1
	6.00	2 .0		5 .1	1 .0	8 .0
	7.00			3 .1		3 .0
	8.00				1 .0	1 .0
	9.00			2 .0		2 .0
	Column Total	7443 40.8	1392 7.6	5876 32.2	3513 19.3	18224 100.0

Number of Missing Observations: 0

STOPBCOD Stop before activity purpose by TOURTYPE Tour purpose category

TOURTYPE Page 1 of 1

STOPBCOD	Count / Col Pct	primary work tou 1.00	work-bas ed tour 2.00	maintena nce tour 3.00	discreti onary to 4.00	Row Total
Meals	11.00	129	20	176	74	399
		11.5	13.6	14.1	21.4	14.0
Work	12.00	146	10	9	2	167
		13.0	6.8	.7	.6	5.8
Work-related	13.00	66	23	19		108
		5.9	15.6	1.5		3.8
Shopping (genera	14.00	70	16	229	57	372
		6.3	10.9	18.4	16.5	13.0
Shopping (major)	15.00	3	1	8	1	13
		.3	.7	.6	.3	.5
Personal service	16.00	25	4	54	11	94
		2.2	2.7	4.3	3.2	3.3
Medical care	17.00	37	2	52	4	95
		3.3	1.4	4.2	1.2	3.3
Professional ser	18.00			7		7
				.6		.2
Personal busines	19.00	34	14	164	13	225
		3.0	9.5	13.2	3.8	7.9
Household mainte	20.00	5	4	6		15
		.4	2.7	.5		.5
Household obliga	21.00	11	1	15	4	31
		1.0	.7	1.2	1.2	1.1
Pick-Up/Drop-Off	22.00	436	17	244	62	759
		38.9	11.6	19.6	17.9	26.5
Visiting	31.00	27	4	69	44	144
		2.4	2.7	5.5	12.7	5.0
Casual entertain	32.00			1	2	3
				.1	.6	.1
Formal entertain	33.00	1			2	3
		.1			.6	.1
School	41.00	36		2	1	39
		3.2		.2	.3	1.4
Culture	42.00			4	4	8
				.3	1.2	.3
Religion/Civil S	43.00	7		18	10	35
		.6		1.4	2.9	1.2
	44.00	11		11	10	32

Civic	1.0		.9	2.9	1.1
45.00	1		8		9
Volunteer work	.1		.6		.3
51.00		5	1		6
Amusements (at-h		3.4	.1		.2
52.00	7	2	52	15	76
Amusements (out-	.6	1.4	4.2	4.3	2.7
53.00	1		4	2	7
Hobbies	.1		.3	.6	.2
54.00	52	5	66	13	136
Exercise/Athleti	4.6	3.4	5.3	3.8	4.8
55.00	7	9	8	5	29
Rest and relaxat	.6	6.1	.6	1.4	1.0
56.00			7	1	8
Spectator events			.6	.3	.3
90.00	7	9	8	8	32
Incidental trip	.6	6.1	.6	2.3	1.1
91.00	1	1	5	1	8
Tag along trip	.1	.7	.4	.3	.3
Column	1120	147	1247	346	2860
Total	39.2	5.1	43.6	12.1	100.0

Number of Missing Observations: 15364

STOPBPER Stop before departure period by TOURTYPE Tour purpose category

TOURTYPE Page 1 of 1

Count / Col Pct	primary work tou 1.00	work-bas ed tour 2.00	maintena nce tour 3.00	discreti onary to 4.00	Row Total
STOPBPER					
1.00	32		4		36
Early 3-6:29am	2.9		.3		1.3
2.00	582	9	91	30	712
AM peak 6:30-9am	52.0	6.1	7.3	8.7	24.9
3.00	472	122	812	148	1554
Midday 9am -4pm	42.1	83.0	65.1	42.8	54.3
4.00	24	12	190	93	319
PM peak 4pm -7pm	2.1	8.2	15.2	26.9	11.2
5.00	10	4	150	75	239
Night 7pm-2:59	.9	2.7	12.0	21.7	8.4
Column	1120	147	1247	346	2860
Total	39.2	5.1	43.6	12.1	100.0

Number of Missing Observations: 15364

STOPBCOM Stop before time combination by TOURTYPE Tour purpose category

TOURTYPE — Page 1 of 1

STOPBCOM	Count / Col Pct	primary work tou 1.00	work-based tour 2.00	maintenance tour 3.00	discretionary to 4.00	Row Total
1.00	Early -Early	32 2.9		4 .3		36 1.3
2.00	Early -AM peak	92 8.2	3 2.0	5 .4	1 .3	101 3.5
3.00	Early -Midday	20 1.8		2 .2		22 .8
4.00	Early -PM peak	1 .1	1 .7	1 .1		3 .1
6.00	AM peak-AM peak	490 43.8	6 4.1	86 6.9	29 8.4	611 21.4
7.00	AM peak-Midday	272 24.3	16 10.9	96 7.7	39 11.3	423 14.8
8.00	AM peak-PM peak	1 .1				1 .0
9.00	AM peak-Night	1 .1				1 .0
10.00	Midday -Midday	180 16.1	106 72.1	711 57.0	108 31.2	1105 38.6
11.00	Midday -PM peak	14 1.3	9 6.1	64 5.1	17 4.9	104 3.6
12.00	Midday -Night	2 .2	1 .7	1 .1		4 .1
13.00	PM peak-PM peak	6 .5	2 1.4	124 9.9	75 21.7	207 7.2
14.00	PM peak-Night	4 .4	2 1.4	86 6.9	53 15.3	145 5.1
15.00	Night -Night	5 .4	1 .7	67 5.4	24 6.9	97 3.4
	Column Total	1120 39.2	147 5.1	1247 43.6	346 12.1	2860 100.0

Number of Missing Observations: 15364

STOPSAFT Stops made on trip to origin by TOURTYPE Tour purpose category

TOURTYPE Page 1 of 1

STOPSAFT (Count / Col Pct)	primary work tou 1.00	work-based tour 2.00	maintenance tour 3.00	discretionary to 4.00	Row Total
.00	5114 68.7	1244 89.4	4468 76.0	3060 87.1	13886 76.2
1.00	1534 20.6	98 7.0	959 16.3	336 9.6	2927 16.1
2.00	504 6.8	34 2.4	293 5.0	74 2.1	905 5.0
3.00	192 2.6	9 .6	90 1.5	28 .8	319 1.8
4.00	59 .8	5 .4	41 .7	11 .3	116 .6
5.00	26 .3		9 .2	2 .1	37 .2
6.00	9 .1	1 .1	9 .2	1 .0	20 .1
7.00	3 .0		4 .1	1 .0	8 .0
8.00			2 .0		2 .0
9.00		1 .1			1 .0
10.00	1 .0		1 .0		2 .0
12.00	1 .0				1 .0
Column Total	7443 40.8	1392 7.6	5876 32.2	3513 19.3	18224 100.0

Number of Missing Observations: 0

STOPACOD Stop after activity purpose by TOURTYPE Tour purpose category

TOURTYPE Page 1 of 1

STOPACOD	Count / Col Pct	primary work tou 1.00	work-based tour 2.00	maintenance tour 3.00	discretionary to 4.00	Row Total
Meals	11.00	248	35	189	117	589
		11.7	25.9	14.4	28.0	14.8
Work	12.00	123	6	3	3	135
		5.8	4.4	.2	.7	3.4
Work-related	13.00	104	18	13		135
		4.9	13.3	1.0		3.4
Shopping (genera	14.00	489	16	492	67	1064
		23.1	11.9	37.4	16.0	26.7
Shopping (major)	15.00	7		16	5	28
		.3		1.2	1.2	.7
Personal service	16.00	59	4	17	4	84
		2.8	3.0	1.3	1.0	2.1
Medical care	17.00	69	1	31	4	105
		3.3	.7	2.4	1.0	2.6
Professional ser	18.00	12	1	6		19
		.6	.7	.5		.5
Personal busines	19.00	107	9	121	9	246
		5.1	6.7	9.2	2.2	6.2
Household mainte	20.00	16	1	8		25
		.8	.7	.6		.6
Household obliga	21.00	15		7	2	24
		.7		.5	.5	.6
Pick-Up/Drop-Off	22.00	369	12	185	60	626
		17.4	8.9	14.0	14.4	15.7
Visiting	31.00	147	5	98	52	302
		6.9	3.7	7.4	12.4	7.6
Casual entertain	32.00	1		3	1	5
		.0		.2	.2	.1
Formal entertain	33.00	6	1		2	9
		.3	.7		.5	.2
School	41.00	43	2	5	1	51
		2.0	1.5	.4	.2	1.3
Culture	42.00	10		6		16
		.5		.5		.4
Religion/Civil S	43.00	12	1	6	6	25
		.6	.7	.5	1.4	.6
	44.00	19		5	8	32

Civic	.9		.4	1.9	.8
45.00	10	1	6	1	18
Volunteer work	.5	.7	.5	.2	.5
51.00	2	8	3		13
Amusements (at-h	.1	5.9	.2		.3
52.00	84		48	35	167
Amusements (out-	4.0		3.6	8.4	4.2
53.00	7		5	5	17
Hobbies	.3		.4	1.2	.4
54.00	128	1	24	6	159
Exercise/Athleti	6.0	.7	1.8	1.4	4.0
55.00	8	6	2	8	24
Rest and relaxat	.4	4.4	.2	1.9	.6
56.00	7		4	1	12
Spectator events	.3		.3	.2	.3
90.00	14	7	13	18	52
Incidental trip	.7	5.2	1.0	4.3	1.3
91.00	2		1	3	6
Tag along trip	.1		.1	.7	.2
Column	2118	135	1317	418	3988
Total	53.1	3.4	33.0	10.5	100.0

Number of Missing Observations: 14236

STOPAPER Stop after departure period by TOURTYPE Tour purpose category

TOURTYPE — Page 1 of 1

STOPAPER / Count / Col Pct	primary work tou 1.00	work-bas ed tour 2.00	maintena nce tour 3.00	discreti onary to 4.00	Row Total
1.00	3		1	1	5
Early 3-6:29am	.1		.1	.2	.1
2.00	1	4	31	1	37
AM peak 6:30-9am	.0	3.0	2.4	.2	.9
3.00	485	101	739	137	1462
Midday 9am -4pm	22.9	74.8	56.1	32.8	36.7
4.00	1098	19	321	97	1535
PM peak 4pm -7pm	51.8	14.1	24.4	23.2	38.5
5.00	531	11	225	182	949
Night 7pm-2:59	25.1	8.1	17.1	43.5	23.8
Column	2118	135	1317	418	3988
Total	53.1	3.4	33.0	10.5	100.0

Number of Missing Observations: 14236

STOPACOM Stop after time combination by TOURTYPE Tour purpose category

TOURTYPE Page 1 of 1

STOPACOM	Count / Col Pct	primary work tou 1.00	work-based tour 2.00	maintenance tour 3.00	discretionary to 4.00	Row Total
Early -Early	1.00	2		1	1	4
		.1		.1	.2	.1
Early -AM peak	2.00			1		1
				.1		.0
Early -Midday	3.00	2				2
		.1				.1
Early -PM peak	4.00	11				11
		.5				.3
Early -Night	5.00	9				9
		.4				.2
AM peak-AM peak	6.00	1	4	30	1	36
		.0	3.0	2.3	.2	.9
AM peak-Midday	7.00	6	1	15	1	23
		.3	.7	1.1	.2	.6
AM peak-PM peak	8.00				1	1
					.2	.0
AM peak-Night	9.00	1				1
		.0				.0
Midday -Midday	10.00	475	100	724	136	1435
		22.4	74.1	55.0	32.5	36.0
Midday -PM peak	11.00	425	9	120	43	597
		20.1	6.7	9.1	10.3	15.0
Midday -Night	12.00	69	3	5		77
		3.3	2.2	.4		1.9
PM peak-PM peak	13.00	658	10	201	53	922
		31.1	7.4	15.3	12.7	23.1
PM peak-Night	14.00	348	5	60	25	438
		16.4	3.7	4.6	6.0	11.0
Night -Night	15.00	111	3	160	157	431
		5.2	2.2	12.1	37.6	10.8
	Column Total	2118	135	1317	418	3988
		53.1	3.4	33.0	10.5	100.0

Number of Missing Observations: 14236

CHAINTYP Type of trip chaining by TOURTYPE Tour purpose category

TOURTYPE Page 1 of 1

CHAINTYP	Count / Col Pct	primary work tou 1.00	work-based tour 2.00	maintenance tour 3.00	discretionary to 4.00	Row Total
	1.00	3665	1131	3583	2819	11198
ODO		49.2	81.3	61.0	80.2	61.4
	2.00	1388	98	962	307	2755
ODaO		18.6	7.0	16.4	8.7	15.1
	3.00	531	113	885	241	1770
ObDO		7.1	8.1	15.1	6.9	9.7
	4.00	463	50	446	146	1105
ObDaO		6.2	3.6	7.6	4.2	6.1
	5.00	789				789
ODdDO		10.6				4.3
	6.00	365				365
ODdDaO		4.9				2.0
	7.00	129				129
ObDdDO		1.7				.7
	8.00	113				113
ObDdDaO		1.5				.6
	Column	7443	1392	5876	3513	18224
	Total	40.8	7.6	32.2	19.3	100.0

Number of Missing Observations: 0

HHSIZE Total household size by TOURTYPE Tour purpose category

TOURTYPE Page 1 of 1

HHSIZE (Count / Col Pct)	primary work tou 1.00	work-based tour 2.00	maintenance tour 3.00	discretionary to 4.00	Row Total
1.00	1076	245	810	588	2719
	14.5	17.6	13.8	16.7	14.9
2.00	2740	541	2273	1479	7033
	36.8	38.9	38.7	42.1	38.6
3.00	1535	246	944	552	3277
	20.6	17.7	16.1	15.7	18.0
4.00	1370	229	1150	560	3309
	18.4	16.5	19.6	15.9	18.2
5.00	482	79	465	224	1250
	6.5	5.7	7.9	6.4	6.9
6.00	168	42	173	79	462
	2.3	3.0	2.9	2.2	2.5
7.00	67	9	53	31	160
	.9	.6	.9	.9	.9
8.00	4	1	8		13
	.1	.1	.1		.1
9.00	1				1
	.0				.0
Column Total	7443	1392	5876	3513	18224
	40.8	7.6	32.2	19.3	100.0

Number of Missing Observations: 0

HHCHU5 HH children under age 5 by TOURTYPE Tour purpose category

TOURTYPE — Page 1 of 1

HHCHU5 (Count / Col Pct)	primary work tou 1.00	work-bas ed tour 2.00	maintena nce tour 3.00	discreti onary to 4.00	Row Total
.00	6524	1238	5054	3152	15968
	87.7	88.9	86.0	89.7	87.6
1.00	738	122	606	268	1734
	9.9	8.8	10.3	7.6	9.5
2.00	163	31	191	83	468
	2.2	2.2	3.3	2.4	2.6
3.00	17	1	25	10	53
	.2	.1	.4	.3	.3
4.00	1				1
	.0				.0
Column Total	7443	1392	5876	3513	18224
	40.8	7.6	32.2	19.3	100.0

Number of Missing Observations: 0

HHC511 HH children age 5-11 by TOURTYPE Tour purpose category

TOURTYPE — Page 1 of 1

HHC511 (Count / Col Pct)	primary work tou 1.00	work-bas ed tour 2.00	maintena nce tour 3.00	discreti onary to 4.00	Row Total
.00	6055	1149	4561	2938	14703
	81.4	82.5	77.6	83.6	80.7
1.00	894	141	785	352	2172
	12.0	10.1	13.4	10.0	11.9
2.00	420	87	426	179	1112
	5.6	6.3	7.2	5.1	6.1
3.00	68	12	82	42	204
	.9	.9	1.4	1.2	1.1
4.00	6	3	22	2	33
	.1	.2	.4	.1	.2
Column Total	7443	1392	5876	3513	18224
	40.8	7.6	32.2	19.3	100.0

Number of Missing Observations: 0

HH1217 HH children age 12-17 by TOURTYPE Tour purpose category

TOURTYPE — Page 1 of 1

Count / Col Pct	primary	work-bas	maintena	discreti

		work tou 1.00	ed tour 2.00	nce tour 3.00	onary to 4.00	Row Total
HH1217						
	.00	5859	1117	4674	2874	14524
		78.7	80.2	79.5	81.8	79.7
	1.00	1115	186	791	405	2497
		15.0	13.4	13.5	11.5	13.7
	2.00	390	79	357	204	1030
		5.2	5.7	6.1	5.8	5.7
	3.00	63	8	42	25	138
		.8	.6	.7	.7	.8
	4.00	10	1	8	5	24
		.1	.1	.1	.1	.1
	5.00	6	1	4		11
		.1	.1	.1		.1
	Column Total	7443	1392	5876	3513	18224
		40.8	7.6	32.2	19.3	100.0

Number of Missing Observations: 0

HHADLT HH adults 18+ by TOURTYPE Tour purpose category

TOURTYPE Page 1 of 1

	Count / Col Pct	primary work tou 1.00	work-bas ed tour 2.00	maintena nce tour 3.00	discreti onary to 4.00	Row Total
HHADLT						
	.00		1			1
			.1			.0
	1.00	1316	291	996	672	3275
		17.7	20.9	17.0	19.1	18.0
	2.00	4743	885	3999	2331	11958
		63.7	63.6	68.1	66.4	65.6
	3.00	1080	161	688	387	2316
		14.5	11.6	11.7	11.0	12.7
	4.00	258	44	161	97	560
		3.5	3.2	2.7	2.8	3.1
	5.00	29	9	26	7	71
		.4	.6	.4	.2	.4
	6.00	4		5	14	23
		.1		.1	.4	.1
	7.00	13	1	1	5	20
		.2	.1	.0	.1	.1
	Column Total	7443	1392	5876	3513	18224
		40.8	7.6	32.2	19.3	100.0

Number of Missing Observations: 0

HHFULL HH employed full time by TOURTYPE Tour purpose category

TOURTYPE Page 1 of 1

HHFULL	Count / Col Pct	primary work tou 1.00	work-based tour 2.00	maintenance tour 3.00	discretionary to 4.00	Row Total
	.00	368	68	1771	1072	3279
		4.9	4.9	30.1	30.5	18.0
	1.00	2711	566	2104	1192	6573
		36.4	40.7	35.8	33.9	36.1
	2.00	3481	632	1648	1016	6777
		46.8	45.4	28.0	28.9	37.2
	3.00	747	99	296	193	1335
		10.0	7.1	5.0	5.5	7.3
	4.00	118	23	52	33	226
		1.6	1.7	.9	.9	1.2
	5.00	5	3	4	2	14
		.1	.2	.1	.1	.1
	6.00	13	1	1	5	20
		.2	.1	.0	.1	.1
	Column	7443	1392	5876	3513	18224
	Total	40.8	7.6	32.2	19.3	100.0

Number of Missing Observations: 0

HHPART HH employed part time by TOURTYPE Tour purpose category

TOURTYPE Page 1 of 1

HHPART	Count / Col Pct	primary work tou 1.00	work-based tour 2.00	maintenance tour 3.00	discretionary to 4.00	Row Total
	.00	6565	1207	5120	3067	15959
		88.2	86.7	87.1	87.3	87.6
	1.00	786	159	662	405	2012
		10.6	11.4	11.3	11.5	11.0
	2.00	81	21	90	39	231
		1.1	1.5	1.5	1.1	1.3
	3.00	11	5	4	2	22
		.1	.4	.1	.1	.1
	Column	7443	1392	5876	3513	18224
	Total	40.8	7.6	32.2	19.3	100.0

Number of Missing Observations: 0

HHDLIC HH drivers licenses by TOURTYPE Tour purpose category

TOURTYPE Page 1 of 1

HHDLIC	Count / Col Pct	primary work tou 1.00	work-based tour 2.00	maintenance tour 3.00	discretionary to 4.00	Row Total
	.00	104	20	111	66	301
		1.4	1.4	1.9	1.9	1.7
	1.00	1456	306	1188	762	3712
		19.6	22.0	20.2	21.7	20.4
	2.00	4367	822	3666	2088	10943
		58.7	59.1	62.4	59.4	60.0
	3.00	1122	181	704	441	2448
		15.1	13.0	12.0	12.6	13.4
	4.00	346	56	187	143	732
		4.6	4.0	3.2	4.1	4.0
	5.00	35	6	19	8	68
		.5	.4	.3	.2	.4
	7.00	13	1	1	5	20
		.2	.1	.0	.1	.1
	Column Total	7443	1392	5876	3513	18224
		40.8	7.6	32.2	19.3	100.0

Number of Missing Observations: 0

NMVEH HH vehicles owned by TOURTYPE Tour purpose category

TOURTYPE Page 1 of 1

NMVEH	Count / Col Pct	primary work tou 1.00	work-based tour 2.00	maintenance tour 3.00	discretionary to 4.00	Row Total
	.00	202	32	174	106	514
		2.7	2.3	3.0	3.0	2.8
	1.00	1612	317	1508	866	4303
		21.7	22.8	25.7	24.7	23.6
	2.00	3618	696	2834	1636	8784
		48.6	50.0	48.2	46.6	48.2
	3.00	1393	225	992	654	3264
		18.7	16.2	16.9	18.6	17.9
	4.00	463	95	275	187	1020
		6.2	6.8	4.7	5.3	5.6
	5.00	102	18	70	45	235
		1.4	1.3	1.2	1.3	1.3
	6.00	31	3	17	13	64
		.4	.2	.3	.4	.4
	7.00	14	4	3	1	22
		.2	.3	.1	.0	.1
	8.00	8	2	3	5	18
		.1	.1	.1	.1	.1
	Column Total	7443	1392	5876	3513	18224
		40.8	7.6	32.2	19.3	100.0

Number of Missing Observations: 0

INCOME HH annual income by TOURTYPE Tour purpose category

TOURTYPE Page 1 of 1

Count / Col Pct		primary work tou 1.00	work-based tour 2.00	maintenance tour 3.00	discretionary to 4.00	Row Total
INCOME						
1.00	$0 - $4,999	27 / .4	3 / .2	29 / .5	26 / .7	85 / .5
2.00	$5,000 - $9,999	88 / 1.2	14 / 1.0	143 / 2.4	80 / 2.3	325 / 1.8
3.00	$10,000 - $14,99	193 / 2.6	26 / 1.9	204 / 3.5	115 / 3.3	538 / 3.0
4.00	$15,000 - $19,99	253 / 3.4	32 / 2.3	248 / 4.2	164 / 4.7	697 / 3.8
5.00	$20,000 - $24,99	337 / 4.5	52 / 3.7	328 / 5.6	185 / 5.3	902 / 4.9
6.00	$25,000 - $29,99	390 / 5.2	69 / 5.0	356 / 6.1	230 / 6.5	1045 / 5.7
7.00	$30,000 - $34,99	538 / 7.2	113 / 8.1	438 / 7.5	241 / 6.9	1330 / 7.3
8.00	$35,000 - $39,99	490 / 6.6	69 / 5.0	393 / 6.7	241 / 6.9	1193 / 6.5
9.00	$40,000 - $44,99	647 / 8.7	107 / 7.7	411 / 7.0	251 / 7.1	1416 / 7.8
10.00	$45,000 - $49,99	441 / 5.9	72 / 5.2	328 / 5.6	183 / 5.2	1024 / 5.6
11.00	$50,000 - $54,99	631 / 8.5	118 / 8.5	411 / 7.0	225 / 6.4	1385 / 7.6
12.00	$55,000 - $59,99	247 / 3.3	42 / 3.0	167 / 2.8	105 / 3.0	561 / 3.1
13.00	$60,000 or more	1742 / 23.4	400 / 28.7	1125 / 19.1	675 / 19.2	3942 / 21.6
14.00	Missing	1419 / 19.1	275 / 19.8	1295 / 22.0	792 / 22.5	3781 / 20.7
Column Total		7443 / 40.8	1392 / 7.6	5876 / 32.2	3513 / 19.3	18224 / 100.0

Number of Missing Observations: 0

GENDER Gender by TOURTYPE Tour purpose category

TOURTYPE Page 1 of 1

	Count / Col Pct	primary work tou 1.00	work-bas ed tour 2.00	maintena nce tour 3.00	discreti onary to 4.00	Row Total
GENDER						
Male	1.00	3961	761	2267	1614	8603
		53.2	54.7	38.6	45.9	47.2
Female	2.00	3482	631	3609	1899	9621
		46.8	45.3	61.4	54.1	52.8
	Column Total	7443	1392	5876	3513	18224
		40.8	7.6	32.2	19.3	100.0

Number of Missing Observations: 0

AGE Age by TOURTYPE Tour purpose category

TOURTYPE Page 1 of 1

	Count / Col Pct	primary work tou 1.00	work-bas ed tour 2.00	maintena nce tour 3.00	discreti onary to 4.00	Row Total
AGE						
age 16-19	1.00	506	47	183	197	933
		6.8	3.4	3.1	5.6	5.1
age 20-24	2.00	473	73	216	171	933
		6.4	5.2	3.7	4.9	5.1
age 25-34	3.00	1636	289	982	596	3503
		22.0	20.8	16.7	17.0	19.2
age 35-44	4.00	2184	447	1480	775	4886
		29.3	32.1	25.2	22.1	26.8
age 45-54	5.00	1708	367	1059	623	3757
		22.9	26.4	18.0	17.7	20.6
age 55-64	6.00	671	120	742	418	1951
		9.0	8.6	12.6	11.9	10.7
age 65-74	7.00	120	20	762	476	1378
		1.6	1.4	13.0	13.5	7.6
age 75+	8.00	22	10	326	179	537
		.3	.7	5.5	5.1	2.9
missing	9.00	123	19	126	78	346
		1.7	1.4	2.1	2.2	1.9
	Column Total	7443	1392	5876	3513	18224
		40.8	7.6	32.2	19.3	100.0

Number of Missing Observations: 0

DRLIC Drivers license status by TOURTYPE Tour purpose category

TOURTYPE — Page 1 of 1

DRLIC	Count / Col Pct	primary work tou 1.00	work-bas ed tour 2.00	maintena nce tour 3.00	discreti onary to 4.00	Row Total
Yes	1.00	7082	1350	5564	3303	17299
		95.1	97.0	94.7	94.0	94.9
No	2.00	346	42	295	197	880
		4.6	3.0	5.0	5.6	4.8
Missing	3.00	15		17	13	45
		.2		.3	.4	.2
	Column Total	7443	1392	5876	3513	18224
		40.8	7.6	32.2	19.3	100.0

Number of Missing Observations: 0

EMPLOY Employment status by TOURTYPE Tour purpose category

TOURTYPE — Page 1 of 1

EMPLOY	Count / Col Pct	primary work tou 1.00	work-bas ed tour 2.00	maintena nce tour 3.00	discreti onary to 4.00	Row Total
Employed full-ti	1.00	5523	1125	1825	1274	9747
		74.2	80.8	31.1	36.3	53.5
Employed part-ti	2.00	938	112	647	361	2058
		12.6	8.0	11.0	10.3	11.3
Self-employed fu	3.00	337	90	328	173	928
		4.5	6.5	5.6	4.9	5.1
Self-employed pa	4.00	78	15	152	81	326
		1.0	1.1	2.6	2.3	1.8
Unemployed but l	5.00	87	5	295	145	532
		1.2	.4	5.0	4.1	2.9
Retired	6.00	47	3	1398	843	2291
		.6	.2	23.8	24.0	12.6
Full-time homema	7.00	36	5	854	351	1246
		.5	.4	14.5	10.0	6.8
Not employed	8.00	204	13	218	135	570
		2.7	.9	3.7	3.8	3.1
Missing	9.00	193	24	159	150	526
		2.6	1.7	2.7	4.3	2.9
	Column Total	7443	1392	5876	3513	18224
		40.8	7.6	32.2	19.3	100.0

Number of Missing Observations: 0

Summary of PATTRN10.DAT

Valid Variable	Mean	Std Dev	Minimum	Maximum	N	Label
SAMPNO	294671.84	131678.05	200007.0	508184.0	14774	Household number
PERSNO	1.67	.95	1.00	9.00	14774	Person number
DAYNO	1.50	.50	1.00	2.00	14774	Diary day number
DAYOFWK	3.06	1.43	1.00	5.00	14774	Diary day of the week
NACTS	6.72	2.62	1.00	26.00	14774	Number of activities on diary d
PATTERN	2.13	1.53	1.00	6.00	14774	Main daily pattern type
WORKTOUR	.59	.49	.00	1.00	14774	Number of primary work tours
WORKBASD	.11	.35	.00	4.00	14774	Number of work-based tours
MAINTTRS	.45	.74	.00	7.00	14774	Number of maintenance tours
MTOURDUR	56.10	115.47	.00	1080.00	14774	Longest maintenance tour durati
DISCRTRS	.30	.54	.00	4.00	14774	Number of discretionary tours
DTOURDUR	57.78	126.51	.00	1275.00	14774	Longest discretionary tour dura
WSTOPBEF	.13	.46	.00	6.00	14774	Work tour stops before dest.
WSTOPAFT	.27	.71	.00	12.00	14774	Work tour stops after dest.
WCHAINTP	1.38	1.80	.00	8.00	14774	Work tour trip chaining type
MSTOPBEF	.13	.50	.00	9.00	14774	Maintenance tour stops before d
MSTOPAFT	.14	.55	.00	12.00	14774	Maintenance tour stops after de
MCHAINTP	.60	1.02	.00	4.00	14774	Maintenance tour trip chaining
DSTOPBEF	.04	.30	.00	8.00	14774	Discretionary tour stops before
DSTOPAFT	.05	.31	.00	7.00	14774	Discretionary tour stops after
DCHAINTP	.35	.72	.00	4.00	14774	Discretionary tour trip chainin
PABEGPER	2.41	.84	1.00	5.00	14774	Primary activity/tour begin per
PAENDPER	3.63	.76	1.00	5.00	14774	Primary activity/tour end perio
PAPERCOM	8.65	2.78	1.00	15.00	14774	Primary activity period combina
WAHNACTS	.15	.46	.00	5.00	14774	Work at home- number of activit
WAHDURAT	24.48	89.35	.00	879.00	14774	Work at home- activity duration
WAHTRAVD	.11	4.79	.00	510.00	14774	Work at home- travel duration
WOTNACTS	.97	1.01	.00	10.00	14774	Work on tour- number of activit
WOTDURAT	274.90	252.46	.00	1040.00	14774	Work on tour- activity duration
WOTTRAVD	34.16	41.97	.00	869.00	14774	Work on tour- travel duration
MAHNACTS	.70	.99	.00	9.00	14774	Maintenance at home- number of
MAHDURAT	82.90	134.02	.00	885.00	14774	Maintenance at home- activity d
MAHTRAVD	.16	3.20	.00	195.00	14774	Maintenance at home- travel dur
MOTNACTS	.95	1.36	.00	12.00	14774	Maintenance on tour- number of
MOTDURAT	35.30	65.44	.00	685.00	14774	Maintenance on tour- activity d
MOTTRAVD	20.61	34.29	.00	510.00	14774	Maintenance on tour- travel dur
DAHNACTS	3.14	1.76	.00	12.00	14774	Discretionary at home- number o
DAHDURAT	294.99	198.65	.00	1200.00	14774	Discretionary at home- activity
DAHTRAVD	1.93	12.41	.00	420.00	14774	Discretionary at home- travel d
DOTNACTS	.81	.97	.00	8.00	14774	Discretionary on tour- number o
DOTDURAT	73.81	113.32	.00	842.00	14774	Discretionary on tour- activity
DOTTRAVD	15.97	34.66	.00	605.00	14774	Discretionary on tour- travel d
HOMEXCO	7655049.0	33362.36	7489745	7761543	14774	Home X coordinate
HOMEYCO	689146.82	38249.03	520046.0	840300.0	14774	Home Y coordinate
WORKXCO	7648339.8	30023.79	7312793	7990656	7614	Work X coordinate
WORKYCO	685703.84	34215.68	88484.00	912437.0	7614	Work Y coordinate
WBASTYP	.26	.80	.00	3.00	14774	Purpose type of work-based tour
STOPBTYP	.34	.82	.00	3.00	14774	Purpose type of stop before pri
STOPATYP	.52	.99	.00	3.00	14774	Purpose type of stop after prim
HHSIZE	2.67	1.30	1.00	9.00	14774	Total household size
HHCHU5	.15	.45	.00	4.00	14774	HH children under age 5
HHC511	.25	.61	.00	4.00	14774	HH children age 5-11
HH1217	.24	.58	.00	5.00	14774	HH children age 12-17
HHADLT	2.02	.72	1.00	7.00	14774	HH adults 18+
HHFULL	1.32	.94	.00	6.00	14774	HH employed full time
HHPART	.13	.38	.00	3.00	14774	HH employed part time
HHDLIC	1.95	.80	.00	7.00	14774	HH drivers licenses
NMVEH	2.01	1.01	.00	8.00	14774	HH vehicles owned
INCOME	9.88	3.73	1.00	14.00	14774	HH annual income

GENDER	1.52	.50	1.00	2.00	14774	Gender
AGE	4.56	1.83	1.00	9.00	14774	Age
DRLIC	1.08	.29	1.00	3.00	14774	Drivers license status
EMPLOY	3.02	2.57	1.00	9.00	14774	Employment status
HRZONE	662.32	386.11	1.00	1244.00	14774	Residence zone number
PCHAINTP	1.89	1.68	.00	8.00	14774	Primary tour trip chain type
SMT	.27	.57	.00	7.00	14774	
DMT	.48	.75	.00	7.00	13687	
SECTOURS	2.42	2.07	1.00	6.00	14774	Secondary tour pattern

PCHAINTP Primary tour trip chain type by PATTERN Main daily pattern type

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PCHAINTP	Count / Col Pct	PATTERN: work on tour 1.00	work at home 2.00	mainten. on tour 3.00	discret. on tour 4.00	mainten. at home 5.00	discret. at home 6.00	Row Total
None	.00		492			919	627	2038
			100.0			100.0	100.0	13.8
HDH	1.00	4389		1313	857			6559
		50.4		47.3	68.1			44.4
HDoH	2.00	1580		598	168			2346
		18.2		21.5	13.3			15.9
HoDH	3.00	629		539	140			1308
		7.2		19.4	11.1			8.9
HoDoH	4.00	533		327	94			954
		6.1		11.8	7.5			6.5
HDoDH	5.00	917						917
		10.5						6.2
HDoDoH	6.00	393						393
		4.5						2.7
HoDoDH	7.00	145						145
		1.7						1.0
HoDoDoH	8.00	114						114
		1.3						.8
	Column	8700	492	2777	1259	919	627	14774
	Total	58.9	3.3	18.8	8.5	6.2	4.2	100.0

Number of Missing Observations: 0

MAINTTRS Number of maintenance tours by PATTERN Main daily pattern type

PATTERN — Page 1 of 1

MAINTTRS (Count / Col Pct)	work on tour 1.00	work at home 2.00	mainten. on tour 3.00	discret. on tour 4.00	mainten. at home 5.00	discret. at home 6.00	Row Total
.00	7137	205		1087	736	555	9720
	82.0	41.7		86.3	80.1	88.5	65.8
1.00	1390	196	1886	139	122	57	3790
	16.0	39.8	67.9	11.0	13.3	9.1	25.7
2.00	151	63	656	26	45	14	955
	1.7	12.8	23.6	2.1	4.9	2.2	6.5
3.00	20	21	180	7	10	1	239
	.2	4.3	6.5	.6	1.1	.2	1.6
4.00	2	5	41		5		53
	.0	1.0	1.5		.5		.4
5.00		1	13		1		15
		.2	.5		.1		.1
7.00		1	1				2
		.2	.0				.0
Column Total	8700	492	2777	1259	919	627	14774
	58.9	3.3	18.8	8.5	6.2	4.2	100.0

Number of Missing Observations: 0

DISCRTRS Number of discretionary tours by PATTERN Main daily pattern type

PATTERN — Page 1 of 1

DISCRTRS (Count / Col Pct)	work on tour 1.00	work at home 2.00	mainten. on tour 3.00	discret. on tour 4.00	mainten. at home 5.00	discret. at home 6.00	Row Total
.00	7233	320	1910		899	617	10979
	83.1	65.0	68.8		97.8	98.4	74.3
1.00	1415	145	736	954	19	10	3279
	16.3	29.5	26.5	75.8	2.1	1.6	22.2
2.00	51	25	121	258	1		456
	.6	5.1	4.4	20.5	.1		3.1
3.00	1	2	10	44			57
	.0	.4	.4	3.5			.4
4.00				3			3
				.2			.0
Column Total	8700	492	2777	1259	919	627	14774
	58.9	3.3	18.8	8.5	6.2	4.2	100.0

Number of Missing Observations: 0

SECTOURS Secondary tour pattern by PATTERN Main daily pattern type

PATTERN Page 1 of 1

SECTOURS	Count / Col Pct	work on tour 1.00	work at home 2.00	mainten. on tour 3.00	discret. on tour 4.00	mainten. at home 5.00	discret. at home 6.00	Row Total
	1.00	5819	119	1290	822	720	549	9319
None		66.9	24.2	46.5	65.3	78.3	87.6	63.1
	2.00	1266	134	446	108	120	54	2128
1 Maintenance		14.6	27.2	16.1	8.6	13.1	8.6	14.4
	3.00	148	67	174	24	59	14	486
2+ Maintenance		1.7	13.6	6.3	1.9	6.4	2.2	3.3
	4.00	1274	71	500	224	16	6	2091
1 Discretionary		14.6	14.4	18.0	17.8	1.7	1.0	14.2
	5.00	44	15	96	41			196
2+ Discretionary		.5	3.0	3.5	3.3			1.3
	6.00	149	86	271	40	4	4	554
1+ Maint.,1+ Dis		1.7	17.5	9.8	3.2	.4	.6	3.7
	Column Total	8700	492	2777	1259	919	627	14774
		58.9	3.3	18.8	8.5	6.2	4.2	100.0

Number of Missing Observations: 0

DAYOFWK Diary day of the week by PATTERN Main daily pattern type

PATTERN Page 1 of 1

DAYOFWK	Count / Col Pct	work on tour 1.00	work at home 2.00	mainten. on tour 3.00	discret. on tour 4.00	mainten. at home 5.00	discret. at home 6.00	Row Total
	1.00	1669	91	564	255	198	139	2916
Monday		19.2	18.5	20.3	20.3	21.5	22.2	19.7
	2.00	1675	97	496	204	186	110	2768
Tuesday		19.3	19.7	17.9	16.2	20.2	17.5	18.7
	3.00	1710	111	493	221	158	116	2809
Wednesday		19.7	22.6	17.8	17.6	17.2	18.5	19.0
	4.00	1818	99	576	282	165	119	3059
Thursday		20.9	20.1	20.7	22.4	18.0	19.0	20.7
	5.00	1828	94	648	297	212	143	3222
Friday		21.0	19.1	23.3	23.6	23.1	22.8	21.8
	Column Total	8700	492	2777	1259	919	627	14774
		58.9	3.3	18.8	8.5	6.2	4.2	100.0

Number of Missing Observations: 0

DAYNO Diary day number by PATTERN Main daily pattern type

PATTERN — Page 1 of 1

DAYNO	Count / Col Pct	work on tour 1.00	work at home 2.00	mainten. on tour 3.00	discret. on tour 4.00	mainten. at home 5.00	discret. at home 6.00	Row Total
1.00	Count	4392	243	1462	624	433	290	7444
	Col Pct	50.5	49.4	52.6	49.6	47.1	46.3	50.4
2.00	Count	4308	249	1315	635	486	337	7330
	Col Pct	49.5	50.6	47.4	50.4	52.9	53.7	49.6
Column Total		8700	492	2777	1259	919	627	14774
		58.9	3.3	18.8	8.5	6.2	4.2	100.0

Number of Missing Observations: 0

WBASTYP Purpose type of work-based tour (if any) by PATTERN Main daily pattern type

PATTERN — Page 1 of 1

WBASTYP	Count / Col Pct	work on tour 1.00	work at home 2.00	mainten. on tour 3.00	discret. on tour 4.00	mainten. at home 5.00	discret. at home 6.00	Row Total
none	.00	7213	492	2777	1259	919	627	13287
		82.9	100.0	100.0	100.0	100.0	100.0	89.9
	1.00	213						213
work/school		2.4						1.4
	2.00	264						264
maintenance		3.0						1.8
	3.00	1010						1010
discretionary		11.6						6.8
Column Total		8700	492	2777	1259	919	627	14774
		58.9	3.3	18.8	8.5	6.2	4.2	100.0

Number of Missing Observations: 0

STOPBTYP Purpose type of stop before primary tour by PATTERN Main daily pattern type

PATTERN — Page 1 of 1

STOPBTYP	Count / Col Pct	work on tour 1.00	work at home 2.00	mainten. on tour 3.00	discret. on tour 4.00	mainten. at home 5.00	discret. at home 6.00	Row Total
none	.00	7436	492	1956	1036	919	627	12466
		85.5	100.0	70.4	82.3	100.0	100.0	84.4
work/school	1.00	296		14	1			311
		3.4		.5	.1			2.1
maintenance	2.00	687		522	107			1316
		7.9		18.8	8.5			8.9
discretionary	3.00	281		285	115			681
		3.2		10.3	9.1			4.6
	Column Total	8700	492	2777	1259	919	627	14774
		58.9	3.3	18.8	8.5	6.2	4.2	100.0

Number of Missing Observations: 0

STOPATYP Purpose type of stop after primary tour by PATTERN Main daily pattern type

PATTERN — Page 1 of 1

STOPATYP	Count / Col Pct	work on tour 1.00	work at home 2.00	mainten. on tour 3.00	discret. on tour 4.00	mainten. at home 5.00	discret. at home 6.00	Row Total
none	.00	6389	492	1907	1016	919	627	11350
		73.4	100.0	68.7	80.7	100.0	100.0	76.8
work/school	1.00	314		12	3			329
		3.6		.4	.2			2.2
maintenance	2.00	1245		583	108			1936
		14.3		21.0	8.6			13.1
discretionary	3.00	752		275	132			1159
		8.6		9.9	10.5			7.8
	Column Total	8700	492	2777	1259	919	627	14774
		58.9	3.3	18.8	8.5	6.2	4.2	100.0

Number of Missing Observations: 0

PABEGPER Primary activity/tour begin period by PATTERN Main daily pattern type

PATTERN Page 1 of 1

PABEGPER	Count / Col Pct	work on tour 1.00	work at home 2.00	mainten. on tour 3.00	discret. on tour 4.00	mainten. at home 5.00	discret. at home 6.00	Row Total
	1.00	1489	13	63	45	18	26	1654
Early	3-6:29am	17.1	2.6	2.3	3.6	2.0	4.1	11.2
	2.00	5623	161	418	304	227	96	6829
AM peak	6:30-9am	64.6	32.7	15.1	24.1	24.7	15.3	46.2
	3.00	1352	265	1989	648	608	326	5188
Midday	9am -4pm	15.5	53.9	71.6	51.5	66.2	52.0	35.1
	4.00	162	23	232	219	43	116	795
PM peak	4pm -7pm	1.9	4.7	8.4	17.4	4.7	18.5	5.4
	5.00	74	30	75	43	23	63	308
Night	7pm-2:59	.9	6.1	2.7	3.4	2.5	10.0	2.1
	Column	8700	492	2777	1259	919	627	14774
	Total	58.9	3.3	18.8	8.5	6.2	4.2	100.0

Number of Missing Observations: 0

PAENDPER Primary activity/tour end period by PATTERN Main daily pattern type

PATTERN Page 1 of 1

PAENDPER	Count / Col Pct	work on tour 1.00	work at home 2.00	mainten. on tour 3.00	discret. on tour 4.00	mainten. at home 5.00	discret. at home 6.00	Row Total
	1.00	135	3	14	8	2	15	177
Early	3-6:29am	1.6	.6	.5	.6	.2	2.4	1.2
	2.00	54	5	69	25	9	6	168
AM peak	6:30-9am	.6	1.0	2.5	2.0	1.0	1.0	1.1
	3.00	2926	223	1932	628	546	194	6449
Midday	9am -4pm	33.6	45.3	69.6	49.9	59.4	30.9	43.7
	4.00	4600	188	545	282	282	216	6113
PM peak	4pm -7pm	52.9	38.2	19.6	22.4	30.7	34.4	41.4
	5.00	985	73	217	316	80	196	1867
Night	7pm-2:59	11.3	14.8	7.8	25.1	8.7	31.3	12.6
	Column	8700	492	2777	1259	919	627	14774
	Total	58.9	3.3	18.8	8.5	6.2	4.2	100.0

Number of Missing Observations: 0

PAPERCOM Primary activity period combination by PATTERN Main daily pattern type

PATTERN Page 1 of 1

PAPERCOM	Count / Col Pct	work on tour 1.00	work at home 2.00	mainten. on tour 3.00	discret. on tour 4.00	mainten. at home 5.00	discret. at home 6.00	Row Total
Early -Early	1.00	84		14	6	1	2	107
		1.0		.5	.5	.1	.3	.7
Early -AM peak	2.00	44	4	18	11	3	3	83
		.5	.8	.6	.9	.3	.5	.6
Early -Midday	3.00	769	8	9	17	14	20	837
		8.8	1.6	.3	1.4	1.5	3.2	5.7
Early -PM peak	4.00	541	1	17	4		1	564
		6.2	.2	.6	.3		.2	3.8
Early -Night	5.00	51		5	7			63
		.6		.2	.6			.4
AM peak-AM peak	6.00	7	1	51	14	3		76
		.1	.2	1.8	1.1	.3		.5
AM peak-Midday	7.00	1799	116	333	210	198	73	2729
		20.7	23.6	12.0	16.7	21.5	11.6	18.5
AM peak-PM peak	8.00	3554	41	24	67	24	20	3730
		40.9	8.3	.9	5.3	2.6	3.2	25.2
AM peak-Night	9.00	263	3	10	13	2	3	294
		3.0	.6	.4	1.0	.2	.5	2.0
Midday -Midday	10.00	357	99	1584	401	334	99	2874
		4.1	20.1	57.0	31.9	36.3	15.8	19.5
Midday -PM peak	11.00	496	142	379	174	244	194	1629
		5.7	28.9	13.6	13.8	26.6	30.9	11.0
Midday -Night	12.00	499	24	26	73	30	33	685
		5.7	4.9	.9	5.8	3.3	5.3	4.6
PM peak-PM peak	13.00	23	4	120	36	14	4	201
		.3	.8	4.3	2.9	1.5	.6	1.4
PM peak-Night	14.00	139	19	112	183	29	112	594
		1.6	3.9	4.0	14.5	3.2	17.9	4.0
Night -Night	15.00	74	30	75	43	23	63	308
		.9	6.1	2.7	3.4	2.5	10.0	2.1
	Column Total	8700	492	2777	1259	919	627	14774
		58.9	3.3	18.8	8.5	6.2	4.2	100.0

Number of Missing Observations: 0

HHSIZE Total household size by PATTERN Main daily pattern type

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HHSIZE	Count / Col Pct	work on tour 1.00	work at home 2.00	mainten. on tour 3.00	discret. on tour 4.00	mainten. at home 5.00	discret. at home 6.00	Row Total
	1.00	1285	70	510	227	128	128	2348
		14.8	14.2	18.4	18.0	13.9	20.4	15.9
	2.00	3220	200	1224	628	449	266	5987
		37.0	40.7	44.1	49.9	48.9	42.4	40.5
	3.00	1761	82	407	173	123	119	2665
		20.2	16.7	14.7	13.7	13.4	19.0	18.0
	4.00	1583	98	389	149	114	77	2410
		18.2	19.9	14.0	11.8	12.4	12.3	16.3
	5.00	563	31	168	54	68	22	906
		6.5	6.3	6.0	4.3	7.4	3.5	6.1
	6.00	202	7	61	18	26	13	327
		2.3	1.4	2.2	1.4	2.8	2.1	2.2
	7.00	79	2	16	10	10	2	119
		.9	.4	.6	.8	1.1	.3	.8
	8.00	6	2	2				10
		.1	.4	.1				.1
	9.00	1				1		2
		.0				.1		.0
	Column Total	8700	492	2777	1259	919	627	14774
		58.9	3.3	18.8	8.5	6.2	4.2	100.0

Number of Missing Observations: 0

HHCHU5 HH children under age 5 by PATTERN Main daily pattern type

PATTERN Page 1 of 1

HHCHU5	Count / Col Pct	work on tour 1.00	work at home 2.00	mainten. on tour 3.00	discret. on tour 4.00	mainten. at home 5.00	discret. at home 6.00	Row Total
	.00	7634	421	2434	1136	806	573	13004
		87.7	85.6	87.6	90.2	87.7	91.4	88.0
	1.00	835	48	251	86	85	43	1348
		9.6	9.8	9.0	6.8	9.2	6.9	9.1
	2.00	210	21	80	35	19	10	375
		2.4	4.3	2.9	2.8	2.1	1.6	2.5
	3.00	20	2	12	2	8	1	45
		.2	.4	.4	.2	.9	.2	.3
	4.00	1				1		2
		.0				.1		.0
	Column Total	8700	492	2777	1259	919	627	14774
		58.9	3.3	18.8	8.5	6.2	4.2	100.0

Number of Missing Observations: 0

HHC511 HH children age 5-11 by PATTERN Main daily pattern type

PATTERN Page 1 of 1

HHC511	Count / Col Pct	work on tour 1.00	work at home 2.00	mainten. on tour 3.00	discret. on tour 4.00	mainten. at home 5.00	discret. at home 6.00	Row Total
	.00	7074	399	2341	1111	766	559	12250
		81.3	81.1	84.3	88.2	83.4	89.2	82.9
	1.00	1043	52	266	87	79	49	1576
		12.0	10.6	9.6	6.9	8.6	7.8	10.7
	2.00	497	32	132	49	51	16	777
		5.7	6.5	4.8	3.9	5.5	2.6	5.3
	3.00	76	7	33	10	18	3	147
		.9	1.4	1.2	.8	2.0	.5	1.0
	4.00	10	2	5	2	5		24
		.1	.4	.2	.2	.5		.2
	Column Total	8700	492	2777	1259	919	627	14774
		58.9	3.3	18.8	8.5	6.2	4.2	100.0

Number of Missing Observations: 0

HH1217 HH children age 12-17 by PATTERN Main daily pattern type

PATTERN — Page 1 of 1

HH1217 (Count / Col Pct)	work on tour 1.00	work at home 2.00	mainten. on tour 3.00	discret. on tour 4.00	mainten. at home 5.00	discret. at home 6.00	Row Total
.00	6849	403	2379	1109	800	563	12103
	78.7	81.9	85.7	88.1	87.1	89.8	81.9
1.00	1308	67	278	96	92	44	1885
	15.0	13.6	10.0	7.6	10.0	7.0	12.8
2.00	450	18	109	48	22	18	665
	5.2	3.7	3.9	3.8	2.4	2.9	4.5
3.00	73	4	8	5	3	2	95
	.8	.8	.3	.4	.3	.3	.6
4.00	10		3	1	2		16
	.1		.1	.1	.2		.1
5.00	10						10
	.1						.1
Column Total	8700	492	2777	1259	919	627	14774
	58.9	3.3	18.8	8.5	6.2	4.2	100.0

Number of Missing Observations: 0

HHADLT HH adults 18+ by PATTERN Main daily pattern type

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HHADLT (Count / Col Pct)	work on tour 1.00	work at home 2.00	mainten. on tour 3.00	discret. on tour 4.00	mainten. at home 5.00	discret. at home 6.00	Row Total
1.00	1582	80	569	251	149	140	2771
	18.2	16.3	20.5	19.9	16.2	22.3	18.8
2.00	5549	352	1851	862	629	355	9598
	63.8	71.5	66.7	68.5	68.4	56.6	65.0
3.00	1218	50	275	124	105	98	1870
	14.0	10.2	9.9	9.8	11.4	15.6	12.7
4.00	287	5	68	14	35	30	439
	3.3	1.0	2.4	1.1	3.8	4.8	3.0
5.00	44	5	11	1	1	3	65
	.5	1.0	.4	.1	.1	.5	.4
6.00	6		3	7		1	17
	.1		.1	.6		.2	.1
7.00	14						14
	.2						.1
Column Total	8700	492	2777	1259	919	627	14774
	58.9	3.3	18.8	8.5	6.2	4.2	100.0

Number of Missing Observations: 0

HHFULL HH employed full time by PATTERN Main daily pattern type

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HHFULL (Count / Col Pct)	work on tour 1.00	work at home 2.00	mainten. on tour 3.00	discret. on tour 4.00	mainten. at home 5.00	discret. at home 6.00	Row Total
.00	434 5.0	123 25.0	1251 45.0	616 48.9	441 48.0	314 50.1	3179 21.5
1.00	3216 37.0	215 43.7	908 32.7	377 29.9	298 32.4	175 27.9	5189 35.1
2.00	4055 46.6	130 26.4	513 18.5	219 17.4	144 15.7	98 15.6	5159 34.9
3.00	842 9.7	23 4.7	91 3.3	44 3.5	31 3.4	29 4.6	1060 7.2
4.00	127 1.5	1 .2	11 .4	3 .2	5 .5	11 1.8	158 1.1
5.00	12 .1		3 .1				15 .1
6.00	14 .2						14 .1
Column Total	8700 58.9	492 3.3	2777 18.8	1259 8.5	919 6.2	627 4.2	14774 100.0

Number of Missing Observations: 0

HHPART HH employed part time by PATTERN Main daily pattern type

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HHPART (Count / Col Pct)	work on tour 1.00	work at home 2.00	mainten. on tour 3.00	discret. on tour 4.00	mainten. at home 5.00	discret. at home 6.00	Row Total
.00	7673 88.2	262 53.3	2492 89.7	1145 90.9	851 92.6	577 92.0	13000 88.0
1.00	920 10.6	189 38.4	251 9.0	107 8.5	59 6.4	47 7.5	1573 10.6
2.00	95 1.1	40 8.1	31 1.1	7 .6	9 1.0	3 .5	185 1.3
3.00	12 .1	1 .2	3 .1				16 .1
Column Total	8700 58.9	492 3.3	2777 18.8	1259 8.5	919 6.2	627 4.2	14774 100.0

Number of Missing Observations: 0

HHDLIC HH drivers licenses by PATTERN Main daily pattern type

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HHDLIC	Count / Col Pct	work on tour 1.00	work at home 2.00	mainten. on tour 3.00	discret. on tour 4.00	mainten. at home 5.00	discret. at home 6.00	Row Total
.00	Count	129	10	97	42	35	58	371
	Col Pct	1.5	2.0	3.5	3.3	3.8	9.3	2.5
1.00	Count	1752	90	664	299	205	180	3190
	Col Pct	20.1	18.3	23.9	23.7	22.3	28.7	21.6
2.00	Count	5114	324	1674	772	565	293	8742
	Col Pct	58.8	65.9	60.3	61.3	61.5	46.7	59.2
3.00	Count	1268	55	262	111	91	73	1860
	Col Pct	14.6	11.2	9.4	8.8	9.9	11.6	12.6
4.00	Count	378	8	75	34	19	23	537
	Col Pct	4.3	1.6	2.7	2.7	2.1	3.7	3.6
5.00	Count	45	5	5	1	4		60
	Col Pct	.5	1.0	.2	.1	.4		.4
7.00	Count	14						14
	Col Pct	.2						.1
Column Total		8700	492	2777	1259	919	627	14774
		58.9	3.3	18.8	8.5	6.2	4.2	100.0

Number of Missing Observations: 0

NMVEH HH vehicles owned by PATTERN Main daily pattern type

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NMVEH	Count / Col Pct	PATTERN work on tour 1.00	work at home 2.00	mainten. on tour 3.00	discret. on tour 4.00	mainten. at home 5.00	discret. at home 6.00	Row Total
	.00	252	20	152	57	61	73	615
		2.9	4.1	5.5	4.5	6.6	11.6	4.2
	1.00	1933	112	758	343	266	209	3621
		22.2	22.8	27.3	27.2	28.9	33.3	24.5
	2.00	4218	234	1295	577	432	238	6994
		48.5	47.6	46.6	45.8	47.0	38.0	47.3
	3.00	1586	87	424	208	118	80	2503
		18.2	17.7	15.3	16.5	12.8	12.8	16.9
	4.00	539	26	107	65	29	18	784
		6.2	5.3	3.9	5.2	3.2	2.9	5.3
	5.00	114	11	33	6	10	8	182
		1.3	2.2	1.2	.5	1.1	1.3	1.2
	6.00	35		5	2			42
		.4		.2	.2			.3
	7.00	15	2	1				18
		.2	.4	.0				.1
	8.00	8		2	1	3	1	15
		.1		.1	.1	.3	.2	.1
	Column Total	8700	492	2777	1259	919	627	14774
		58.9	3.3	18.8	8.5	6.2	4.2	100.0

Number of Missing Observations: 0

INCOME HH annual income by PATTERN Main daily pattern type

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INCOME	Count / Col Pct	PATTERN work on tour 1.00	work at home 2.00	mainten. on tour 3.00	discret. on tour 4.00	mainten. at home 5.00	discret. at home 6.00	Row Total
$0 - $4,999	1.00	33	4	22	10	6	11	86
		.4	.8	.8	.8	.7	1.8	.6
$5,000 - $9,999	2.00	107	5	105	36	29	31	313
		1.2	1.0	3.8	2.9	3.2	4.9	2.1
$10,000 - $14,99	3.00	240	7	119	64	47	55	532
		2.8	1.4	4.3	5.1	5.1	8.8	3.6
$15,000 - $19,99	4.00	311	16	172	48	78	52	677
		3.6	3.3	6.2	3.8	8.5	8.3	4.6
$20,000 - $24,99	5.00	427	29	174	97	65	46	838
		4.9	5.9	6.3	7.7	7.1	7.3	5.7
$25,000 - $29,99	6.00	445	17	171	97	78	43	851
		5.1	3.5	6.2	7.7	8.5	6.9	5.8
$30,000 - $34,99	7.00	605	46	204	98	68	46	1067
		7.0	9.3	7.3	7.8	7.4	7.3	7.2
$35,000 - $39,99	8.00	564	41	168	87	61	30	951
		6.5	8.3	6.0	6.9	6.6	4.8	6.4
$40,000 - $44,99	9.00	732	39	157	86	57	34	1105
		8.4	7.9	5.7	6.8	6.2	5.4	7.5
$45,000 - $49,99	10.00	522	31	137	57	50	32	829
		6.0	6.3	4.9	4.5	5.4	5.1	5.6
$50,000 - $54,99	11.00	744	39	163	55	42	32	1075
		8.6	7.9	5.9	4.4	4.6	5.1	7.3
$55,000 - $59,99	12.00	271	14	61	31	8	9	394
		3.1	2.8	2.2	2.5	.9	1.4	2.7
$60,000 or more	13.00	2061	105	441	176	105	59	2947
		23.7	21.3	15.9	14.0	11.4	9.4	19.9
Missing	14.00	1638	99	683	317	225	147	3109
		18.8	20.1	24.6	25.2	24.5	23.4	21.0
	Column Total	8700	492	2777	1259	919	627	14774
		58.9	3.3	18.8	8.5	6.2	4.2	100.0

Number of Missing Observations: 0

GENDER Gender by PATTERN Main daily pattern type

PATTERN Page 1 of 1

GENDER	Count / Col Pct	work on tour 1.00	work at home 2.00	mainten. on tour 3.00	discret. on tour 4.00	mainten. at home 5.00	discret. at home 6.00	Row Total
	1.00	4731	275	957	546	285	288	7082
Male		54.4	55.9	34.5	43.4	31.0	45.9	47.9
	2.00	3969	217	1820	713	634	339	7692
Female		45.6	44.1	65.5	56.6	69.0	54.1	52.1
	Column	8700	492	2777	1259	919	627	14774
	Total	58.9	3.3	18.8	8.5	6.2	4.2	100.0

Number of Missing Observations: 0

AGE Age by PATTERN Main daily pattern type

PATTERN Page 1 of 1

AGE	Count / Col Pct	work on tour 1.00	work at home 2.00	mainten. on tour 3.00	discret. on tour 4.00	mainten. at home 5.00	discret. at home 6.00	Row Total
	1.00	583	14	60	40	10	35	742
age 16-19		6.7	2.8	2.2	3.2	1.1	5.6	5.0
	2.00	565	26	75	41	20	27	754
age 20-24		6.5	5.3	2.7	3.3	2.2	4.3	5.1
	3.00	1916	94	357	168	128	76	2739
age 25-34		22.0	19.1	12.9	13.3	13.9	12.1	18.5
	4.00	2551	143	542	181	123	67	3607
age 35-44		29.3	29.1	19.5	14.4	13.4	10.7	24.4
	5.00	1978	119	412	176	108	71	2864
age 45-54		22.7	24.2	14.8	14.0	11.8	11.3	19.4
	6.00	774	58	413	206	142	73	1666
age 55-64		8.9	11.8	14.9	16.4	15.5	11.6	11.3
	7.00	144	27	578	279	209	95	1332
age 65-74		1.7	5.5	20.8	22.2	22.7	15.2	9.0
	8.00	31	6	269	127	158	162	753
age 75+		.4	1.2	9.7	10.1	17.2	25.8	5.1
	9.00	158	5	71	41	21	21	317
missing		1.8	1.0	2.6	3.3	2.3	3.3	2.1
	Column	8700	492	2777	1259	919	627	14774
	Total	58.9	3.3	18.8	8.5	6.2	4.2	100.0

Number of Missing Observations: 0

DRLIC Drivers license status by PATTERN Main daily pattern type

PATTERN — Page 1 of 1

DRLIC	Count / Col Pct	work on tour 1.00	work at home 2.00	mainten. on tour 3.00	discret. on tour 4.00	mainten. at home 5.00	discret. at home 6.00	Row Total
Yes	1.00	8234	461	2543	1143	811	454	13646
		94.6	93.7	91.6	90.8	88.2	72.4	92.4
No	2.00	438	30	219	110	104	169	1070
		5.0	6.1	7.9	8.7	11.3	27.0	7.2
Missing	3.00	28	1	15	6	4	4	58
		.3	.2	.5	.5	.4	.6	.4
	Column Total	8700	492	2777	1259	919	627	14774
		58.9	3.3	18.8	8.5	6.2	4.2	100.0

Number of Missing Observations: 0

EMPLOY Employment status by PATTERN Main daily pattern type

PATTERN — Page 1 of 1

EMPLOY	Count / Col Pct	work on tour 1.00	work at home 2.00	mainten. on tour 3.00	discret. on tour 4.00	mainten. at home 5.00	discret. at home 6.00	Row Total
Employed full-ti	1.00	6463	166	484	227	120	125	7585
		74.3	33.7	17.4	18.0	13.1	19.9	51.3
Employed part-ti	2.00	1065	53	226	82	58	31	1515
		12.2	10.8	8.1	6.5	6.3	4.9	10.3
Self-employed fu	3.00	413	162	104	34	17	23	753
		4.7	32.9	3.7	2.7	1.8	3.7	5.1
Self-employed pa	4.00	88	41	59	24	8	3	223
		1.0	8.3	2.1	1.9	.9	.5	1.5
Unemployed but l	5.00	95	10	168	60	55	35	423
		1.1	2.0	6.0	4.8	6.0	5.6	2.9
Retired	6.00	62	17	1070	549	444	300	2442
		.7	3.5	38.5	43.6	48.3	47.8	16.5
Full-time homema	7.00	38	13	472	182	169	39	913
		.4	2.6	17.0	14.5	18.4	6.2	6.2
Not employed	8.00	249	19	115	55	35	44	517
		2.9	3.9	4.1	4.4	3.8	7.0	3.5
Missing	9.00	227	11	79	46	13	27	403
		2.6	2.2	2.8	3.7	1.4	4.3	2.7
	Column Total	8700	492	2777	1259	919	627	14774
		58.9	3.3	18.8	8.5	6.2	4.2	100.0

Number of Missing Observations: 0

Appendix C: Description of the Portland TROS Model Application System

Memo by Mark Bradley

1. Model Structure

The basic behavioral unit for the sample enumeration is a person-day. In both estimation and application we have limited the sample to persons aged 16 and over, and limited the days to weekdays (Monday to Friday). We know the basic socio-demographic characteristics of each person and his/her household, as well as the zone (TAZ) in which the person lives. We also know the number of vehicles owned by the household and, for this project, we assume car ownership to be exogenous.

1.1. The tour pattern model
The top level model is based on the work of Bowman and Ben-Akiva, and on memos written by John Bowman for a related Portland project. It simultaneously predicts:

(a) the primary activity of the person day:	(1) work or school away from home
	(2) work or school at home
	(3) maintenance away from home
	(4) discretionary away from home
	(5) maintenance at home
	(6) discretionary at home
(b) the primary tour type, if applicable:	(0) no tour (activity at home)
	(1) simple tour (no intermediate stops)
	(2) stop on way to primary destination
	(3) stop on way from primary destination
	(4) stop in both directions
	(5) simple tour & work-based subtour
	(6) stop before work & work-based subtour
	(7) stop after work & work-based subtour
	(8) stop both directions & work-bas. subtour
(c) number and type of secondary tours:	(1) no secondary tours
	(2) 1 additional maintenance tour
	(3) 1 additional discretionary tour
	(4) 2+ additional maintenance tours
	(5) 2+ additional discretionary tours
	(6) 1+ maintenance and 1+ discretionary additional tours

Since not all of the tour types apply to all of the primary activity types, there are 8+1+4+4+1+1 = 19 possible combinations of (a) and (b) above. Each of the possible secondary tour patterns are possible for all primary tour types, so the model has a total of 19 x 6 = 114 alternatives.

Table 1: Full Day Activity Pattern Choice Model

Activity Pattern Model Estimation Results		
Observations	14774	
Final log(L)	-47622.3	
Rho-squared (0)	0.319	
Rho-squared (c)	0.089	
Alternative / variable	**Coefficient**	**T-stat**
Mode / destination model logsums		
Work/school primary tour	0.1815	6.5
Maintenance primary tour	0.04437	1.9
Discretionary primary tour	0.1039	3.3
Maintenance secondary tours	0.1472	8.8
Discretionary secondary tours	0.04685	4.3
WT-Work on tour variables		
Constant	-1.958	-6.5
Full time worker	3.125	39.6
Part time worker	2.674	27.9
Age under 20	2.109	15.2
Age 20-24	0.8328	7.5
Age 25-34	0.2458	4.0
Age 55-64	-0.398	-5.5
Age over 65	-1.676	-16.0
Female, 2+ adults in hh	-0.2473	-4.3
Kids under 5 in hh	-0.4059	-5.7
WH-Work at home variables		
Constant	-2.799	-16.1
Full time worker	2.302	14.8
Part time worker	2.282	12.6
Age over 65	-0.73	-3.6
Male, only adult in hh, worker	0.7659	4.5
Male, 2+ adults in hh	0.2364	2.2
MT-Maintenance on tour variables		
Constant	-0.1193	-0.5
Part time worker	0.229	2.3
Age under 20	-0.7626	-4.4
Male, 2+ adults in hh	-0.371	-6.1
Female, kids under 12 in hh	0.3196	4.1
No cars in hh	-0.00818	-0.1
Fewer cars then adults in hh	-0.1113	-1.4
MH-Maintenance at home variables		
Constant	0.2151	2.6
Full time worker	-0.5532	-5.1
Age under 20	-1.379	-4.1
Female, kids under 12 in hh	0.3932	3.6
Female, 2+ adults in hh	0.4894	6.0

(Table 1 continued)

DT-Discretionary on tour variables	**Coefficient**	**T-stat**
Constant	-0.6862	-2.2
Full time worker	-0.3153	-3.5
No cars in hh	-0.5246	-3.1
Fewer cars then adults in hh	-0.4174	-4.2
DH-Discretionary at home variables		
Income under $30,000	0.3247	3.6
Income over $60,000	-0.2256	-1.5
WT-Work on tour type constants		
Constant-stop on way to	-1.194	-23.0
Constant-stop on way back	-2.001	-37.6
Constant-stop both ways	-2.502	-30.7
Constant- no stops plus subtour	-1.99	-23.3
Constant, stop on way to & subtour	-3.03	-29.3
Constant, stop on way back & subtour	-3.904	-32.8
Constant,	-4.452	-31.8
WI- Work intermediate stop variables		
Income over $60,000	0.2646	7.0
Age under 20	-0.3113	-3.9
Age over 45	-0.08683	-2.3
Female, kids under 12 in hh	0.6242	12.3
Male, 2+ adults in hh, 1+ non-wker	-0.2247	-4.2
Female, single, worker	0.2457	4.3
No cars in hh	-0.2681	-2.4
Fewer cars then adults in hh	-0.2233	-4.4
WS-Work-based subtour variables		
Income over $60,000	0.2721	4.3
Full time worker	0.5434	6.7
Female, kids under 12 in hh	-0.3532	-3.5
Male, single, worker	0.2833	2.9
No cars in hh	-0.2913	-1.6
Fewer cars then adults in hh	-0.1551	-1.9
MT-Maintenance tour type constants		
Constant-stop on way to	-0.5774	-8.2
Constant-stop on way back	-0.5494	-8.5
Constant-stop both ways	-1.047	-10.8
MI-Maintenance intermediate stop variables		
Full time worker	-0.2123	-3.2
Age over 65	-0.2521	-4.4
No cars in hh	-0.6641	-4.6
Fewer cars then adults in hh	-0.2376	-3.2
DT-Discretionary tour type constants		
Constant-stop on way to	-1.408	-14.1
Constant-stop on way back	-1.456	-14.4
Constant-stop both ways	-1.823	-14.0

(Table 1 continued)

DI-Discretionary intermediate stop variables		
Age over 65	-0.3606	-3.7
Male, 2+ adults in hh, 1+ non-wker	-0.3894	-3.6
No cars in hh	-0.7553	-2.5
Fewer cars then adults in hh	-0.1963	-1.5
All purposes - additional variables		
Stop on way to- No kids in hh	0.1941	4.3
Stop both ways- Kids under age 5 in hh	0.5752	6.7
SM-secondary maintenance tour variables		
Full time worker	-0.168	-2.5
Part time worker	0.2507	3.1
Female, no kids in hh	-0.1809	-3.2
Age over 65	-0.3541	-4.8
Female, kids in hh	0.4878	7.3
Female, 2+ adults in hh, all workers	-0.02182	-0.3
No cars in hh	-0.604	-4.6
Fewer cars then adults in hh	0.07806	1.4
SD-secondary discretionary tour variables		
Age under 35	0.1246	2.4
Full time worker	-0.2837	-5.1
Age under 20	0.1819	1.8
Age over 65	-0.2838	-4.0
No cars in hh	-0.4526	-3.7
Fewer cars then adults in hh	-0.232	-3.9
SM-1 secondary maintenance tour constants		
Primary = work/school on tour	-2.738	-16.0
Primary = work/school at home	-1.153	-5.6
Primary = maintenance on tour	-2.201	-12.9
Primary = maintenance at home	-3.014	-16.0
Primary = discretionary on tour	-3.193	-16.8
Primary = discretionary at home	-3.464	-16.2
Primary tour has 1 intermediate stop	-0.2244	-3.9
Primary tour has 2 intermediate stops	-0.1938	-2.0
Primary tour has a work-based subtour	-0.1447	-1.7
SD-1 secondary discretionary tour constants		
Primary = work/school on tour	-1.632	-13.6
Primary = work/school at home	-0.7052	-3.8
Primary = maintenance on tour	-1.038	-8.6
Primary = maintenance at home	-4.01	-14.7
Primary = discretionary on tour	-1.47	-11.2
Primary = discretionary at home	-4.697	-11.1
Primary tour has 1 intermediate stop	-0.2343	-4.2
Primary tour has 2 intermediate stops	-0.4573	-4.5
Primary tour has a work-based subtour	-0.07079	-0.9

(Table 1 continued)

SMM-2+ secondary maintenance tours constants		
Primary = work/school on tour	-6.226	-18.6
Primary = work/school at home	-3.218	-9.2
Primary = maintenance on tour	-4.522	-13.8
Primary = maintenance at home	-5.08	-14.9
Primary = discretionary on tour	-6.073	-16.1
Primary = discretionary at home	-6.163	-15.0
Primary tour has 1 intermediate stop	-0.154	-1.3
Primary tour has 2 intermediate stops	-0.3307	-1.6
Primary tour has a work-based subtour	-0.6844	-2.5
SDD-2+ secondary discretionary tours constants		
Primary = work/school on tour	-5.416	-19.7
Primary = work/school at home	-2.697	-7.9
Primary = maintenance on tour	-3.107	-12.8
Primary = maintenance at home	-5	*
Primary = discretionary on tour	-3.597	-13.6
Primary = discretionary at home	-5	*
Primary tour has 1 intermediate stop	-0.2219	-1.3
Primary tour has 2 intermediate stops	-0.7337	-2.3
Primary tour has a work-based subtour	-0.1867	-0.5
SMD-1+ maint. & 1+ discret. tours constants		
Primary = work/school on tour	-5.048	-22.4
Primary = work/school at home	-1.829	-7.5
Primary = maintenance on tour	-2.943	-13.9
Primary = maintenance at home	-6.704	-12.5
Primary = discretionary on tour	-4.468	-17.5
Primary = discretionary at home	-6.329	-11.8
Primary tour has 1 intermediate stop	-0.3399	-3.1
Primary tour has 2 intermediate stops	-0.3125	-1.9
Primary tour has a work-based subtour	-0.5777	-2.2

The model is based on person and household characteristics, as well as logsums from the lower level time-of-day and mode/destination choice models. The model was estimated using nested and non-nested structures, with nesting adding no significant improvement to the model. The final estimation results are given in Table 1.

The mode/destination model logsums (weighted by the time-of-day model probabilities) are all significant in the range 0.04 to 0.20. The largest and most significant logsums are for primary work/school tours and secondary maintenance tours. Other than the variables such as employment status, age, gender and household type, which one would expect to have large effects, variables such as income and car availability also have large effects, particularly for discretionary travel. Those with lower incomes and fewer cars tend to have the primary activity within the home more often.

In application of the model, the alternatives are collapsed to predict the number of tours by 3 purposes and 12 types. For work/school, there are only 8 possible tour types, as listed above. For maintenance and discretionary, there are 12 types, as listed below:

(1) primary tour, no stops
(2) primary tour, stop on way to primary destination
(3) primary tour, stop and way back from primary destination
(4) primary tour, stops in both directions
(5) secondary tour, no stops, no work tour in pattern
(6) secondary tour, stop on way to primary destination, no work tour in pattern
(7) secondary tour, stop and way back from primary destination, no work tour in pattern
(8) secondary tour, stops in both directions, no work tour in pattern
(9) secondary tour, no stops, work tour in pattern
(10) secondary tour, stop on way to primary destination, work tour in pattern
(11) secondary tour, stop and way back from primary destination, work tour in pattern
(12) secondary tour, stops in both directions, work tour in pattern

For secondary tours, we distinguish whether or not the primary activity is a work tour because this is an important variable in the time-of-day models.

As there is no explicit tour type model for secondary tours, we use fixed values for the tour type probabilities based on the survey sample distribution, as follows:

Tour-type distributions applied for secondary tours

	Maintenance Work tour %	Maintenance No work tour %	Discretionary Work tour %	Discretionary No work tour %
No stops	70.4	74.2	84.0	86.4
Stop before	12.9	11.7	7.0	6.7
Stop after	11.9	11.0	6.3	4.1
Stop both ways	4.8	3.1	2.8	2.8

Also, some of the secondary tour alternatives do not exactly describe the number of secondary tours, so again we use average values from the survey sample:

Average number of secondary tours applied for modeled alternatives

	Maintenance Work tour	Maintenance No work tour	Discretionary Work tour	Discretionary No work tour
no secondary tours	0	0	0	0
1 maintenance tour	1.0	1.0	0	0
1 discretionary tour	0	0	1.0	1.0
2+ maintenance tours	2.115	2.325	0	0
2+ discretionary tours	0	0	2.000	2.066
1+ both purposes	1.215	1.316	1.060	1.146

1.2. The time of day models

There are three time of day models, corresponding to the work/school, maintenance and discretionary tour purposes. We distinguish 5 different times of day..........

EA = early, 3AM to 7AM
AM = am peak, 7AM to 9:30 AM
MD = midday, 9:30 AM to 4PM
PM = pm peak, 4PM to 7PM
LA = late, 7PM to 3AM

The dependent variable in the model is the combination of the time leaving home to begin the tour and the time leaving the primary destination to begin the return leg of the tour. (Note, no allowance is made for tour legs which straddle different time periods. For example, someone leaving home at 5:55 PM is treated as being in the PM peak, even though most of the trip may be made during the "late" period.

Since we make the simplifying assumption that no tours last over night, there are 15 possible time of day combinations:

(1) EA-EA	(2) EA-AM	(3) EA-MD	(4) EA-PM	(5) EA-LA
	(6) AM-AM	(7) AM-MD	(8) AM-PM	(9) AM-LA
		(10) MD-MD	(11) MD-PM	(12) MD-LA
			(13) PM-PM	(14) PM-LA
				(15) LA-LA

In estimation, we further grouped some of the periods for which there are very few observations, depending on tour purpose. For all purposes, for example, the tours that are started completed by 9:30 AM (EA-EA, EA-AM and AM-AM) are grouped. All 15 combinations have a separate alternative-specific constant, however.

In the models, shown in Tables 2 and 3 below, various person and household variables were used, as well as logsums from the lower level mode/destination choice models. Tour purpose, tour importance, and tour trip chain type were also used as variables, as well as whether or not a work tour was made during the day. Other variables related mainly to age, household type and employment status.

Note that it was only possible to get a significant mode/destination logsum coefficient for the work/school model, where the coefficient is 0.175. This coefficient could be estimated only on the peak period logsums, but in the final model this parameter was constrained to apply to all time periods. For the non-work tour purposes, no significant logsum coefficients could be estimated, although there was an indication of a result in the range 0.05 to 0.20. Lacking stronger evidence, we have constrained the maintenance and discretionary models to have the same logsum coefficient as the work/school model.

Table 2: Home-Based Work/School Tour Times of Day Choice Model

	Work/School	
Observations	7443	
Final log(L)	-12735.9	
Rho-squared (0)	0.368	
Rho-squared (c)	0.075	
Alternative / variable	**Coef.**	**T-Stat.**
Logsum variables		
Mode / destination choice logsum	0.175	3.3
1- Early combinations		
Constant- Early-Early	-3.074	-17.0
Constant- Early-AM peak	-3.17	-16.7
Constant- AM peak-AM peak	-5.076	-11.2
2- Early - Midday		
Constant	-1.496	-8.1
No intermediate stops	-0.2794	-3.1
Full time worker	1.407	9.2
Age under 35	-0.3322	-3.4
Male, no children in hhld	0.6681	6.5
Children over age 12 in hhld	0.7253	5.5
Children under age 5 in hhld	0.5195	3.8
3- Early - PM peak, Late		
Constant- Early - PM peak	-3.026	-11.5
Constant- Early - Late	-5.456	-18.1
Intermediate stop on way back home	0.6805	4.9
Full time worker	2.275	9.0
Male	0.612	5.6
4- AM peak - Midday		
Constant	0.05433	0.6
Intermediate stop on way from home	0.8926	13.3
Age under 20	1.334	11.8
Male, children over 12 in hhld	0.4845	4.2
Female, children in household	0.4864	6.2
5- AM peak - PM peak		
Intermediate stop on way back home	0.6956	8.4
Full time worker	1.357	17.0
Household income over 60K	0.2442	4.2
Female	0.1455	2.5
6- AM peak - Late		
Constant	-2.057	-9.2
No intermediate stops	0.4983	2.2
Intermediate stop on way back home	1.746	7.0
Male, single worker	0.6793	3.1

(Table 2 continued)

7- Midday - Midday	**Coef.**	**T-Stat.**
Constant	-1.04	-7.4
No intermediate stops	-0.8178	-6.6
Part time worker	1.104	8.3
1+ non-working adult in hhld	0.694	5.5
8- Midday - PM peak		
Constant	-1.55	-10.9
Intermediate stop on way back home	1.045	7.6
Part time worker	0.6398	5.2
Male, no children in hhld	0.8838	6.7
Female, no children in hhld	0.4365	3.2
Household income under 30K	0.4485	3.8
9 - Midday - Late		
Constant	-1.823	-9.5
No intermediate stops	0.7554	4.4
Intermediate stop on way back home	1.522	7.5
Age under 25	1.244	10.5
Male, no children in hhld	0.4102	3.7
Household income under 30K	0.4679	4.0
Household income over 60K	-0.593	-3.7
10 - Late combinations		
Constant - PM peak - PM peak	-4.686	-16.1
Constant - PM peak - Late	-2.886	-13.7
Constant - Late - Late	-3.674	-15.9
No intermediate stops	0.6219	3.4
Part time worker	0.628	3.8
Age under 25	0.7022	3.9
Male, no children in hhld	0.5364	3.4
Female, children under 5 in hhld	1.202	5.0

Table 3: Home-Based Non-Work Tour Times of Day Choice Models

	Maintenance		Discretionary	
Observations	5876		3513	
Final log(L)	-9228.7		-5787.4	
Rho-squared (0)	0.42		0.392	
Rho-squared (c)	0.126		0.117	
Alternative / variable	**Coef.**	**T-Stat.**	**Coef.**	**T-Stat.**
Logsum variables				
Mode / destination choice logsum	0.175	constr.	0.175	constr.
1- Early combinations				
Constant- Early-Early	-6.026	-19.7	-4.7	-11.9
Constant- Early-AM peak	-6.373	-19.8	-3.321	-13.3
Constant- AM peak-AM peak	-3.851	-14.3	-2.971	-12.6
Secondary tour	1.459	10.1		
No intermediate stops	1.31	5.2		
Intermediate stop on way from home	1.183	4.1		
Work tour made during the day	-2.115	-10.3	-1.115	-2.8
Full time worker	0.5257	4.4	0.5396	1.8
Age over 65			0.7721	2.9
2- Early or AM peak - Midday				
Constant- Early-Midday	-5.319	-14.4	-3.046	-9.5
Constant- AM peak-Midday	-1.268	-11.0	0.004247	0.0
Secondary tour	-0.8329	-6.6		
No intermediate stops	-0.4637	-3.7	-1.079	-6.1
Intermediate stops, both directions	1.314	8.3	0.8681	3.3
Household income under 15K	0.5662	3.4		
Age over 65	0.7228	5.4	0.2733	1.8
Work tour made during the day			-2.354	-6.3
3- Early or AM - PM or Late				
Constant - Early-PM peak	-4.527	-14.0	-4.078	-6.5
Constant- Early-Late	-5.49	-10.9	-3.294	-7.4
Constant- AM peak-PM peak	-3.544	-16.5	-1.29	-4.6
Constant- AM peak-Late	-4.811	-12.5	-2.627	-7.0
Secondary tour	-3.11	-5.2	-3.031	-5.8
No intermediate stops			-0.867	-2.8
Intermediate stops, both directions			1.129	2.6
4- Midday - Midday				
Secondary tour			0.3142	2.6
Intermediate stop on way from home	0.7611	8.7	0.7641	5.2
Age over 65	0.5536	6.2	0.3545	3.3
No children in household	0.358	5.4		
Work tour made during the day	-1.38	-11.1	-1.681	-9.2

(Table 3 continued)

	Maintenance		Discretionary	
5- Midday - PM peak	**Coef.**	**T-Stat.**	**Coef.**	**T-Stat.**
Constant	-0.5367	-5.2	-0.483	-2.6
No intermediate stops	-0.4483	-4.3	-0.6384	-3.5
Secondary tour	-0.4893	-4.6		
Children under age 12 in hhld	-0.4783	-4.6		
Intermediate stops, both directions	0.7021	4.5	0.8306	2.8
Age under 20			0.8789	3.9
6- Midday - Late				
Constant	-3.174	-15.6	-0.8297	-3.7
No intermediate stops	-1.332	-4.1	-1.393	-5.5
Secondary tour			-0.8405	-3.2
Age under 20			1.312	3.6
7- PM peak - PM peak				
Constant	-2.597	-15.3	-2.057	-10.9
Secondary tour	1.041	8.6	1.404	6.7
No intermediate stops	0.6305	4.2		
Full time worker	0.4076	4.3		
Work tour made during the day	0.2062	1.6		
Intermediate stop on way from home	0.7849	4.5		
8- PM peak - Late				
Constant	-2.641	-24.4	-0.8091	-7.0
Intermediate stop on way back home	0.583	5.0	0.862	5.8
Full time worker	0.6669	5.9	0.3426	3.5
Work tour made during the day	1.644	11.4	0.483	3.8
Secondary tour			1.215	9.2
9- Late - Late				
Constant	-2.839	-19.7	-2.664	-10.6
Secondary tour	0.8704	5.5	2.034	9.5
Full time worker	0.732	6.6	0.3746	3.0
Age under 35	0.3291	3.3	0.4955	4.9
Work tour made during the day	0.7225	4.9	0.5486	3.8
No intermediate stops			0.397	2.3
Children under age 12 in hhld			-0.5221	-4.1
2+ adults, 1+ non-worker in hhld			0.3132	2.6

1.3. Home-base tour mode/destination choice models

Again, there are three different models, corresponding to the work/school, maintenance and discretionary tour purposes. We distinguish 9 different modes:

(1)	DA	drive alone
(2)	DP	drive with passenger
(3)	PA	car passenger
(4)	MW	MAX/walk access
(5)	MP	MAX/park and ride
(6)	BW	bus/walk access
(7)	BP	bus/park and ride
(8)	BI	bicycle
(9)	WA	walk only

For application, 21 different destination zones are used, as described in an earlier memo:

(1)	the residence zone
(2-5)	4 zones sampled from a distance less than D1
(6-9)	4 zones sampled from a distance between D1 and D2 and employment < E
(10-13)	4 zones sampled from a distance between D1 and D2 and employment > E
(14-17)	4 zones sampled from a distance greater than D2 and employment < E
(18-21)	4 zones sampled from a distance greater than D2 and employment > E,

where D1 = the 20th percentile distance of all actual tour destinations for the purpose
D2 = the 60th percentile distance of all actual tour destinations for the purpose
E = the 50th percentile employment of all actual tour destinations for the purpose
(total employment used for work/school,
retail+service employment used for maintenance,
retail+service employment + households used for discretionary)

The maximum number of available alternatives is 21 destinations x 9 modes = 189. Alternatives are unavailable if the travel time in the data is greater than 240 minutes (only occurs for bike and walk over long distances) or less than 0 (only occurs for transit alternatives that aren't connected in the networks). The transit modes are made unavailable for intra-zonal alternatives, or if the network wait time is greater than 120 minutes. Only one of the two park and ride alternatives is available for any individual depending on what type of park and ride lot is in the zonal data file for that residence zone. Finally, the two car driver alternatives are unavailable for households that do not own any vehicles. (Data on driver's license was not used in the models because it is not available in the PUMS data being used to apply the models.)

The mode/destination models use household and person data as well as network distance, time and cost data. In the course of extensive testing, it was found that the RP data would not support estimation of reasonable coefficients for both the time and cost variables for any of the tour purposes. This is probably due to the fact that both parking costs and traffic congestion are fairly low (at least at the level of definition in the data), meaning that both car costs and car travel times are strong related to distance and thus highly correlated with each other. Another possible explanation is that there is very low transit usage in Portland, and those who do use transit may be basing their choice on factors other than travel time and cost.

For these reasons, a decision was made to constrain the values of travel time to be equal to those estimated from the concurrent Stated Preference survey. Another attractive feature of the SP data is that it looked directly at reactions to congestion pricing - an important policy measure to be analyzed with the model and which does not exist in Portland presently. The SP-based values of time were estimated separately for home-work trips and home-other trips, and were estimated for three different income classes. The results are shown in Table 4 below. The variation is greater between income classes than it is between purposes, particularly for the work trips.

Table 4: Values of Time Estimated from Stated Preference Data

(All values in cents per minute, except for Transit Boardings)

Purpose	Home to Work			Home to Other		
Income	Less than $30,000	$30-60,000	More than $60,000	Less than $30,000	$30-60,000	More than $60,000
Drive alone In-vehicle	8.9	12.3	17.7	12.2	12.2	23.7
Drive w/pass. In-vehicle	9.4	13.1	18.8	7.9	7.9	15.3
Transit In-vehicle	5.8	8.1	11.6	1.6	1.6	3.1
Transit Walk	21.5	29.7	42.8	29.4	29.4	56.9
Transit Headway	4.9	6.8	9.8	9.8	9.8	19.0
Transit Boardings	39.0	53.9	77.8	75.0	75.0	145.2

These values were used to calculate "generalized time" for the car and transit modes (the total time and cost utility divided by the car drive alone time coefficient), which was used as a variable in the mode/destination choice models shown below in Table 5. In each of the three models, a function was estimated that contained linear, quadratic and cubic terms for the generalized time. The results are highly significant, with the same general shape in all the models. The function is slightly S-shaped, with disutility rising sharply at first, then leveling off a bit, and then rising more sharply again at very high travel times. This function gives a reasonable match to the actual distribution of tour distances in the data for all modes.

The other mode-specific variables in the models are mostly related to age, gender and household type. The car availability variables are very strong, particularly for the car driver and transit alternatives.

Several of the destination-specific land use density variables are also very significant. This indicates that the size variables as defined do not fully account for the attractiveness of the zones.

Table 5: Home-Based Tour Mode/Destination Choice Models

Tour type	Work/School		Maintenance		Discretionary	
Observations	7353		5852		3488	
Final log(L)	-23455.8		-20186		-13660.5	
Rho-squared (0)	0.335		0.284		0.188	
Alternative / variable	**Coefficient**	**T-st.**	**Coefficient**	**T-st.**	**Coefficient**	**T-st.**
Car and transit modes						
SP-based generalized time (min)	-0.06668	-23.2	-0.1763	-36.7	-0.1262	-21.2
SP-based generalized time squared	3.52E-04	8.3	0.001514	14.7	7.70E-04	6.9
SP-based generalized time cubed	-1.10E-06	-6.3	-5.59E-06	-9.3	-2.03E-06	-3.6
Drive alone						
Car competition in hhld*	-1.981	-19.5	-0.8392	-9.5	-1.163	-7.5
Age under 20	-1.292	-9.7	-0.4316	-2.1	-0.5352	-3.1
Age over 45	0.2951	3.9	0.2722	3.6		
Age over 65			-0.3434	-3.7		
Income over 45K			0.2389	3.8		
Children under age 5 in hhld	0.2937	2.7	-0.357	-3.0		
Female in 2+ adult HH, 1+ non-worker	-0.4483	-3.6				
2+ adults in household, all workers	0.1852	2.3			-0.2505	-2.6
No intermediate stops	-0.6925	-9.3	0.1852	2.3		
Secondary tour			0.3176	4.0	-0.3256	-3.1
Leave home before AM peak	-0.265	-2.1	1.115	3.5	0.8652	2.5
Leave home during AM peak	-0.1664	-1.9	0.5792	6.2	0.5061	3.8
Drive with passenger						
Constant	-3.334	-16.4	-1.593	-11.6	-1.512	-9.4
Log of distance (miles)	-0.4338	-10.6	-0.3063	-10.8	-0.4475	-12.1
Car competition in hhld*	-0.9051	-5.1	-0.5058	-5.1	-0.9564	-5.9
Age under 25	-0.3338	-1.8	-0.7288	-4.0	-1.204	-7.2
Male	0.651	4.6			0.4878	4.0
Children in household			0.406	4.3		
Female, children under 5 in hhld	1.317	6.1	1.388	10.2	1.391	8.5
Female, children 5 to 11 in hhld			0.6648	5.7	0.8226	5.3
Male in 2+ adult HH, 1+ non-worker	-1.026	-4.3	0.5894	6.6	0.3886	2.9
Single adult, no children in hhld	-1.814	-4.9	-1.596	-8.4	-1.591	-8.7
Intermediate stop on way from home	1.014	7.5	0.1306	1.5	0.3891	3.1
Intermediate stop on way back home	0.8121	5.6	0.2859	3.2	0.2749	2.0
Leave home in PM peak or later			0.6638	8.2	0.7675	7.6
Car passenger						
Constant	-2.671	-15.5	-2.41	-16.3	-2.017	-11.2
Car competition in hhld*					-0.5533	-3.4
Age under 25	0.6181	4.7	0.744	4.6		
Female	0.3747	3.5	0.7871	8.4	1.142	11.2
2+ adults, 1+ non-worker, no children			0.553	5.4	0.3525	3.2
Single adult	-0.9054	-4.9	-1.197	-7.5	-1.113	-7.3

* car competition = <1 vehicle per worker for work/school, <1 vehicle per adult for other purposes

- **(Table 5 continued)**

Secondary tour			-0.5366	-4.9	-0.7501	-5.8
Leave home before AM peak	-0.558	-3.0	0.8411	2.0	1.201	2.8
Return home after PM peak	-0.6223	-3.4	0.6168	4.6	0.6849	4.5
Leave home in PM peak or later			0.6518	4.9	0.669	3.9
Transit with walk access						
Constant	-4.536	-7.3	-4.541	-3.8	-2.416	-1.7
MAX LRT constant	-0.319	-2.1	-1.712	-2.3	-0.5283	-1.2
No car in household	1.045	5.9	2.178	6.5	1.917	4.8
Car competition in hhld*			0.8529	2.3	0.8264	2.2
Secondary tour			-0.5801	-2.0	-1.611	-5.1
Hhld within 1/4 mi of transit, origin zone	1.73	6.4	4.561	3.8	0.5758	0.9
Empl. within 1/4 mi. of transit, dest. zone	1.875	3.2			1.62	1.2
Park and ride						
Constant	-4.553	-3.8	-1.169	-2.9	-1.418	-2.7
MAX LRT constant	-0.319	-2.1	-1.712	-2.3	-0.5283	-1.2
Car competition in hhld*	-0.8869	-3.5				
Secondary tour			-1.979	-1.8	-2.069	-3.4
Return home after PM peak	-2.353	-3.3				
Mixed use within half mile of dest. zone	3.14E-04	4.8			4.19E-04	1.9
Empl. within 1/4 mi. of transit, dest. zone	2.223	1.8				
Bicycle						
Constant	-3.24	-10.2	-3.772	-10.0	-3.184	-9.3
Travel time (min)	-0.09731	-6.2	-0.1107	-8.0	-0.0925	-7.6
Travel time squared	4.88E-04	2.2				
Travel time cubed	-9.95E-07	-1.3				
Female	-0.9397	-4.0	-0.5491	-1.7	-0.7731	-2.1
Mixed use within half mile of origin zone			5.19E-04	3.4		
Mixed use within half mile of dest. zone	2.12E-04	2.7				
Walk only						
Constant	-1.496	-7.0	-2.828	-11.2	-1.94	-7.0
Travel time (min)	-0.0422	-19.9	-0.04804	-18.1	-0.03695	-18.0
Age under 20	0.7079	3.3				
Age under 35	0.4211	2.8				
Female, children under 5 in hhld			1.224	5.5	0.614	2.3
Female, children 5 to 11 in hhld			1.177	6.2		
No intermediate stops			1.502	8.0	1.239	5.5
Secondary tour			0.3535	2.2		
Mixed use within half mile of origin zone			6.06E-04	8.0		
Mixed use within half mile of dest. zone	2.78E-04	5.0				
Origin zone dummy	0.4912	2.5	1.128	7.1	1.714	10.0
Destination land use						
Origin zone dummy	0.3622	3.4	0.2781	3.9	0.3104	3.0
Household within half-mile radius			3.34E-04	11.4	3.33E-04	8.5
Mixed use within half-mile radius			-0.00102	-14.1	-7.60E-04	-8.1
Employment within half-mile radius	3.55E-05	18.0			3.78E-05	9.2
Retail empl. within half-mile radius	-1.91E-04	-10.0	1.63E-04	8.0	-1.97E-04	-5.7
Fraction of land used for recreation	1.161	7.6			2.026	9.1
Log of relevant size variable**	1.0	constr	1.0	constr	1.0	constr

** size variables = total employment, retail + service employment and retail + service emp. + households, respectively

Other variables include tour purpose, tour type and time of day, so this model must be applied conditional on both the tour pattern and time of day models. At this "bottom" level of the application, probabilities are generated for 3 tour purposes x 8 tour types x 15 time of day combinations x 21 destinations x 9 modes, which is almost 70,000 elemental alternatives. Because of this large size and resulting limitations on computer run time, the models for intermediate stop location and work-based tour mode/destination - which would be yet another level lower -were not made part of the sample enumeration system. Those models are applied in a separate, aggregate module, with no logsum feedback to the sample enumeration system.

NOTE: The models also included an adjustment for the sampling of destinations, equal to the log of the inverse of the sampling probability, with the coefficient constrained to 1.0.

1.4. Work-based tour mode/destination choice model

For work-based subtours, tour type (no stops, stop before, stop after, stop-both) and time-of-day combination are predicted using fixed fractions based on observed distributions in the survey data. They are conditional on the times of day the actual tour is made. Only the mode/destination probabilities are based on a model, and these depend on the mode and times of day of the work tour, as well as the income class of the person.

The results are shown in Table 6 below. The results are comparable to the model for home-based tour mode/destination, with a significant S-shaped function for generalized time. The main difference is that there are far fewer person-type and household-type variables here due to the aggregate nature in which the model will be applied. (Additional tests indicated that very few such variables would have been significant in any case.) Many person and household type effects are captured indirectly by including a dummy for each mode if that same mode was used to get from home to work. These dummy variables are positive in all cases, and significant in all cases except transit.

1.5: Intermediate stop location choice models

These models were estimated only for car driver tours, and used only mode (drive alone vs. drive with passenger), time of day, and income class as variables, as these are all the information that is available in the aggregate application. Also used was whether each location zone is the same as the tour origin or primary destination.

Separate models were estimated for work/school related tours (including work-based subtours) and other tours. The results, shown in Table 7 below, include the same S-shaped function of generalized time as was found for the mode/destination choice models. Otherwise, there are very few significant variables in either model. Of the land use variables tested, only mixed use within a half mile radius was significant.

Table 6: Work-Based Tour Mode/Destination Choice Model

	Work-Based Tours	
Observations	1331	
Final log(L)	-4270.1	
Rho-squared (0)	0.328	
Alternative / variable	**Coefficient**	**T-stat.**
Car and transit modes		
SP-based generalized time (min)	-0.1234	-18.7
SP-based generalized time squared	6.23E-04	5.9
SP-based generalized time cubed	-1.01E-06	-2.7
Drive alone		
Household income over 60K	-0.4665	-3.1
Leave work in AM peak	1.005	2.6
Leave work in PM peak or later	0.7945	1.8
Drive with passenger		
Constant	-2.062	-11.1
Drive with passenger to work	1.089	3.1
Log of distance (miles)	-0.2479	-3.1
Car passenger		
Constant	-2.539	-13.2
Car passenger to work	1.861	4.6
Transit		
Constant -walk access	-1.565	-4.0
Constant- park and ride	-3.583	-3.4
Constant - MAX LRT	0.4805	0.6
Transit to work	0.5864	1.1
Bicycle		
Constant	-5.461	-6.6
Bicycle to work	3.426	4.8
Travel time (min)	-0.1015	-3.1
Mixed use in half-mile radius	4.83E-04	1.8
Walk only		
Constant	0.6105	2.0
Walk only to work	1.227	2.4
Travel time (min)	-0.1064	-7.9
Travel time squared	4.50E-04	2.8
Travel time cubed	-4.93E-07	-1.0
Mixed use in half-mile radius	4.73E-04	6.5
Origin zone dummy	0.4369	2.9
Destination land use		
Households in half-mile radius	3.12E-04	5.1
Mixed use in half-mile radius	-0.001042	-7.6
Employment in half-mile radius	1.84E-05	4.9
Log of retail + service employment	1.0	constr

Table 7: Intermediate Activity Location Choice Models for Car Driver Tours

	Work/School Tours		Other Tours	
Observations	3016		2630	
Final log(L)	-8602.6		-6966.1	
Rho-squared (0)	0.077		0.143	
Alternative / Variable	**Coefficient**	**T-stat.**	**Coefficient**	**T-stat.**
Car driver modes				
SP-based generalized time (min)	-0.1387	-16.8	-0.2405	-24.8
SP-based generalized time squared	6.03E-04	4.0	0.002298	9.8
SP-based generalized time cubed	-8.38E-07	-1.0	-9.21E-06	-5.8
Specific locations				
tour origin zone dummy	1.084	7.0	0.6321	4.3
tour origin zone * drive w/pass			1.051	4.8
tour origin zone * AM peak	1.196	5.0		
tour origin zone * PM peak	0.4804	2.1	-0.4251	-1.5
tour destination zone dummy	0.329	2.3	-0.05166	-0.4
tour dest. zone * drive w/pass			0.4438	2.2
tour dest. zone * midday	0.678	3.9		
tour dest. zone * from home	0.784	4.5		
Location land use				
Mixed use in half-mile radius	-2.19E-04	-7.3	-2.52E-04	-6.5
Log of retail + service employment	1.0	constr.	1.0	constr.

1.6. Example model application results

The results in this section are taken from the simultaneous application of the full day activity pattern model, the home-based tour time of day models and the home-based tour mode/destination choice models to the household survey data. The application used the same disaggregate sample enumeration procedure that is used in the full model system. What is <u>not</u> included in this example are the models for work-based tours and intermediate stops, the route choice assignment procedure, and the expansion of the sample to the larger Portland area population. Because route choice tends to be the decision that is most sensitive to shifts in car times and costs, we can expect that the policy effects for the system as a whole will be much larger than the effects shown in this example. The most interesting results to focus on here are the <u>relative</u> policy effects on mode choice, trip distance, time of day choice, and activity participation.

Application results are given in Tables 8 to 11 below. Results are given for three policies, each with respect to the base case 1994 road and transit networks. For the first policy, a 10% increase in all car travel times, the results show a mode choice elasticity for car drive alone tours of -0.13, and for drive alone tour distance of -0.36. This indicates that the destination choice element is more sensitive than the mode choice element for this policy. (Clearly, this must be interpreted as a longer-term elasticity, since people cannot easily change their work or school destinations in the short term.). For maintenance and discretionary tours, the car drive alone tour and distance elasticities with respect to travel time appear higher than for work/school, with values around -0.30 and -0.65 respectively. For all tour purposes, the effects on car drive alone tours are about the same for all periods of the day.

For the first policy, the decrease in the number of total tours across all modes and all times of day is about -0.2% for work/school, -1.0% for maintenance and -0.3% for discretionary. This indicates the activity suppression effects of the policy, which are predicted via the full day activity pattern model. As one would expect, this effect is much smaller than the mode choice or destination choice effects. The fraction of tours suppressed is about the same during all of the periods of the day.

The second policy simulates a 100% increase in car fuel and operating costs, from 8 cents per mile in the base case to 16 cents per mile in the policy case. The implied elasticities for car drive alone in this case are about -0.06 and -0.15 for work/school tours and mileage, and about -0.10 and -0.21 for both maintenance and discretionary tours and mileage. Again, there are similar effects during all periods of the day. A difference with respect to the travel time policy, which can be seen in Tables 9 to 11 is that increasing car costs causes an increase in multiple occupant car tours, whereas increasing car travel times causes a decrease in all types of car tours.

The third policy simulates a toll charged only during the AM peak and PM peak periods, which has the effect of doubling the car fuel and operating costs during those periods (i.e. it is equivalent to the second policy, but applied only during the peaks). For the last policy, the tables show that there is also some shift of tours out of the peak periods into the midday and off-peak periods. To offset this change, some tours that previously had one half tour in one of the peak periods and the other half tour outside the peak may now switch modes or destinations or be suppressed altogether. For work/school car driver tours, we see that the net effect from these two offsetting changes is negative in the midday period (-0.4%) and positive in the early and late off-peak periods (+1.0%). The results for maintenance and discretionary tours are similar to those for work/school. Using the tour-based approach with time-of-day sensitivity allows the models to capture such complex shifts.

There are also offsetting changes predicted by the full day activity pattern model. When some peak period activities are suppressed, this allows other activities to be substituted during the midday and off-peak periods when travel costs have not increased. These new activities in the off-peak periods tend to be non-work activities, many of which would have otherwise been made as intermediate stops on a work tour. For maintenance, these types of changes cancel each other out (net effect of 0), while for discretionary there is even a slight increase in the total number of tours made (+0.2%), although the distance traveled while making those tours has decreased slightly. Table 8 provides more detail as to which types of tours are made. For discretionary tours, for example, the 0.2% increase arises from an increase in the number of primary tours which more than offsets a decrease in the number of secondary tours made after work/school tours. Although these changes are not large in this example, they illustrate the range of realistic policy effects added by adopting the activity based modeling approach.

Table 8: Example application results for predicted tours by type

	Base case -	10 % increase in all travel time by auto	100% increase in all variable costs by auto	100% increase in auto variable. costs during peak
Subsistence	**Tours**	**% change**	**% change**	**% change**
All types	8700.2	-0.2	-0.8	-0.6
Simple, no subtour	4389.1	-0.2	-0.8	-0.5
Stop before, no subtour	1580.0	-0.3	-0.9	-0.6
Stop after, no subtour	629.0	-0.3	-1.0	-0.9
Stop both, no subtour	533.0	-0.3	-0.8	-0.8
Simple, & subtour	917.0	-0.1	-0.5	-0.5
Stop before, & subtour	393.0	-0.2	-0.7	-0.5
Stop after, & subtour	145.0	-0.2	-0.7	-0.9
Stop both, & subtour	114.0	-0.2	-0.5	-0.7
Maintenance	**Tours**	**% change**	**% change**	**% change**
All types	6718.9	-1.0	-2.3	0.0
Primary-Simple	1313.0	0.0	+0.3	+0.7
Primary-Stop before	598.0	+0.1	+0.6	+0.8
Primary-Stop after	539.0	+0.1	+0.6	+0.7
Primary-Stop both	327.0	+0.1	+0.6	+0.7
Secondary-Simple, no work tour	1619.1	-1.6	-3.5	+0.1
Secondary-Stop before, no work tour	255.3	-1.6	-3.5	+0.1
Secondary-Stop after, no work tour	240.0	-1.6	-3.5	+0.1
Secondary-Stop both, no work tour	67.6	-1.6	-3.5	+0.1
Secondary-Simple, & work tour	1239.0	-2.2	-5.2	-1.4
Secondary-Stop before, & work tour	227.0	-2.2	-5.2	-1.4
Secondary-Stop after, & work tour	209.4	-2.2	-5.2	-1.4
Secondary-Stop both, & work tour	84.5	-2.2	-5.2	-1.4
Subsistence	**Tours**	**% change**	**% change**	**% change**
All types	4410.1	-0.3	-0.6	+0.2
Primary-Simple	857.6	-0.1	-0.1	+0.5
Primary-Stop before	168.1	0.0	+0.1	+0.6
Primary-Stop after	140.1	0.0	+0.1	+0.5
Primary-Stop both	94.0	0.0	+0.4	+0.4
Secondary-Simple, no work tour	1407.3	-0.2	-0.2	+0.7
Secondary-Stop before, no work tour	109.1	-0.2	-0.2	+0.8
Secondary-Stop after, no work tour	66.8	-0.1	-0.2	+0.7
Secondary-Stop both, no work tour	45.6	-0.2	-0.2	+0.7
Secondary-Simple, & work tour	1276.8	-0.5	-1.5	-0.6
Secondary-Stop before, & work tour	106.4	-0.5	-1.5	-0.6
Secondary-Stop after, & work tour	95.8	-0.5	-1.5	-0.6
Secondary-Stop both, & work tour	42.6	-0.5	-1.5	-0.6

Table 9: Example application results for home-based subsistence tours

Subsistence (work/school)		Base case -		10 % increase in all travel time by auto		100% increase in all variable costs by auto		100% increase in auto variable. costs during peak	
Mode	**Period**	**Tours**	**Miles**	**% chg Tours**	**% chg Miles**	**% chg Tours**	**% chg Miles**	**% chg Tours**	**% chg Miles**
Drive alone	AM peak	2139.4	37456.4	-1.4	-4.0	-5.8	-14.6	-5.9	-13.1
Drive alone	PM peak	1853.1	32279.1	-1.4	-3.9	-5.6	-14.4	-6.1	-13.6
Drive alone	Midday	1619.2	29593.1	-1.2	-3.3	-6.2	-15.0	-0.4	-2.5
Drive alone	Free flow	1022.7	18941.2	-1.0	-2.9	-5.9	-14.5	1.0	0.0
Drive w/pas	AM peak	117.6	1657.2	-1.3	-4.7	12.1	8.7	8.5	5.6
Drive w/pas	PM peak	92.4	1282.8	-1.2	-4.5	12.7	9.5	9.3	6.3
Drive w/pas	Midday	90.0	1345.8	-1.4	-4.3	12.4	9.0	4.3	3.5
Drive w/pas	Free flow	53.9	815.6	-1.2	-3.9	13.5	10.4	3.8	3.7
Car passngr	AM peak	198.8	2762.5	-2.4	-5.6	7.9	4.5	5.3	2.5
Car passngr	PM peak	141.8	1883.0	-2.3	-5.4	8.6	5.6	6.2	3.2
Car passngr	Midday	149.9	2222.6	-2.4	-5.3	7.4	4.0	2.9	1.9
Car passngr	Free flow	55.5	820.3	-2.3	-4.8	8.7	5.7	2.7	2.7
MAX + walk	AM peak	10.7	145.9	7.5	8.8	19.6	24.3	15.1	18.9
MAX + walk	PM peak	9.3	123.4	7.4	8.8	19.6	25.0	15.9	20.3
MAX + walk	Midday	6.9	89.7	6.8	8.0	19.0	23.9	5.8	7.4
MAX + walk	Free flow	4.2	51.6	6.2	7.8	19.8	25.4	4.0	5.4
MAX + drive	AM peak	10.1	180.6	10.8	12.6	29.8	36.7	22.6	27.5
MAX + drive	PM peak	8.2	140.9	10.6	12.6	30.6	38.0	25.0	31.1
MAX + drive	Midday	6.5	116.3	10.2	12.0	30.8	37.8	10.0	12.3
MAX + drive	Free flow	2.4	40.0	9.5	11.8	32.5	41.8	7.0	9.0
Bus + walk	AM peak	154.4	1700.4	6.8	8.3	17.3	22.4	13.2	17.1
Bus + walk	PM peak	133.2	1433.9	6.6	8.2	17.3	22.9	13.8	18.3
Bus + walk	Midday	113.4	1176.1	6.0	7.4	16.6	21.8	4.9	6.4
Bus + walk	Free flow	72.3	726.8	5.7	7.2	17.3	23.5	3.5	4.6
Bus + drive	AM peak	61.5	1241.7	10.4	12.8	29.6	39.5	22.8	30.2
Bus + drive	PM peak	52.6	1040.1	10.3	12.7	30.3	40.8	24.7	33.2
Bus + drive	Midday	38.0	741.5	9.7	12.1	29.9	40.8	9.5	12.8
Bus + drive	Free flow	15.9	299.6	9.4	11.7	32.4	45.2	7.4	10.0
Bicycle	AM peak	38.6	254.7	8.0	10.1	21.0	28.3	15.8	21.0
Bicycle	PM peak	33.2	209.8	7.8	10.0	21.0	28.6	16.5	22.4
Bicycle	Midday	29.4	189.8	7.2	9.4	21.1	28.9	6.0	8.3
Bicycle	Free flow	19.4	119.6	6.9	8.9	21.9	30.4	4.3	5.8
Walk only	AM peak	112.1	240.3	6.4	6.8	16.8	17.7	12.3	12.9
Walk only	PM peak	89.2	188.1	6.2	6.6	16.7	17.6	13.1	13.9
Walk only	Midday	91.1	193.2	5.9	6.4	16.8	18.0	5.1	5.5
Walk only	Free flow	53.1	111.1	5.6	5.9	17.4	18.5	3.3	3.5

Subsistence (continued)		Base case -		10 % increase in all travel time by auto		100% increase in all variable costs by auto		100% increase in auto variable. costs during peak	
Mode	**Period**	**Tours**	**Miles**	**% chg Tours**	**% chg Miles**	**% chg Tours**	**% chg Miles**	**% chg Tours**	**% chg Miles**
All modes	All periods	8700.2	141814.7	-0.2	-2.7	-0.8	-9.4	-0.6	-5.5
Drive alone	All periods	6634.3	118269.8	-1.3	-3.6	-5.8	-14.6	-3.5	-8.5
Drive w/pas	All periods	353.9	5101.4	-1.3	-4.4	12.6	9.3	6.9	4.9
Car passngr	All periods	545.9	7688.4	-2.3	-5.4	8.0	4.7	4.6	2.5
MAX + walk	All periods	31.1	410.6	7.2	8.5	19.5	24.5	11.8	15.1
MAX + drive	All periods	27.2	477.8	10.5	12.4	30.5	37.8	18.9	23.3
Bus + walk	All periods	473.4	5037.2	6.4	7.9	17.1	22.6	9.9	13.1
Bus + drive	All periods	168.0	3322.9	10.1	12.5	30.1	40.7	18.9	25.4
Bicycle	All periods	120.7	773.9	7.6	9.7	21.2	28.9	11.8	15.9
Walk only	All periods	345.5	732.7	6.1	6.5	16.9	17.9	9.2	9.8
All modes	All periods	8700.2	141814.7	-0.2	-2.7	-0.8	-9.4	-0.6	-5.5
All modes	AM peak	2843.3	45639.7	-0.3	-2.9	-0.6	-9.0	-1.6	-8.6
All modes	PM peak	2413.0	38581.1	-0.2	-2.8	-0.6	-9.0	-1.8	-9.1
All modes	Midday	2144.4	35668.1	-0.2	-2.6	-1.1	-9.8	0.8	-1.2
All modes	Free flow	1299.5	21925.8	-0.1	-2.3	-1.2	-10.1	1.6	0.6

Table 10: Example application results for home-based maintenance tours

Maintenance		Base case -		10 % increase in all travel time by auto		100% increase in all variable costs by auto		100% increase in auto variable. costs during peak	
Mode	**Period**	**Tours**	**Miles**	**% chg Tours**	**% chg Miles**	**% chg Tours**	**% chg Miles**	**% chg Tours**	**% chg Miles**
Drive alone	AM peak	421.4	5319.0	-2.5	-6.6	-6.9	-19.3	-4.2	-11.0
Drive alone	PM peak	760.9	9808.3	-3.3	-7.2	-9.6	-21.9	-4.5	-10.2
Drive alone	Midday	1953.4	26303.0	-2.5	-6.2	-8.2	-21.4	0.3	-0.7
Drive alone	Free flow	497.8	6845.7	-3.4	-6.8	-10.7	-23.5	0.4	0.4
Drive w/pas	AM peak	105.5	1582.6	-0.1	-3.8	4.0	-4.9	1.4	-3.4
Drive w/pas	PM peak	433.9	6607.8	-1.0	-4.7	0.5	-8.9	-0.1	-4.0
Drive w/pas	Midday	776.1	12379.2	-0.1	-3.6	3.1	-6.7	1.3	0.8
Drive w/pas	Free flow	277.1	4457.4	-1.1	-4.5	-0.4	-10.5	0.5	0.5
Car passngr	AM peak	50.7	747.7	-0.6	-4.1	2.9	-5.9	0.6	-4.2
Car passngr	PM peak	209.9	3147.7	-1.1	-4.7	0.3	-9.1	-0.2	-3.8
Car passngr	Midday	458.1	7169.5	-0.5	-3.9	2.0	-7.7	1.1	0.6
Car passngr	Free flow	188.8	2970.1	-1.1	-4.5	-0.5	-10.6	0.6	0.7
MAX + walk	AM peak	0.2	4.1	4.8	7.3	14.3	14.6	9.5	7.3
MAX + walk	PM peak	0.4	7.0	5.3	8.6	15.8	20.0	5.3	8.6
MAX + walk	Midday	1.2	23.9	5.6	6.3	15.3	16.3	1.6	1.7
MAX + walk	Free flow	0.1	2.1	9.1	4.8	27.3	19.0	0.0	0.0
MAX + drive	AM peak	0.1	1.2	0.0	16.7	20.0	41.7	0.0	16.7
MAX + drive	PM peak	0.1	2.2	11.1	13.6	33.3	40.9	11.1	18.2
MAX + drive	Midday	0.3	8.8	14.3	14.8	40.0	43.2	2.9	5.7
MAX + drive	Free flow	0.0	0.6	50.0	16.7	50.0	50.0	0.0	0.0
Bus + walk	AM peak	10.0	164.4	5.7	6.4	13.3	15.3	6.3	7.2
Bus + walk	PM peak	18.6	300.4	6.7	7.5	15.4	17.9	6.3	7.4
Bus + walk	Midday	68.1	1084.6	5.8	6.4	14.1	16.3	1.5	1.7
Bus + walk	Free flow	7.2	109.2	7.2	8.2	18.0	21.2	0.4	0.5
Bus + drive	AM peak	0.8	22.2	15.5	17.1	47.6	55.9	21.4	24.3
Bus + drive	PM peak	1.7	45.4	15.2	16.7	46.2	54.2	18.7	21.4
Bus + drive	Midday	6.2	162.2	15.3	16.7	49.6	58.4	5.2	6.0
Bus + drive	Free flow	0.5	12.2	14.6	15.6	47.9	55.7	2.1	2.5
Bicycle	AM peak	4.3	20.7	9.6	10.6	23.3	27.1	11.1	12.6
Bicycle	PM peak	10.9	53.1	9.6	10.5	23.0	26.0	9.0	10.2
Bicycle	Midday	31.7	153.4	9.4	10.5	24.8	28.3	2.5	2.7
Bicycle	Free flow	5.6	26.8	9.4	10.4	24.5	27.6	0.5	0.4
Walk only	AM peak	39.3	94.5	8.5	9.2	20.5	22.2	9.8	10.6
Walk only	PM peak	97.8	232.0	8.4	9.1	19.8	21.6	8.0	8.7
Walk only	Midday	226.8	540.8	8.2	8.9	21.3	23.2	2.1	2.2
Walk only	Free flow	53.5	124.8	8.3	9.0	21.6	23.6	0.3	0.3

Maintenance (continued)		Base case -		10 % increase in all travel time by auto		100% increase in all variable costs by auto		100% increase in auto variable. costs during peak	
Mode	**Period**	**Tours**	**Miles**	**% chg Tours**	**% chg Miles**	**% chg Tours**	**% chg Miles**	**% chg Tours**	**% chg Miles**
All modes	All periods	6719.0	90534.6	-1.0	-5.0	-2.3	-14.2	0.0	-2.1
Drive alone	All periods	3633.5	48276.0	-2.8	-6.5	-8.7	-21.5	-1.2	-3.6
Drive w/pas	All periods	1592.5	25027.0	-0.5	-4.1	1.8	-7.9	0.8	-0.8
Car passngr	All periods	907.5	14035.0	-0.8	-4.2	1.2	-8.5	0.7	-0.6
MAX + walk	All periods	1.9	37.1	5.7	6.7	16.0	17.0	3.1	3.5
MAX + drive	All periods	0.5	12.8	13.7	14.8	37.3	43.0	3.9	8.6
Bus + walk	All periods	103.9	1658.6	6.0	6.7	14.5	16.8	2.7	3.2
Bus + drive	All periods	9.2	242.0	15.3	16.7	48.7	57.2	9.0	10.4
Bicycle	All periods	52.6	254.0	9.5	10.5	24.3	27.6	4.3	4.8
Walk only	All periods	417.5	992.1	8.3	9.0	20.9	22.8	4.0	4.3
All modes	All periods	6719.0	90534.6	-1.0	-5.0	-2.3	-14.2	0.0	-2.1
All modes	AM peak	632.2	7956.4	-1.0	-5.2	-2.0	-13.6	-1.7	-8.0
All modes	PM peak	1534.2	20203.9	-1.4	-5.5	-2.9	-14.3	-1.6	-6.6
All modes	Midday	3522.0	47825.4	-0.7	-4.6	-1.6	-13.7	0.8	0.0
All modes	Free flow	1030.6	14548.9	-1.6	-5.3	-4.0	-15.9	0.5	0.5

Table 11: Example application results for home-based discretionary tours

Discretionary		Base case -		10 % increase in all travel time by auto		100% increase in all variable costs by auto		100% increase in auto variable. costs during peak	
Mode	**Period**	**Tours**	**Miles**	**% chg Tours**	**% chg Miles**	**% chg Tours**	**% chg Miles**	**% chg Tours**	**% chg Miles**
Drive alone	AM peak	153.9	1657.2	-2.5	-6.4	-7.9	-20.4	-5.5	-12.5
Drive alone	PM peak	413.6	4655.4	-3.3	-6.7	-11.1	-23.3	-3.1	-6.4
Drive alone	Midday	621.3	7133.2	-2.9	-6.4	-10.0	-22.6	-0.6	-2.2
Drive alone	Free flow	516.3	6039.5	-3.2	-6.4	-11.9	-24.3	0.6	0.6
Drive w/pas	AM peak	43.7	499.8	0.4	-4.0	4.9	-5.9	1.4	-4.7
Drive w/pas	PM peak	377.5	4563.9	-0.3	-4.4	1.2	-9.9	0.2	-2.0
Drive w/pas	Midday	271.8	3333.1	0.0	-4.1	2.9	-8.6	1.2	0.1
Drive w/pas	Free flow	479.6	6018.6	-0.3	-4.1	0.9	-10.6	0.6	0.7
Car passngr	AM peak	37.3	420.8	-0.2	-4.5	3.1	-7.6	0.5	-4.9
Car passngr	PM peak	283.3	3379.4	-0.6	-4.6	0.4	-10.7	0.2	-1.4
Car passngr	Midday	202.1	2444.1	-0.6	-4.6	1.4	-9.9	1.0	-0.1
Car passngr	Free flow	445.1	5486.4	-0.5	-4.3	0.2	-11.2	0.6	0.7
MAX + walk	AM peak	0.4	7.3	7.0	9.6	18.6	23.3	9.3	12.3
MAX + walk	PM peak	0.9	15.9	7.5	8.8	19.4	23.9	5.4	7.5
MAX + walk	Midday	1.6	27.8	6.7	7.9	18.2	21.6	2.4	3.6
MAX + walk	Free flow	0.7	11.4	7.0	8.8	19.7	24.6	0.0	0.9
MAX + drive	AM peak	0.2	5.0	13.0	14.0	34.8	38.0	17.4	20.0
MAX + drive	PM peak	0.5	9.7	13.0	12.4	32.6	37.1	10.9	11.3
MAX + drive	Midday	0.9	19.5	11.6	12.3	33.7	37.4	5.3	5.6
MAX + drive	Free flow	0.4	7.3	11.1	13.7	33.3	41.1	0.0	1.4
Bus + walk	AM peak	7.3	106.5	7.2	9.0	18.2	24.4	9.0	12.1
Bus + walk	PM peak	16.5	236.9	7.6	9.5	19.0	25.8	5.5	7.7
Bus + walk	Midday	31.2	435.4	6.8	8.8	18.0	24.6	2.7	3.6
Bus + walk	Free flow	14.8	193.0	7.4	9.7	19.8	27.7	0.5	0.8
Bus + drive	AM peak	1.7	43.1	13.5	15.1	40.9	49.9	19.9	24.1
Bus + drive	PM peak	3.7	92.8	13.2	14.9	39.9	49.6	12.1	15.1
Bus + drive	Midday	7.0	171.8	13.0	14.7	41.3	51.4	6.2	7.5
Bus + drive	Free flow	3.0	70.5	12.8	15.0	41.1	52.9	1.3	1.8
Bicycle	AM peak	2.5	10.1	9.6	10.9	25.2	28.7	11.6	13.9
Bicycle	PM peak	11.9	48.4	9.5	10.1	23.7	25.8	5.2	5.6
Bicycle	Midday	14.8	60.3	9.4	10.1	25.4	27.7	3.5	3.8
Bicycle	Free flow	14.3	57.4	9.2	9.9	24.6	26.8	0.5	0.3
Walk only	AM peak	23.6	47.3	9.1	10.1	23.6	26.0	10.9	12.1
Walk only	PM peak	117.4	236.0	8.8	9.5	22.4	24.2	4.9	5.3
Walk only	Midday	146.5	295.6	8.6	9.4	23.5	25.7	3.1	3.3
Walk only	Free flow	142.6	283.4	8.7	9.3	23.4	25.3	0.4	0.5

Discretionary (continued)		Base case -		10 % increase in all travel time by auto		100% increase in all variable costs by auto		100% increase in auto variable. costs during peak	
Mode	**Period**	**Tours**	**Miles**	**% chg Tours**	**% chg Miles**	**% chg Tours**	**% chg Miles**	**% chg Tours**	**% chg Miles**
All modes	All periods	4410.1	48123.8	-0.3	-4.4	-0.6	-13.3	0.2	-1.2
Drive alone	All periods	1705.2	19485.3	-3.1	-6.5	-10.7	-23.1	-1.3	-3.2
Drive w/pas	All periods	1172.6	14415.4	-0.2	-4.2	1.6	-9.8	0.6	-0.5
Car passngr	All periods	967.8	11730.7	-0.5	-4.5	0.6	-10.6	0.6	-0.3
MAX + walk	All periods	3.7	62.4	7.0	8.5	18.8	22.9	3.5	5.1
MAX + drive	All periods	2.0	41.5	12.0	12.8	33.5	38.1	7.0	8.0
Bus + walk	All periods	69.8	971.8	7.2	9.1	18.7	25.5	3.6	5.0
Bus + drive	All periods	15.4	378.2	13.1	14.8	40.9	51.1	8.2	10.2
Bicycle	All periods	43.5	176.2	9.4	10.1	24.7	27.0	3.4	3.7
Walk only	All periods	430.2	862.3	8.7	9.4	23.2	25.2	3.1	3.4
All modes	All periods	4410.1	48123.8	-0.3	-4.4	-0.6	-13.3	0.2	-1.2
All modes	AM peak	270.7	2797.1	-0.2	-4.3	-0.2	-11.9	-1.4	-7.8
All modes	PM peak	1225.3	13238.4	-0.3	-4.6	-0.5	-12.9	-0.3	-2.9
All modes	Midday	1297.3	13920.8	-0.2	-4.3	-0.3	-13.2	0.6	-0.8
All modes	Free flow	1616.9	18167.5	-0.3	-4.5	-0.9	-14.0	0.6	0.7

2 Structure of the Application System

21. The disaggregate tour forecasting program (PTOURAP2.EXE)

The sample enumeration program currently has the following structure:

A. Read in control file input, with input and output file names and other run control variables.

B. Open all input files and initialize all associated variables:
   1. the zonal data file (see section 3.1)
   2. the zone-to-zone car and transit level of service file (see section 3.2)
   3. the zone to zone car toll charge and time file (see section 3.3)
   4. the household/person sample file (see section 3.4)
   5. various model coefficient files (ALOGIT F12 files)

C. Open all output files and initialize all associated variables
   1. half-tour matrix output file (see section 3.5)
   2. summary output file (see section 3.6)
   3. work-based tour location output file (see section 3.7)

D. Loop on valid records from the household/person sample file
   (sorted by residence zone)

   E. If person lives in a new residence zone then:
      1. write a half-tour matrix output record for all tours from the previous residence zone
      2. read in new zone-to-zone level of service data
      3. set new sampling strata for all possible destination zones

   F. set person/household-specific variables

   Loop on tour purposes
      G. draw random sample of destinations

      Loop on tour types

         Loop on time of day combinations

            H Apply mode/destination choice model
            to calculate mode/destination probabilities
            = MDesProb(purpose, tour type, TOD, mode, destination)

         end of loop on time of day combinations

         I. Apply time of day model to calculate time of day probabilities

= TODProb(purpose, tour type, TOD)
end of loop on tour types
end of loop on tour purposes

J. Apply tour pattern model to calculate predicted numbers of tours
= PredTour(purpose, tour type)

K. Accumulate output
Loop simultaneously on tour purposes, tour types, times of day,
modes, and destinations
1. calculate predicted tours = expansion factor
x PredTour(purpose, tour type)
x TODProb(purpose, tour type, TOD)
x MDesProb(purpose, tour type, TOD, mode, destination)
2. add to summary output accumulators
3. if relevant tour type, add to work-based tour accumulator
4. add to half-tour matrix accumulators
end of loops

end of loop on valid sample records (end of file or finished valid residence zones)

L. Loop on all workplace zones
1. read in a half-tour matrix record with sample enumeration results for that zone
2. read in new zone-to-zone level of service data
3. set new sampling strata for all possible destination zones

M. Loop on income classes, work tour modes & work tour time of day combinations
N. Draw new sample of destinations for work-based tour model

O. Loop on time-of-day combinations

P. Apply the work-based tour mode/destination model

Q. Add the work-based tour results into the sample enumeration results
end of loop on time of day combinations
end of loop on income classes, work tour modes & work tour time of day combinations

R. Write out revised half-tour matrix results record
end of loop on workplace zones

S. Write final output records, close output files, and release memory

T. Close input files and release memory.

U. Close control file and log file

2.2. The aggregate trip forecasting program (PTRIPAP2.EXE)

This program converts the half-tours predicted by the disaggregate forecasting program into trips, including locating intermediate stops for car driver tours. The structure is as follows:

A. Read in control file input, with input and output file names and other run control variables.

B. Open input files, and initialize all associated variables.

1. the zonal data file (see section 3.1)
2. the zone-to-zone car and transit level of service file (see section 3.2)
3. the zone to zone car toll charge and time file (see section 3.3)
5. various model coefficient files (ALOGIT F12 files)

C: Loop on output matrices indicated in control file: each output matrix is associated with a mode, time of day, tour purpose and income class.

   1. Open the half-tour matrix file output by the tour application run (see section 3.5)
   2. Open new trip matrix output file (see section 3.8)

   D. Loop on each origin zone

      1. Read in half-tour matrix record for the origin zone

      E. Loop on half tour direction (outbound or return)

         F. Loop on each destination zone

            1. For half-tours with no stops or not by car-driver - add half-tours directly into trip matrices.
            2. For car driver, half tours:
            - Set new location sampling strata
            - Draw a new sample of stop locations
            - Apply the intermediate stop location model
            - Split the half-tour into pairs of trips as indicated by the model probabilities, and add them into the trip matrices

         end of loop on destinations

      end of loop on half tour directions

   end of loop on origin zones

   G. Write output trip matrix to disk

end of loop on output matrices.

H. Close all files and free memory.

3. Input and Output File Formats

3.1. The zonal data file

The zonal data file is a binary file with 29 records, one each for each of the variables listed below. Each record contains 1244 4-byte floating-point numbers, one value for each TAZ. The current file is TAZDATA2.BIN.

1. TAZ number
2. total households
3. total employment
4. retail employment
5. service employment
6. total acres
7. recreational acres
8. total households within half mile radius
9. total households within quarter mile radius
10. total employment within half mile radius
11. total employment within quarter mile radius
12. retail employment within half mile radius
13. retail employment within quarter mile radius
14. mixed use measure within half mile radius
15. mixed use measure within quarter mile radius
16. long term parking cost
17 short term parking cost
18. GIS-based centroid walk time to transit
19. Avg walk time to transit from employment
20. Avg walk time to transit from households
21. Employment accessible within 30 minutes by transit
22. Number of local intersections
23. Average parcel size
24. Off-Peak fraction of employment within quarter mile of transit
25. Off-Peak fraction of households within quarter mile of transit
26. Peak fraction of employment within quarter mile of transit
27. Peak fraction of households within quarter mile of transit
28. TAZ of assigned park and ride lot from zone to downtown
29. type of assigned park and ride lot (MAX=1, bus=0)

3.2. Zone-to-zone level of service matrix files

These binary files are sorted by origin zone, with 55 records per origin. Each record contains 1244 2-byte integers, a value for each destination zone. The first 3 records are for variables that don't vary by time of day:

tripdist, {trip distance (miles x 100) }
tranfare, {transit fare (cents) }
pkrdfare; {park and ride transit fare (cents)}

The next 13 records are for level of service during the AM peak:

autinvet, {auto in-vehicle time (minutes x 100) }
businvet, {bus in-vehicle time (minutes x 100) }
buswaitt, {bus total wait time (minutes x 100) }
buswalkt, {bus total walk time (minutes x 100) }
busboard, {bus total boardings (x 100) }
maxinvet, {max in-vehicle time (minutes x 100) }
maxwaitt, {max total wait time (minutes x 100) }
maxwalkt, {max total walk time (minutes x 100) }
maxboard, {max total boardings (x 100) }
pkrinvet, {pkrd total in-vehicle time (minutes x 100) }
pkrwaitt, {pkrd total wait time (minutes x 100) }
pkrboard, {pkrd total boardings (x 100) }
pkrwalkt, {pkrd total walk time (minutes x 100) }

Following that are the same 13 variables during the PM peak, followed by the same 13 variables during the midday, and finally the same 13 variables for off-peak.

There are two separate level of service files, one with the level of service from the origin zone to all destination zones (for the outbound tour leg) TAZ2TAZ1.BIN, and another with level of service from all destinations to the origin (for the return leg) TAZ2TAZ2.BIN. Both files are sorted by origin zone.

3.3. Zone-to-zone toll charge and time matrix files
These two files have the same structure as the level of service files, but only have 24 records per origin zone instead of 55.

The first two records are for the AM peak:
sovtoll, {toll for single-occupant autos on tolled route (cents) }
sovtivt, {in-vehicle time for single occupant autos on tolled route (min x 100) }
sovnivt, {in-vehicle time for single occupant autos on non-tolled route (min x 100) }
hovtoll, {toll for multi-occupant autos on tolled route (cents) }
hovtivt, {in-vehicle time for multi-occupant autos on tolled route (min x 100) }
hovnivt, {in-vehicle time for multi-occupant autos on non-tolled route (min x 100) }

These 6 records are followed by the same 6 for PM peak, midday and off-peak, in that order. Program MKCARLOS.EXE produces two of these files for the base no-toll case - CAR2TAZ1.BIN and CAR2TAZ2.BIN. For policy scenarios which involve tolls or other forms of link-specific pricing, new versions of these files must be generated.

3.4. Household/person sample file (

This file was created using Eco Northwest's synthetic sample generation program. It is a binary file, with a single record for each person record. The record structure is as follows. All values are 1-byte integers unless indicated otherwise.

```
hrzone    :2-byte integer;  {residence zone (1-1244)}
hhsize    ,     {number of person in household}
hhfull    ,     {number of full time workers in household}
hhpart    ,     {number of part time workers in household}
hhadlt    ,     {number of people aged 18+ in household}
hh1217    ,     {number of children aged 12-17 in household}
hhc511    ,     {number of children aged 5-11 in household}
hhchu5    ,     {number of children aged 0-4 in household}
nmveh     ,     {number of vehicles for use by household}
hhdlic    ,     {number of driver's licenses in household (set equal to hhadlt)}
income    ,     {household annual gross income (1000's of 1994$) }
gender    ,     {person's sex, 1=male, 2=female}
age       ,     {person's age in years}
drlic     ,     {person's driver's license status, 1=yes, 2=no  (set to 1 if age>=16)}
employ:byte     {person's employment status, 1 or 3=employed full time,
                                  2 or 4= employed part time,
                                  otherwise not employed}
expfact   :     4-byte floating point  {expansion factor}
```

The current file for the base year is 1994SAM1.BIN, which contains about 150,000 records.

3.5 The half-tour matrix output file

The current version of the tour forecasting program writes out a file for each output mode defined by the user. The program requires that car drive alone be output to matrix 1 and car drive with passenger be output to matrix 2. Otherwise, the modes can be grouped or omitted as desired. For example, car passenger, bicycle and walk only will typically be omitted, since OD level detail will not be required for those modes. The transit sub-modes will typically be grouped. For instance, MAX and bus can be output separately, but park and ride and walk access can be added together for each sub-mode.

In each file, a record for is written for each origin zone. A record contains the predicted number of half-tours for each combination of:

- time of day (4- am peak, pm peak, between peaks, outside peaks)
- socioeconomic group (3- income<30K, income 30-60K, income>60K)
- tour purpose category (2- work/school, other)
- half-tour type (2- 1+ intermediate stops, no intermediate stops)
- half-tour direction (2- outbound (O-D) or return (D-O))
- destination zone (1244)

The structure for each record is

TripMat=array[1..NTPer,
1..NISegs,
1..NPSegs,
1..NITypes,
1..NTDirs,
1..NZones] of 4-byte floating point.

This is the same as if each value were written in a nested loop structure, with the nesting from top to bottom (all values for period 1, then all values for period 2, etc.)

3.6. The tour summary output file
This is an ASCII text file, with the following information on each record:

1. tour purpose (4 possible)
2. tour type (8 possible)
3. time of day combination (15 possible)
4. income class (3 possible)
5. mode (9 possible)
6. total number of tours predicted
7. total travel distance predicted (miles)

A single record is written for each combination of the first 5 dimensions, giving 4x8x15x3x9 = 12960 records. This file can easily be analyzed with SPSS or STATA to get totals along any of the 5 dimensions or any combination of them. It will also be easy to merge the output files from two separate runs and analyze the differences between the runs.

3.7. The work-based tour location file
The program writes out a single record at the end of the simulation which contains the number of work-based tours predicted for each combination of:

- workplace zone (1-1244)
- income class (3- income<30K, income 30-60K, income>60K)
- main mode for home-work tour (9, as described in section 1.3)
- time of day combination for home-work tour (15, as described in section 1.2)

The structure of the record is:

TWBasLoc = array[1..NZones,
1..NISegs,
1..NModes,
1..NTComb] of 4-byte floating point.

This is the same as if each value were written in a nested loop structure, with the nesting from top to bottom (all values for zone 1, then all values for zone 2, etc.

3.8 The trip matrix output file

For each half-tour matrix that the user specifies, the current version of the trip forecasting program writes out a single OD trip matrix for each combination of time of day, income class and tour purpose. The file name extension is three letters which identify the combination as follows:

- time of day: A = AM peak P = PM peak M = Midday F = Free flow
- income class L = <30K M = 30-60K H = >60K
- tour purpose W = work/school O = other

Each file contains 1244 x 1244 4-byte floating point numbers:

The number of trips from zone 1 to zone 1
The number of trips from zone 1 to zone 2
etc.
The number of trips from zone 1 to zone 1244
The number of trips from zone 2 to zone 1
etc.
etc.
The number of trips from zone 1244 to zone 1244

These matrices are ready for input to the pivot procedure or assignment.

Appendix D: Differences between the Activity-Based Model System as Initially Planned and as Currently Implemented

Memo by John Bowman

In 1996 and 1997 an activity based model system was designed for a federally sponsored demonstration project. A system based on the design was subsequently developed for implementation in the context of a congestion pricing project. Both projects have benefited by sharing the design, with the pricing project incorporating many activity based features, and the demonstration project achieving a production implementation. On the other hand, objectives of the demonstration project were sacrificed in the pricing project for the sake of immediate implementation.

In this memo, we compare the original design with the implemented system, and discuss priorities for enhancing the system in the demonstration project or a separately funded sequel. It is based on a discussion with Mark Bradley and a review of the following documents:

1. Activity Based Model System for Portland Metro: Model System Design, Draft 3 (design08.doc, John L. Bowman, Aug 14, 1996). As the name says, this documents lays out the original design of the model system.
2. Results of Processing Activity Data into Tours and Daily Patterns (actproc6.doc, Mark Bradley, Sep 3, 1996?). This document describes the development of the tour and daily pattern data sets from the household survey data for model estimation.
3. Documentation of the Sample Enumeration System (trosmod1.doc, Mark Bradley, Jun 17, 1997). This document describes the model structure, estimation results, application program, data inputs and outputs, and program control file for the implemented system.
4. Instructions for Version 1 of the TROS Tour Forecasting System (instruct.doc, Mark Bradley, Jul 13, 1997). This document is the instructions for operating the model system.

Further discussion with Mark would help to correct potential misunderstandings of what has been done and improve the list of priorities.

The System Design document contains 9 sections. We list the sections below, providing a comparison of the implemented system to the design for each section, and suggesting follow-up work.

1 Daily Activity Schedule Hierarchy

Shows the explicitly modeled dimensions of the daily activity schedule and the hierarchy which relates them

The implemented hierarchy is different than the design in three ways:

1. 1.1 The Daily Activity Pattern lacks the primary tour time of day. As a result the secondary tours, unconditioned by the details of the primary tour, are not constrained or otherwise influenced by primary tour timing.
2. 1.2 Nonwork tours are modeled with optional stops before and after the primary stop, following the work tour design, rather than with secondary and tertiary stops, as prescribed in the design.
3. 1.3 Secondary stops are modeled using aggregate output of the primary stop tour models, which include no accessibility logsum from the secondary stops. They also do not include the time-of-day dimension, despite the fact that a substantial percentage of secondary stops extend into the next time period.

   Items 1.1 and 1.3 and 1.4 are the most important weaknesses of the current implementation. They are all more important than the inclusion of the time-of-day models in the accessibility linkages of the system. Along this line, it would be possible to include items 1.1 and 1.3 (making the model perhaps 40 times as resource intensive because of secondary stops on tours), and if simplification is needed for the sake of processing time, then use time-of-day models that don't rely on accessibility from lower levels and are skipped in the accessibility feedback to higher levels (reducing computation requirements by approximately 15 times, or 225 times if item 1 is implemented).
4. 1.4 The modeling of work destination is not conditioned by a principal workplace. Although this is exactly according to design, subsequent research has indicated that, when this model system is extended to include residential choice, the logsum measure from the tour models only contains useful accessibility information if it is conditioned on the work destination (or, probably, on the principal workplace). Thus, it is important either to condition the work timing and mode choices on the work destination, allowing for the subsequent insertion of the residential choice model between work destination and other work tour dimensions, or better yet to explicitly model choice of workplace and work destination, conditioning the work destination on a longer term choice of principal workplace.

   The inclusion of the preferred approach to item 1.4 would require the explicit modeling of workplace before the model system could be used for forecasting. However, it would also enable the demonstration system to serve as the foundation for a subsequent development phase, extending the model system to include household residential, workplace and activity program choices, with the daily schedule providing accessibility information for these longer term decisions.

2	**Daily Activity Schedule Definition of Alternatives**	**Defines the alternatives for each dimension of the hierarchy.**

The implementation differs from the design in three ways:

1. 2.1 The design called for the definition of destination alternatives in 1 acre grid cells, whereas the current implementation uses the existing 1244 traffic analysis zones.

   This is a serious deficiency, but our current judgment is that it is more feasible to provide enhanced dimensionality via items 1.1 and 1.3 than it is to improve geographic resolution. Subsequent attention to item 2.1 is an important future objective
2. 2.2 The design used 4 time periods and allowed all 16 departure-time-return-time pairs. The implementation distinguishes early AM (3-7AM) from late night, and eliminates all pairs extending overnight.

   This is not a major deviation from the design. On the other hand, coarse aggregation of timing is a major weakness of the design, that needs further attention but will be very difficult to address.
3. 2.3 Access for transit alternatives was redefined, from auto and other, to park & ride and other. The reason for this is not clear, but it is probably not a problem, and may be an improvement.

3	**Interpreting the Survey Data**	**Provides rules for translating observed daily schedules into the model hierarchy, providing additional definition of the dimensions of the daily schedule.**

1. 3.1 Minor changes to section 3 were made and documented (Bradley, actproc6.doc) during the generation of the data sets.

4	**Definitions of Activity Purposes**	**Translates the survey activity codes into the three activity purpose categories of work, maintenance and discretionary.**

1. 4.1 Definitions of activity purposes remain unchanged. However, it should be noted that although the 3 purpose categories are used (Work, Maintenance, Discretionary) the mode and destination choice models use detailed activity purpose (e.g., school, shopping) to explain behavior. In model application, simple aggregate models (market segment specific) of activity purpose distributions) are used to provide the needed purpose information.

A fairly simple extension of this important design enhancement would incorporate purpose-specific size variables in the destination choice models. This would require the availability of purpose specific size data (e.g., retail employment) for every zone. It is anticipated that the use of detailed purpose information will improve the information carried by the accessibility variables to higher level models in the system.

---

5 Assigning Mode — **Provides logic for assigning the principal mode of any tour in the daily activity schedule.**

1. 5.1 Mode assignment rules were implemented as designed.

---

6 Sampling of Alternatives — **Explains the stratified importance sampling scheme and procedures for sampling destination alternatives.**

The documentation available for the review of alternative sampling was not intended to carefully document the sampling procedure and is therefore incomplete and ambiguous in this respect (taken from section 1.3 of trosmod1.doc). Some potential differences from the design document follow.

1. 6.1 Several potential deviations from the specified sampling procedure reduce the information in the sample without affecting the consistency of the estimates. Without closer study it is not clear whether the information loss is a major problem. Successful destination choice modeling would suggest otherwise.

   a) The special zone (sampled with probability 1) for work-based tours may be residence zone instead of principal workplace.
   b) The employment threshold used for subdividing the middle and long distance categories may use the median employment across all observations for a purpose instead of using median employment among all observations for the purpose within the particular distance category.
   c) The size measure used for discretionary purpose tours may sum employment counts with household counts, which have two different scales, whereas the design suggested summing the zone's proportion of employment and proportion of households, which are scale-free.
   d) Sampling of alternatives might not have been independent across observations... perhaps the same draw was used for multiple observations. This would put too much weight on draws if the re-use was not random.
   e) I have no documentation of the sampling for stops before and after the primary stop. The design called for using ellipse-shaped distance thresholds, based on the distance along the path from primary stop to secondary stop to home.

1. 6.2 The design calls for stratified importance sampling, in which the chosen zone substitutes for one of the drawn alternatives in its stratum, and receives the same weight. As implemented so far, the chosen alternative was placed in a separate stratum without being weighted. This violates the positive conditioning requirement for consistent estimation with MNL.
2. 6.3 The sampling of alternatives precludes consistent (simultaneous) estimation of nested logit models. Therefore, any model estimation involving destination choice cannot be estimated as a nested logit model; rather, if nesting is required, it must be accomplished by sequential estimation of MNL models. It appears that the current mode-destination model is MNL, so joint estimation does not affect consistency. However, the alternative NL specifications considered may have been inconsistently estimated.

---

7 Availability of Alternatives — **Lists the criteria for evaluating the availability of alternatives in each dimension of the daily activity schedule.**

1. 7.1 The implemented availability criteria are substantially simpler than the design called for:

   a) Work patterns may not be made unavailable to non-employed persons.
   b) Timing of primary tours does not restrict time availability of secondary tours.
   c) Mode-destination availability is not restricted by the maximum observed travel times for similar stops (i.e., matching tour priority, tour purpose, stop type within tour, and perhaps timing). Instead, for the main tour destination, alternatives are unavailable if travel time exceeds 240 minutes. Also, transit is unavailable intrazonally and if the transit network is disconnected; only one park and ride alternative is available; car driver is unavailable if household has no cars.

Improvement of constraints is an important objective, and could substantially improve model results. Time and space constraints, in particular, are an important element of activity-based travel theory.

---

8 Handling the Enriched Sample — **Specifies the dimensions of the model system which require special estimation procedures, the special procedures required, and the weighting factors which should be used.**

1. 8.1 It is not clear whether the observations selected from park and ride lot users were included in the estimation data set and, if so, whether the estimation procedures were properly adjusted to achieve consistent estimation.

9 Primary work tour explanatory variables

This section defines variables which may be important in the various models which comprise the work tour.

1. 9.1 The implemented models include the standard basic travel time and travel cost variables, with value of time fixed by SP models. Distance and zonal attributes are used to distinguish destination alternatives. Models make fairly sophisticated use of market segmentation in the utility functions.

   The more innovative variables suggested in the design were not included. These were either made possible by the activity pattern-based design, or expected to help the design achieve its potential. Some of them include (a) "proportion of time spent in activity", an activity-based enhancement of the basic level of service variables; (b) attributes of non-motorized modes, and pedestrian attributes of work destinations, expected to influence pattern and mode selection; (c) path deviation for stops on the way to or from tour destination, an attribute of secondary stop locations, (d) attributes of the daily pattern expected to influence mode and destination choice.

Summary

We present, in priority order, a list of model development objectives aimed at implementing features of the demonstration system design that were deferred in the congestion pricing project, and some additional desirable features that were omitted from the original design.

Priority	Item(s)	Objectives
		Technical Corrections
1	6.2, 8.1	Correct any procedural mistakes related to alternative sampling and enriched sampling
		Important Design Features
2	1.1	Include primary tour time of day in the daily activity pattern and remove the accessibility linkage of the time-of-day models.
3	1.3, 6.1(e)	Incorporate disaggregate secondary stop models, possibly with a timing dimension, in the conditionality and accessibility hierarchy.
4*	1.4	Condition models on principal workplace.
5*	4.1	Incorporate purpose-specific size variables in destination choice models.
6	7.1	Implement availability constraints, focusing on time and space constraints
7	9.1	Add explanatory variables related to the activity basis of the design.
		Challenging Desirable Features
8*	1.4	Model principal workplace, residential location and long-term household activity pattern choices.
9	2.1	Disaggregate location zones to 1 acre grid cells.
10*	2.2	Enhance the definition of time periods and how they are included in the system hierarchy, with a focus on times in and near the peak period, where congestion induced behavioral shifts occur.
		Low Priority Items
11	6.3	Test sequentially estimated nested destination and mode choice models
12	1.2	Revise nonwork tour hierarchy to use primary, secondary and tertiary stops.
13	6.1	Enhance the alternative sampling scheme to capture more information for model estimation
14	3.1	Improve data interpretation rules.

* These objectives extend the original design.

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