San Francisco Travel Demand Forecasting Model Development

Tour Generation &
Time of Day Models

Final Report

prepared for
San Francisco County Transportation Authority

prepared by
Cambridge Systematics, Inc.

Updated by:
San Francisco County Transportation Authority

October 1, 2002

Table of Contents

Introduction

This report documents the estimation of models to predict the generation of tours and trips and the time periods during which those tours and trips are made. Like the rest of the models for the San Francisco travel demand forecasting model development project, these models were estimated using the 1990 MTC Bay Area Travel Survey (BATS).

This work is based on the "full day pattern" activity modeling approach, first introduced by Bowman and Ben-Akiva (Bowman 1998), and recently updated in the course of projects for Portland METRO (Bradley et al. 1998) and in this project.

The main feature of the day pattern approach is that it simultaneously predicts the main components of all of a person's travel across the day. This includes the frequency of five types of tours:

- Home-based work primary tours
- Home-based education primary tours
- Home-based other primary tours
- Home-based secondary tours
- Work-based sub-tours

A home-based tour includes the entire chain of trips made between leaving home and arriving back at home. The "primary" home-based tour is defined as the main home-based tour made during the day. If a worker makes a work tour or a student makes an education tour, then that is always the primary tour. If there are no work or education tours, the primary tour is the tour with the highest priority activity at the destination (shopping/personal business, followed by social/recreation, followed by serve passenger). If there are two or more tours with the same activity priority, then the one with the longest duration of stay at the destination is the primary tour. All other home-based tours are designated as "secondary" tours. A special type of tour is a work-based "subtour", defined as the entire chain of trips made between leaving the primary workplace and returning back to that workplace in the same day. A half-tour is comprised of the entire set of trips from the origin to the tour destination or from the destination back to the origin.

Figure 1 illustrates the differences between tour types. Figure 2 shows where the tour generation and time of day models fit within the San Francisco model system.

Figure 1. Illustration of "Full Day Tour Pattern"

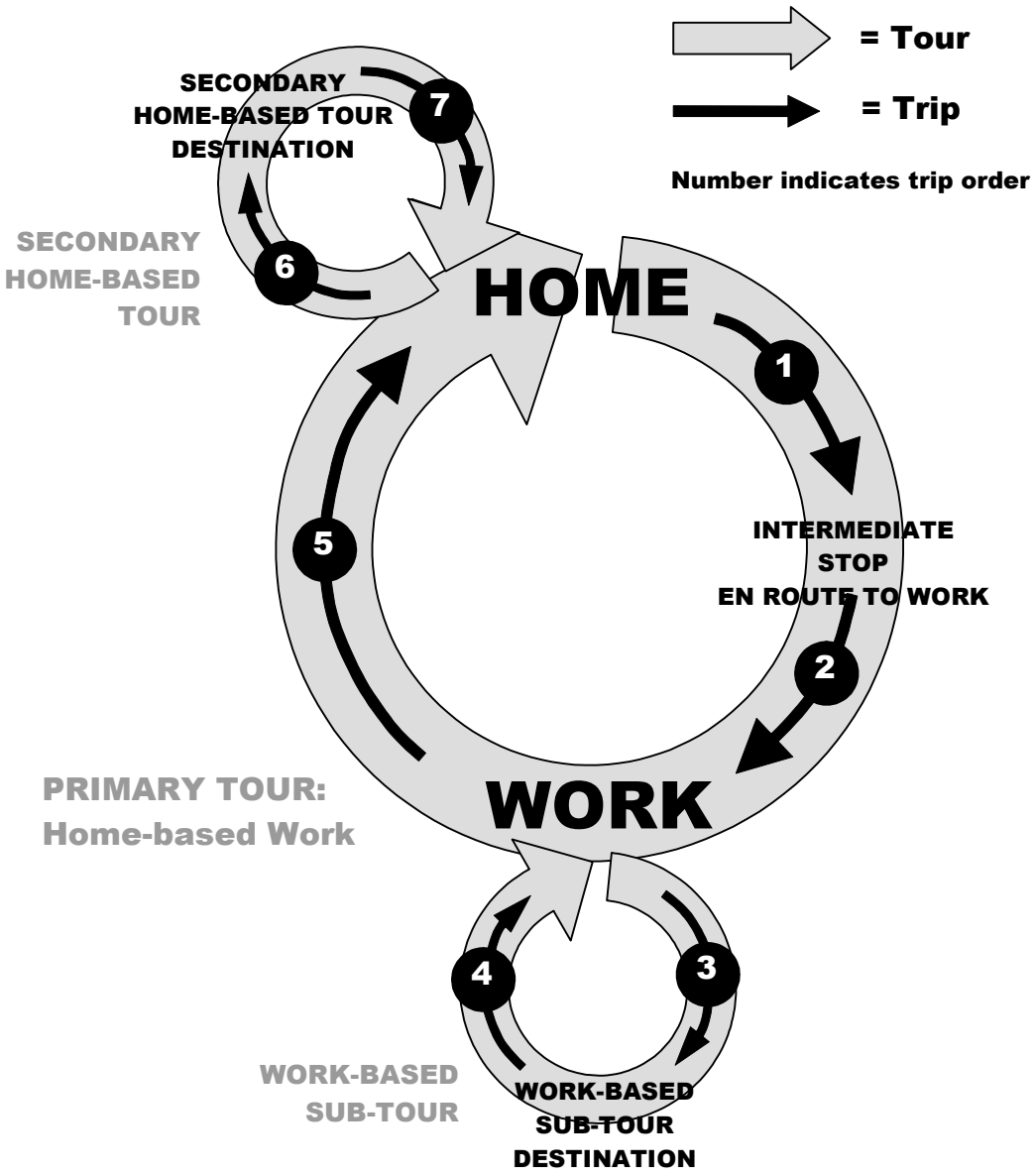
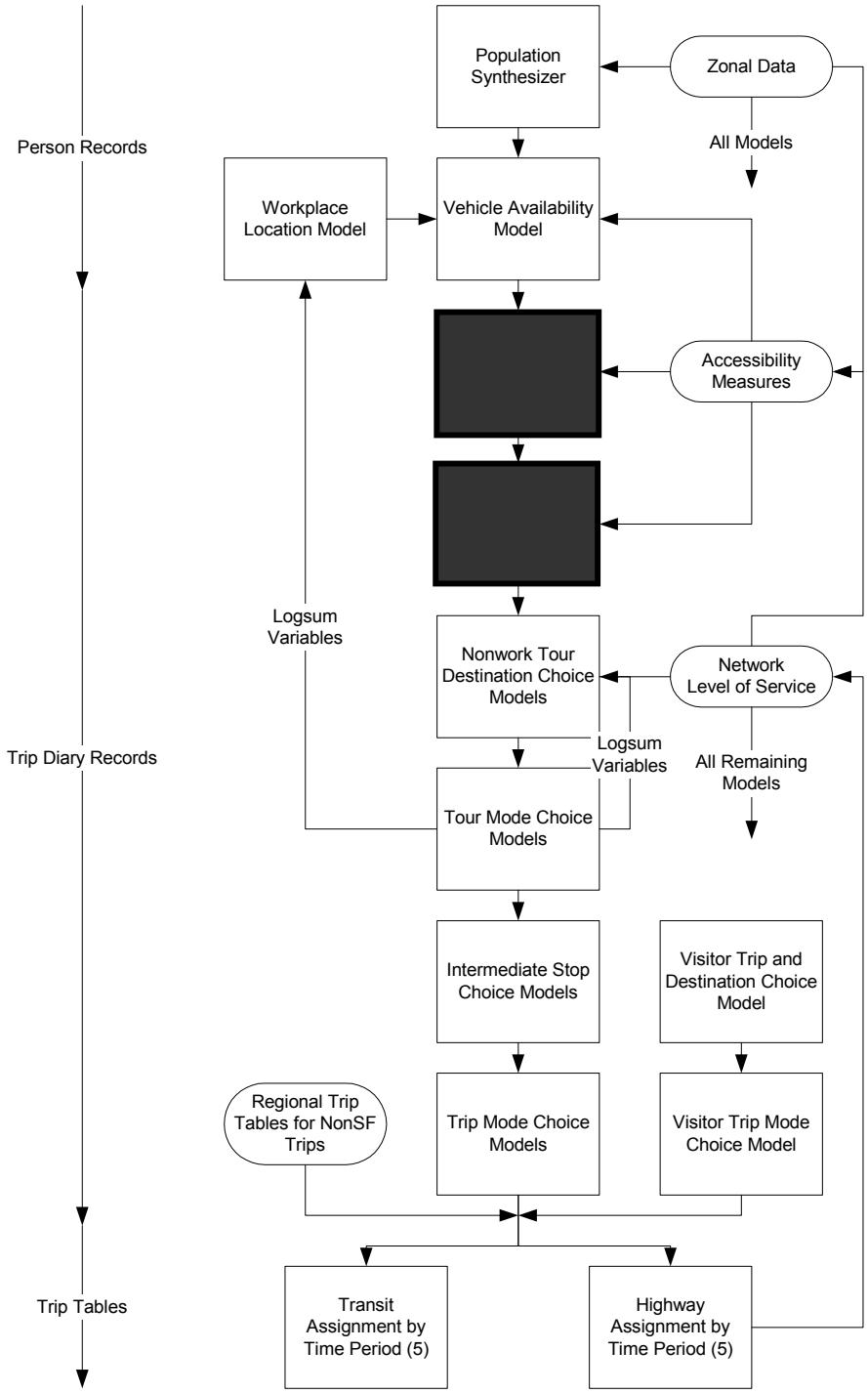


Figure 2. San Francisco Model System



Overview

Table 1 below lists the sequence of models described in this report. The first type of model, the "full day tour pattern" model, is the most critical, as it predicts the key inputs to the subsequent models. As the Outs in the first row of the table indicate, this model predicts:

- The purpose class of the primary tour (work, education, other, or none)
- The trip chain type of the primary tour (extra stops before, after, neither, or both)
- The frequency of home-based secondary tours (0, 1, or 2+)
- The frequency of work-based subtours (0 or 1+)

The second type of model is the time of day model for primary home-based tours. This model is conditional on the type of pattern predicted by the full day pattern model. It predicts the period when the traveler leaves home to begin the primary tour, simultaneously with the period when the traveler leaves the primary destination to return home. The time periods used for the models are defined as:

- Early (3:00 AM to 5:59 AM)
- AM peak (6:00 AM to 8:59 AM)
- Midday (9:00 AM to 3:29 PM)
- PM peak (3:30 PM to 6:29 PM)
- Late (6:30 PM to 2:59 AM)

Excluding overnight tours, of which there are almost none in the data, there are fifteen possible combinations of these five periods.

The next six models in Table 1 simply fill in the remaining details for the secondary tours and work-based subtours, if any. These details are:

- The exact number of such tours in the day (up to 4 of each type are possible)
- The trip chain type of each tour (extra stops before, after, neither, or both)
- The departure time period combination for each tour (the same 15 categories as described above).

The last two "models" in Table 1 fill in the remaining details for each tour in the pattern that has intermediates stops. These details are:

- The exact number of intermediate stops on each tour leg (up to 4 are possible)
- The departure time period from each intermediate stop (the 5 periods above)

The remainder of this memo describes each of the model types in further detail. The most detail is provided for the first two types: the full day pattern models and the primary tour time of day models. These two predict the structure of the activity pattern, and are estimated using full logit choice models. The remaining types fill in the details of the activity pattern, conditional on the predicted structure. These are simple classification models, based on observed distributions in the survey data.

Table 1: Sequence of Models (In = input to the model, Out = output from the model)

Aspect	Primary Home-based Tour			Secondary Home-based Tours				Work-based Tours				Tour Segments	
Aspect	class	chain	time	class	num	chain	time	class	num	chain	time	num	time
Categories	*4*	*4*	*15*	*3*	*4*	*4*	*15*	*2*	*4*	*4*	*15*	*4*	*5*
Full day tour pattern (tables 6-8)	Out	Out		Out				Out					
Primary tour times of day (tables 10-12)	In	In	Out	In				In					
Number of secondary tours (table 13)	In	In		In	Out			In					
Secondary tour chain type (table 15)	In	In			In	Out		In					
Secondary tour times of day (table 16)	In		In		In		Out						
Number of work-based tours (table 14)	In	In		In				In	Out				
Work-based tour chain type (table 15)	In	In							In	Out			
Work-based tour times of day (table 16)	In		In						In		Out		
Number of tour segments (tables 17-18)	In	In			In	In			In	In		Out	

The full day pattern models

Input data

A good deal of work was done examining the 1990 BATS survey data to ensure data quality. Although MTC had already processed this data for its trip-based modeling, the requirements for tour-based modeling in SF county were more rigorous. We needed to geocode locations in San Francisco county at a finer level of detail, and to check the consistency of trip times, purposes and locations across entire chains of trips. This resulted in a good deal of additional data cleaning and screening.

Only residents of San Francisco county were included in the sample for model estimation. Because the sample sizes were limited, we included both the single-day sample and multi-day survey samples. This introduces some serial correlation into the models, since what we are treating as different observed persons may actually be the same person on different days. The majority of records, however, are from the single day sample.

For purposes of estimation, four different person types were defined:

- **Children**: Anyone under age 16
- **Working adults**: Anyone age 16+ who has employment status "employed full time" or "employed part time" OR whose primary tour was for work, with a stay of at least 2 hours at the primary destination
- **Student adults**: Anyone age 16+ who has employment status "full time student" or "part time student" OR whose primary tour was for education, with a stay of at least 2 hours at the primary destination
- **Other adults**: All other people age 16+

Table 2 below shows that the total sample includes 3519 person-days, of which about 63% are working adults, 11% are student adults, 21% are other adults, and only 8% are children age 5 to 15. This percentage of children seems low, but is generally confirmed by the latest 2000 census information, which shows 10% of the San Francisco population is aged 5 to 18.

Table 2 also shows the number of tours in the estimation data by each person type. There are 4176 tours in total. The tours and purpose types are defined in such a way that primary work tours can only be made by workers and primary education tours can only be made by students or children. Other primary tours and secondary tours can be made by all person types. Working adults make more than 1 tour per person-day on average, students and children make slightly less than 1 tour per person-day, and other adults travel the least. Overall, slightly over half of all tours are made either to work or are based from work.

Table 2: Tours made by person type

	Working adults	Student adults	Other Adults	Children under 16	All people
Number of person-days	2203	397	736	283	3519
Primary work tours	1758				1758
Primary education tours		211		207	418
Other primary tours	189	39	409	39	676
Secondary tours with work tour	494				494
Secondary tours with education tour		78		23	101
Secondary tours with other tour	125	27	166	10	328
Work-based subtours	401				401
Total tours	2967	355	575	279	4176

Table 3 shows the number of tours classified by the purpose of the primary tour. Of the 4176 tours, 63% are made by people who make a work tour during the day.

Table 3: Tours made by primary tour purpose

	Work patterns	Education patterns	Other patterns	All patterns
Primary work tours	1758			1758
Primary education tours		418		418
Other primary tours			676	676
Secondary tours w/ work tour	494			494
Secondary tours w/ education tour		101		101
Secondary tours w/ other tours			328	328
Work-based subtours	401			401
Total tours	2653	519	1004	4176

Table 4 shows the various types of tours available as alternatives in the full day pattern choice models. There are 16 primary tour types, 8 for work, 4 for education and 4 for other, based on the presence of intermediate stops before and after the primary tour destination. (The primary destination of the tour is the activity with the highest priority or, in the case of a tie, the activity with the longest duration of stay. Changes of mode were not treated as intermediate stops.) There are three secondary tour frequency classes – 0, 1 or 2+. This gives 16 x 3 or 48 travel alternatives. The forty-ninth alternative is not to make any tours – i.e. to stay at home all day (or at least to report that that was the case). The table shows that the staying at home alternative was not selected very often by workers or students – only about 12% of the time in each case. Among other adults, however, 44% reported no travel. Even accounting for the fact that many of this group are senior citizens, this percentage of stay-at-homes seems unrealistically high. Thus, there may be a need to adjust the overall tour rates upwards during the model calibration process. (This is a common problem of travel surveys.)

The blank areas of Table 4 show the alternatives that are not possible for a given person-type. Each of the remaining possible alternatives has been chosen by at least one person in the sample, with the exception of a single one (an "other" primary tour with intermediate stops before both and after and 2+ secondary tours made by a student). By far the most common pattern type overall is a simple work tour with no intermediate stops and no secondary tours. (Again, some of this reported simplicity may be due to failure to report some intermediate stops or extra tours.)

Table 4: Distribution of full day patterns in estimation sample

		Working Adults			Students / Children			Other Adults		
Person-days		2203			580			736		
Secondary	Tours	0	1	2+	0	1	2+	0	1	2+
Primary tour purpose	Primary tour type									
Work	No stops	708	163	29						
Work	Before	101	25	1						
Work	After	199	45	11						
Work	Both	92	30	5						
Work	Subtour	112	60	10						
Work	Sub+ Before	20	3	2						
Work	Sub+ After	71	21	3						
Work	Sub+ Both	35	11	1						
Education	No stops				250	48	12			
Education	Before				23	3	2			
Education	After				47	8	3			
Education	Both				20	1	1			
Other	No stops	66	29	18	32	11	4	174	54	16
Other	Before	11	9	1	7	1	1	47	16	9
Other	After	12	9	8	10	3	3	47	10	4
Other	Both	14	9	3	5	1	0	17	10	5
No tours	Not Applicable	256			84			327		

Pattern model estimation results

Potential variables available to include in the models are listed in Table 5. The person and household characteristics in the first group are controlled for in synthetic sampling, and are expected to be key determinants of activity patterns. The person and household characteristics in the second group are available in both the estimation and application (PUMS) data sets, but are not controlled for in generating the synthetic sample. Ethnicity and building type distributions in particular are not likely to be transferable across all

zones within a PUMA without some type of control. For that reason, these variables will not be used in the models unless it appears critical to include them. Variables concerning driving licenses are not available in PUMS. If these variables prove important, it may be necessary to make some assumption in application – such as anyone age 16+ is a driver.

The remaining variables in Table 5 are available in the estimation data, but will be endogenous to the model system in application. Residence location zone is an output of the synthetic sampling procedure. Workplace location zone for workers and household vehicle ownership will be predicted by higher level models in the system.

Table 5: List of potential variables

Variables	Comments
• Age • Gender • Employment status • Household adults • Household children • Household workers • Household income	Available in both BATS and PUMS. Controlled in synthetic sampling.
• Occupation • Job position • Ethnicity • Residence building type • Owner/renter • Years lived at residence	Available in both BATS and PUMS, but NOT controlled in synthetic sampling.
• Driving license status • Household drivers	Available in BATS, but NOT in PUMS
• Vehicles owned by household	Available in BATS. Endogenous in model system.
• Residence location	Available in BATS. Endogenous to synthetic sampling.
• Workplace location	Available in BATS Endogenous in model system.
• Residence land use/accessibility • Workplace land use/accessibility • Home to work travel times	Available in base year land use and network data. Travel times and accessibility endogenous in model system.

The last group of variables in Table 5 is critical, as these provide the feedback from the lower levels of the model system that determine network loadings and speeds. As service levels change, they influence accessibility measures such as the numbers of jobs accessible by road and transit from the home and work zones during peak and off-peak periods, as well as travel times between home and work. Because we are not using a full nested

structure with logsums from lower levels, these simpler accessibility measures are necessary to provide feedback from networks to activity/tour patterns.

Tables 6, 7 and 8 present the results of full day pattern choice models estimated for working adults, students/children and other adults respectively. Each model contains a number of utility components, corresponding to:

- The utility of making a primary tour for each purpose class
- The utility of making intermediate stops on primary tours for each purpose
- The utility of making work-based subtours during work tours
- The utility of making secondary tours

Each of these components is shown separately in the tables. A positive coefficient indicates a higher probability of making a particular type of tour or pattern, while a negative coefficient indicates a lower probability – all relative to the "base" alternative of not traveling at all.

There may be a number of different alternative-specific constants within a single component. For example, most of the variables in the utilities for intermediate stops apply to both stops before and stops after the primary destination, but there are separate constants for the two cases. The utility for stops both ways is equal to the utility of stops before plus the utility of stops after, plus an additional constant term. Similarly, the constants for work-based tour and secondary tour utilities can vary depending on what type of primary tour they are combined with.

For the worker and student models, a nested structure was estimated, nesting all alternatives within each primary tour purpose separately, and then nesting all of the travel alternatives separately from the "no travel" alternative.

Without doing an exhaustive description of the estimation results, some important points to note are:

- The segmentation into the three person types itself accounts for much of the difference in tour patterns. There is not much residual systematic variation in terms of who chooses to travel versus not travel, or travel for work or education versus other purposes. There is more systematic variation as to who makes intermediate stops and secondary tours.
- Age is a crucial variable in the model for student and child patterns and somewhat important for other adults, but not very important in the worker model.
- Compared to full-time workers, part-time workers are more likely to make primary non-work tours and to make secondary tours.
- Not having a car in the household is often related to fewer tours and/or stops. For those who can drive and have one or more cars, competition for cars in the household (fewer cars than adults) is sometimes related to fewer intermediate stops but more secondary tours – i.e. less trip chaining.

- For work and education, the logsum coefficients are significantly lower than 1.0, supporting the nesting structure tested: i.e. people are more likely to shift between different activity patterns within the same type (e.g. more or less trip chaining as part of a work tour pattern) than they are to shift to another primary purpose or to not traveling at all.
- Many of the land use and accessibility variables are at least marginally significant:
- Being able to reach more jobs by car somewhat increases the likelihood of a work pattern.
- Being able to reach more retail and service businesses by car increases the probability of making intermediate stops on a primary tour, but having those same businesses within walking distance of home decreases the probability of intermediate stops – people are more likely to go to those places as part of separate home-based tours instead.
- Work-based tours are more likely if the work place is in a location with retail and service businesses nearby. These tend to be instead of stops on the way to or from work.
- Having more retail and service employment within 15 minutes by car in the off-peak increases the probability of making primary non-work tours and stops and secondary tours.
- Land use and accessibility do not have much influence on the patterns for students and children.

Table 6: Working adult full day pattern choice model

Summary Statistics		
Observations	2170	
Final log-likelihood	-5450.1	
Rho-squared (const)	.023	
Rho-squared (0)	.305	
Variable	**Coefficient**	**T-statistic**
Work primary tour pattern utility		
- Age 25-34	2.716	2.2
- No car in household	2.528	1.0
- Less than 1 car per adult in household	.543	0.8
- Total employment within 15 minutes by car in PM peak (000)	.0324	1.5
- Constant	18.58	1.9
Work tour intermediate stop utility		
- No kids in household	-.405	-4.6
- Female, kids under 5	.318	2.1
- Couple, non-worker in household	-.414	-4.9
- No car in household	-.375	-3.1
- Retail + service emp within 15 minutes by car in PM peak (000)	.00957	1.9
- Retail + service employment within half mile (000)	-.0313	-1.5
- Retail + service employment within half mile of work (000)	-.0174	-2.6
- Stop before constant	-1.538	-10.5
- Stop after constant	-.841	-6.4
- Stops both ways constant	1.141	7.8
Work-based sub-tour utility		
- Income under $30,000	-.609	-3.0
- No car in household	-.981	-4.4
- Less than 1 car per adult in household	-.747	-5.6
- Retail + service employment within half mile of work (000)	.0239	2.4
- Constant	-1.336	-10.9
- Combine with stop before work	-1.359	-5.8
- Combine with stop after work	-.743	-5.0
- Combine with stops both ways	-.766	-4.1
Other primary tour pattern utility		
- Part time worker	4.601	2.2
- No car in household	1.718	2.5
- Retail + service emp within 15 minutes by car in off-peak (000)	.0197	1.9
- Constant	9.167	1.1

Table 6: Working adult full day pattern choice model (continued)

Other tour intermediate stop utility		
- No car in household	-.485	-1.6
- Less than 1 car per adult in household	-.508	-2.2
- No kids in household	-.339	-1.5
- Retail + service emp within 15 minutes by car in off-peak (000)	.0197	1.9
- Retail + service employment within half mile (000)	-.1195	-1.6
- Stop before constant	-1.570	-4.1
- Stop after constant	-1.198	-3.3
- Stops both ways constant	1.496	4.0
Secondary tours utility		
- Single adult in household	.535	4.1
- Part time worker	.732	4.1
- Age 25-34	.338	3.0
- No car or no license	-.782	-4.5
- Retail + service emp within 15 minutes by car in off-peak (000)	.0114	3.3
- One with a work tour constant	-1.962	-14.8
- One with a work tour and subtour constant	.458	3.2
- Two with a work tour constant	-3.706	-19.6
- Two with a work tour and subtour constant	.441	1.5
- One with an "other" primary tour constant	-1.195	-5.8
- Two with an "other" primary tour constant	-1.853	-7.7
Logsums		(vs.1.0)
- Across all travel alternatives	.358	4.8
- All alternatives within each primary purpose	.246	7.5

Table 7: Student/child full day pattern choice model

Summary Statistics		
Observations	571	
Final log-likelihood	-1121.8	
Rho-squared (const)	.044	
Rho-squared (0)	.390	
Variable	**Coefficient**	**T-statistic**
Education primary tour pattern utility		
- Age 5-11	1.103	2.5
- Age 12-15	1.099	2.3
- Age 16-19	1.046	2.3
- Age 20-24	.952	2.1
- Age 25-34	2.199	3.7
- Constant	3.407	0.9
Education tour intermediate stop utility		
- Age 5-11	-.726	-3.0
- Age 12-15	-.719	-2.8
- Age 16-19	-.552	-1.9
- Less than 1 car per adult in household	-.491	-2.1
- Stop before constant	-1.825	-7.4
- Stop after constant	-1.097	-5.4
- Stops both ways constant	1.457	4.5
Other primary tour pattern utility		
- Female with children under 5	1.018	2.3
- Retail + service emp within 15 minutes by car in PM peak (000)	.0125	1.2
- Constant	2.096	0.6
Other tour intermediate stop utility		
- No kids in household	.732	2.2
- Stop before constant	-1.910	-4.9
- Stop after constant	-1.399	-4.2
- Stops both ways constant	.585	0.9
Secondary tours utility		
- Male, single adult in household	1.116	2.6
- Income over $60,000	1.704	5.4
- Age 20 or less	-1.243	-4.0
- No car in household	-.473	-1.6
- One with an education tour constant	-1.117	-5.4
- One with an education tour and stops both way	-1.531	-1.5
- Two with an education tour constant	-2.348	-8.3
- One with an "other" primary tour constant	-.693	-2.1
- Two with an "other" primary tour constant	-1.520	-3.5
Logsums		(vs. 1.0)
- Across all travel alternatives	.337	2.8

Table 8: Other adult full day pattern choice model

Summary Statistics		
Observations	729	
Final log-likelihood	-1223.8	
Rho-squared (const)	.025	
Rho-squared (0)	.345	
Variable	**Coefficient**	**T-statistic**
Primary tour pattern utility		
- No kids in household	.493	2.5
- Constant	-.999	-5.7
Primary tour intermediate stop utility		
- Less than 1 car per adult in household	-.303	-1.9
- No kids in household	.324	1.5
- Age 65 or over	-.279	-1.8
- Retail + service emp within 15 minutes by car in off-peak (000)	.00714	1.0
- Retail + service employment within half mile (000)	-.109	-2.1
- Stop before constant	-1.239	-4.2
- Stop after constant	-1.408	-4.7
- Stops both ways constant	.233	0.7
Secondary tours utility		
- Age 25-34	1.030	3.3
- Age 65 or over	.379	1.6
- No car in household	-1.360	-4.9
- Less than 1 car per adult in household	-.754	-3.2
- One with an "other" primary tour constant	-.850	-3.6
- One with an "other" primary tour with stops both ways	.536	1.2
- Two with an "other" primary tour constant	-1.936	-6.8
- Two with an "other" primary tour with stops both ways	1.035	1.9

Primary tour time of day models

Input data

Table 9 shows the chosen departure time period combinations for each of the three types of primary tours in the estimation data set. There are virtually no Education or Other tours that begin in the Early period before 6 AM. There are some Work tours that begin that early, with almost all of those ending either in the Midday or PM peak period. Also, tours beginning after 3:30 PM in the PM peak or Late periods are very rare for Work and Education, but more common for Other primary tours.

The majority of Work tours are AM peak-PM peak, with most of the remaining tours in AM peak-Midday, AM peak-Late, Midday-PM peak and Midday-Late. Almost all Education tours are either AM peak-Midday or AM peak-PM peak. Other primary tours are the most heterogeneous, with Midday-Midday and Midday-PM peak being the most common combinations.

Table 9: Departure Time Combinations for Primary Tours

	Primary Work	Primary Education	Other Primary	All Primary
EE-Early-Early	1	0	0	1
EA-Early-AM peak	2	0	0	2
EM-Early-Midday	53	1	1	55
EP-Early-PM peak	21	0	0	21
EL-Early-Late	1	0	0	1
AA-AM peak-AM peak	2	1	22	25
AM-AM peak-Midday	172	240	68	480
AP-AM peak-PM peak	984	103	21	1108
AL-AM peak-Late	167	7	9	183
MM-Midday-Midday	51	28	310	389
MP-Midday-PM peak	148	25	102	275
ML-Midday-Late	115	8	23	146
PP-PM peak-PM peak	0	0	45	45
PL-PM peak-Late	25	4	36	65
LL- Late-Late	16	1	39	56
Total	1758	418	676	2852

The input variables available for use in the tour time of day models are the same as for the day pattern models. In addition, the time of day models are conditional on the predictions from the day pattern models, so a few further input variables are possible:

- Whether or not intermediate stops are made during the tour

- Whether or not work-based subtours are made
- Whether or not other secondary home-based tours are made

Including these endogenous variables will ensure that certain types of tours and tour patterns are more likely to occur at certain times of day. For instance, tour legs with intermediate stops are more likely to be made during periods when most stores are open, and primary tours that are followed by secondary tours may tend to be made earlier in the day.

Time of day model estimation results

Tables 10, 11, and 12 show estimation results for primary Work, Education and Other tours respectively. The utility function for each time period combination is shown separately. In cases where there are very few observations, only a constant term was estimated, and these alternatives are grouped in the table (e.g. the "Early period" constants in Table 10). In cases where there were no observed choices at all, a constant was fixed at –10.0, ensuring a negligibly low probability of choosing that combination (e.g. most of the "Early period" alternatives in Table 11). Otherwise, a separate constant was estimated for each of the 15 alternatives except for a single "base" alternative. The base alternative was defined as the one with the most demand – AM peak-PM peak for Work, AM peak-Midday for Education, and Midday-Midday for Other. As a result, all of the constants for the other periods have negative coefficients.

Some important results to note are:

For Work tours (Table 10):

- Part time workers are more likely to choose the AM peak-Midday, Midday-PM peak, PM peak-Late and Late-Late combinations.
- Those with secondary tours during the day are more likely to return from work during the Midday, and less likely to return Late.
- Those who make one or more intermediate stops on the way home from work are most likely to be coming home from work in the Midday period, and more likely to be coming home in the PM peak than in the Late period.
- Those with high incomes, those under age 35, and those making stops on the way to work are more likely to work long hours (the AM peak-Late combination).
- Those under age 20 are more likely to work evenings.
- Those with a work-based subtour in the pattern are more likely to work AM peak to PM peak.
- Higher network accessibility to employment during slightly increases the probability of traveling in that period. This is truer for the outbound period than for the return period, and truer for auto accessibility than for transit.

For Education tours (Table 11):

- Those with secondary tours during the day are more likely to start the tour later (Midday) and less likely to end the tour later (PM peak or Late).
- Those under age 20 are more likely to choose the AM peak-Midday combination. Those age 5-11 are most likely to be in school AM peak to PM peak, while those age 25-34 are most likely to begin school later in the Midday.
- Those making intermediate stops on the way home from school are more likely to choose the Midday-Midday combination.
- The network accessibility to service employment (under which schools are included) somewhat increases the probability of traveling in a period. Again, the effect is strongest for auto accessibility in the outbound period, and weak for transit.

For Other primary tours (Table 12):

- Full-time workers and those under age 35 are more likely to travel after 6:30 PM (Late), while those over age 65 are most likely to travel entirely within the Midday period. Those under 16 are most likely to begin their tour in the AM peak.
- Those making a stop on the way to the primary destination are more likely to choose the Midday-Late combination, while those with no stops are least likely to choose Late-Late.
- Those with secondary tours during the day are most likely to begin the primary tour during the PM peak.
- The network accessibility to retail and service establishments has a positive but very weak correlation with the probability of traveling in a period. These tend to be less frequent off-peak trips that are less influenced by congestion than are regular work and school trips.

In general, there is strong relationship between the day pattern type (primary tour purpose, stops before and after the main destination, secondary tours) and the time periods during which the tour is made. This result reinforces the importance of modeling pattern choice in order to predict realistic shifts in time of day distributions.

Table 10: Work primary tour time of day choice model

Summary Statistics		
Observations	1729	
Final log-likelihood	-2486.8	
Rho-squared vs. Constants	.0751	
Rho-squared vs. 0	.4689	
Variable	**Coefficient**	**T-statistic**
Early period utilities		
- Early-Early constant	-6.734	-6.6
- Early-AM peak constant	-5.869	-8.1
- Early-PM peak constant	-3.521	-12.6
- Early-Late constant	-6.734	-6.6
- AM peak-AM peak constant	-5.671	-8.0
Early-Midday utility		
- Constant	-3.187	-11.7
- Secondary tours in pattern	.889	3.1
- Stop after work	1.130	3.5
AM peak-Midday utility		
- Constant	-2.377	-14.1
- Part time worker	2.122	8.0
- Secondary tours in pattern	.629	3.4
- Stop after work	2.088	9.9
AM peak-PM peak utility		
- 2+ secondary tours in pattern	-1.244	-4.0
- Work-based subtour in pattern	.724	4.7
- Stop after work	.826	5.4
- Female	.375	3.7
- Couple, with non-working adult in household	.242	2.2
AM peak-Late utility		
- Constant	-2.061	-9.9
- Age under 35	.638	3.7
- Income over $60,000	.882	4.8
- Secondary tours in pattern	-1.435	-5.0
- Work-based subtour in pattern	1.193	5.3
- Stop before work	.568	2.7
Midday-Midday utility		
- Constant	-3.899	-13.2
- Part time worker	2.760	7.8
- Secondary tours in pattern	.859	2.8
- Stop after work	2.173	6.7

Table 10: Work primary tour time of day choice model (continued)

Variable	Coefficient	T-statistic
Midday-PM peak utility		
- Constant	-1.027	-5.4
- Part time worker	1.346	4.4
- No intermediate stops	-.668	-3.4
Midday-Late utility		
- Constant	-1.900	-11.1
- Part time worker	1.201	3.3
Late period utilities		
- PM peak-PM peak constant	-10.0	Fixed
- PM peak-Late constant	-3.504	-13.8
- Late-Late constant	-4.154	-12.5
- Age under 20	1.560	2.4
- Part time worker	1.726	3.8
Accessibility variables (included in all utilities)		
- Total employment within 15 minutes by auto, outbound period (000)	.00234	2.4
- Total employment within 15 minutes by auto, return period (000)	.00130	1.9
- Total employment within 30 minutes by transit, outbound (000)	.00081	0.9
- Total employment within 30 minutes by transit, return period (000)	.00010	0.2

Table 11: Education primary tour time of day choice model

Summary Statistics		
Observations	411	
Final log-likelihood	-436.9	
Rho-squared (const)	.1356	
Rho-squared (0)	.6075	
Variable	**Coefficient**	**T-statistic**
Early period utilities		
- Early-Early constant	-10.0	Fixed
- Early-AM peak constant	-10.0	Fixed
- Early-Midday constant	-6.488	-4.2
- Early-PM peak constant	-10.0	Fixed
- Early-Late constant	-10.0	Fixed
- AM peak-AM peak constant	-4.348	-4.3
AM peak-Midday utility		
- Age under 20	1.663	6.4
AM peak-Late period utilities		
- AM peak-PM peak constant	.341	1.5
- AM peak-Late constant	-2.890	-5.0
- Secondary tours in pattern	-1.618	-3.8
- Age 5-11	.751	2.7
Midday-Midday utility		
- Constant	-2.302	-5.3
- Secondary tours in pattern	1.135	2.5
- Stop after school	1.458	3.3
Midday-Late period utilities		
- Midday-PM peak constant	-1.687	-3.3
- Midday-Late constant	-3.441	-4.9
- Age 25-34	1.837	4.2
- No intermediate stops	-.878	-2.0
Late period utilities		
- PM peak-PM peak constant	-10.0	Fixed
- PM peak-Late constant	-3.556	-5.3
- Late-Late constant	-7.163	-4.4
Accessibility variables (included in all utilities)		
- Service employment within 15 minutes by auto, outbound period (000)	.07000	2.4
- Service employment within 15 minutes by auto, return period (000)	.02032	1.2
- Service employment within 30 minutes by transit, outbound per. (000)	.01271	0.4
- Service employment within 30 minutes by transit, return period (000)	0	Fixed

Table 12: Other primary tour time of day choice model

Summary Statistics		
Observations	667	
Final log-likelihood	-1116.4	
Rho-squared (const)	.0593	
Rho-squared (0)	.3820	
Variable	**Coefficient**	**T-statistic**
Early period utilities		
- Early-Early constant	-10.0	Fixed
- Early-AM peak constant	-10.0	Fixed
- Early-Midday constant	-5.479	-5.4
- Early-PM peak constant	-10.0	Fixed
- Early-Late constant	-10.0	Fixed
AM peak-early period utilities		
- AM peak-AM peak constant	-2.227	-8.3
- AM peak-Midday constant	-1.125	-5.6
- No intermediate stops	-.519	-2.2
- Age under 16	1.296	3.1
- Non-working adult with kids	.722	2.4
AM peak-PM peak utility		
- AM peak-PM peak constant	-2.757	-10.0
AM peak-late period utilities		
- AM peak-Late constant	-3.736	-9.1
- Age under 16	2.664	5.9
Midday-Midday utility		
- Age over 65	.969	5.5
Midday-PM peak utility		
- Constant	-.751	-5.5
Midday-Late utility		
- Constant	-3.033	-7.7
- Stop before primary destination	1.577	3.6
PM peak-PM peak utility		
- Constant	-2.504	-6.8
- No intermediate stops	.790	2.2
- Secondary tours in pattern	.865	2.7
PM peak-Late utility		
- Constant	-2.289	-7.3
- Secondary tours in pattern	.786	2.3
Late-Late utility		
- Constant	-3.955	-6.7
- Secondary tours in pattern	.877	2.5
- No intermediate stops	1.582	3.2
- Age under 35	.702	2.0
- Full time worker	.551	1.5
Accessibility variables (included in all utilities)		
- Retail + service emp. within 15 minutes by auto, outbound period (000)	.00500	1.2
- Retail + service emp. within 15 minutes by auto, return period (000)	.00304	0.6
- Retail + service emp. within 30 minutes by transit, outbound per. (000)	.00500	1.2
- Retail + service emp. within 30 minutes by transit, return period (000)	0	Fixed

Additional Models

The remaining Tables 13 to 20 show the classification models that are used to fill in the remaining details of the full day pattern, until the whole day's travel can be broken down into a sequence of separate trips, each beginning during a specific period of the day. Each of these tables is a "classification model", based on observed fractions for SF county households in the BATS 1990 estimation data set. The classification models simply add the required detail along the observed distributions. Each table shows a number of different classes down the left-hand columns, followed by the number of observed tours, followed by the distribution of observed probabilities across all of the relevant alternatives.

Table 13 is applied for those patterns with 2+ secondary tours, and each row gives the probability of making 2, 3 or 4 secondary tours as a function of the primary tour purpose, primary tour trip chain type and presence or absence of work-based subtours.

Table 14 is applied for those patterns with 1+ work-based subtours, and each row gives the probability of making 1, 2, 3 or 4 subtours as a function of the work tour trip chain type and the number of secondary tours made.

Table 15 is applied for each secondary tour and work-based subtour, and each row gives the probability of making intermediate stops before and/or after the primary destination as a function of the primary tour purpose and primary tour trip chain type.

Table 16 is also applied for each secondary tour and work-based subtour, and each row gives the probabilities of the various departure time combinations as a function of the primary tour purpose and the primary tour departure time combination. Note that there are many shaded cells in the table that are not possible because secondary tours must be carried out completely before or completely after the primary tour, while work-based subtours must be carried out completely within the work tour. (With this structure, it is possible to predict two or more secondary tours for the same person during overlapping times, but that will not present a problem in application.)

Tables 17 and 18 are applied for any half-tours with 1+ intermediate stops, and each row gives the probability of making 1, 2, 3 or 4 stops as a function of the tour purpose and priority and the tour trip chain type.

Finally, Table 19 is applied for each intermediate stop, and gives the departure time period from that stop as a function of the tour purpose, tour time period combination and stop sequence number (1st stop on half-tour, 2nd stop, etc.).

Table 13: Classification model for number of secondary tours

Classes			Distributions of Number of Secondary Tours		
Primary Tour Purpose	**Primary Tour Stops**	**Tours**	**2**	**3**	**4**
Work	No stops	29	86%	14%	
	Before	1	100%		
	After	11	73%	18%	9%
	Both	5	80%	20%	
	Subtour	10	80%	20%	
	Subtour+ Before	2	100%		
	Subtour +After	3	67%	33%	
	Subtour +Both	1	100%		
Education	No stops	12	92%	8%	
	Before	2	100%		
	After	3		100%	
	Both	1		100%	
Other	No stops	38	76%	16%	8%
	Before	11	73%	27%	
	After	15	73%	20%	7%
	Both	8	75%	25%	
Total	Total	152	78%	19%	3%

Table 14: Classification model for number of work-based subtours

Classes			Distributions of Number of Work-Based Subtours			
Work Tour Stops	**Secondary Tours**	**Tours**	**1**	**2**	**3**	**4**
No stops	None	112	89%	9%	2%	
	One	60	85%	8%	5%	2%
	2 or more	10	80%	10%	10%	
Before	None	20	95%	5%		
	One	3	100%			
	2 or more	2	100%			
After	None	71	90%	7%	1%	1%
	One	21	90%	10%		
	2 or more	3	67%	33%		
Both	None	35	83%	14%	3%	
	One	11	100%			
	2 or more	1	100%			
Total	Total	349	89%	9%	2%	1%

Table 15: Classification model for secondary and work-based tour trip chain types

Classes			Distributions of Tour Trip Chain Types			
Primary tour purpose	**Primary tour type**	**Tours**	**No stops**	**1+ Stops Before**	**1+ Stops After**	**1+ Stops Both**
Secondary Tours						
Work	No stops	225	79%	10%	7%	4%
	Before	27	74%	11%	15%	
	After	71	69%	8%	21%	1%
	Both	41	78%	7%	12%	2%
	Subtour	82	68%	11%	16%	5%
	Sub+Before	7	57%	14%	29%	
	Sub+After	28	71%	4%	18%	7%
	Sub+Both	13	62%	15%	15%	8%
Education	No stops	73	74%	8%	15%	3%
	Before	7	86%		14%	
	After	17	65%	24%	6%	6%
	Both	4	50%	50%		
Other	No stops	182	75%	7%	12%	6%
	Before	51	63%	20%	16%	2%
	After	57	72%	18%	11%	
	Both	38	58%	18%	13%	11%
Work-based Subtours						
Work	Subtour	213	84%	2%	9%	5%
	Sub+Before	26	69%	19%	8%	4%
	Sub+After	108	64%	9%	21%	6%
	Sub+Both	54	81%	7%	9%	2%
Total	Total	1324	74%	9%	13%	4%

Table 16: Classification model for secondary and work-based tour departure times *
(Shaded cells are not possible, E=Early, A=AM peak, M=midday, P=PM peak, L=late)

Classes			Distributions of Secondary Tour Departure Periods									
Primary tour purpose	**Primary tour periods**	**Tours**	**E-A**	**A-A**	**A-M**	**A-P**	**M-M**	**M-P**	**M-L**	**P-P**	**P-L**	**L-L**
Secondary Tours												
Work	E-M	32						9%		44%	19%	28%
	E-P	3								67%	33%	
	A-A	4		25%			50%					25%
	A-M	83		2%			11%	12%	4%	30%	14%	27%
	A-P	217		6%						12%	20%	62%
	A-L	17		12%								88%
	M-M	27		11%	4%		15%		4%	15%	19%	33%
	M-P	55		20%	11%		15%			4%	16%	35%
	M-L	29	3%	17%	31%		28%					21%
	P-L	20	5%	5%	5%	5%	50%	15%				15%
	L-L	7			14%		57%	29%				0%
Education	A-M	53					9%	28%	2%	21%	19%	21%
	A-P	7									29%	71%
	A-L	1										100%
	M-M	23		22%			4%	9%		30%	4%	30%
	M-P	10		20%			50%				10%	20%
	M-L	5			60%		20%					20%
	P-L	2					100%					0%
Other	A-A	8		25%			13%	12%	0%	13%	0%	37%
	A-M	37		5%			14%	24%	8%	11%	8%	30%
	A-P	5								20%	20%	60%
	M-M	145		10%	4%		41%	6%	1%	13%	8%	17%
	M-P	37		8%	8%		35%			11%	11%	27%
	M-L	9		11%	11%		67%					11%
	P-P	31		13%	6%		58%	6%		3%	3%	10%
	P-L	25		4%	16%		60%	8%		8%		4%
	L-L	29		3%			41%	24%		10%		21%
Work-based Subtours												
Work	E-M	14			21%		79%					
	E-P	6					100%					
	E-L	1				100%						
	A-M	26			4%		96%					
	A-P	242		1%	2%		90%	3%		3%		
	A-L	62			5%		63%	6%		13%	10%	3%
	M-M	5					100%					
	M-P	22					77%	18%		5%		
	M-L	23					70%	4%		22%		4%
Total	Total	1322	0%	6%	4%	0%	40%	6%	1%	11%	9%	24%

* Where time period combinations were unreported the survey data, the distributions from next closest time period were used.

Table 17: Classification model for number of stops before primary destination

Classes			Distributions of Number of Stops Before Primary Destination			
Tour Purpose / Priority	**Tour Stops**	**Tours**	**1**	**2**	**3**	**4+**
Work Primary	Before	152	70%	22%	7%	1%
	Both	174	74%	21%	2%	3%
Education Primary	Before	28	68%	25%		7%
	Both	22	95%	5%		
Other Primary	Before	102	68%	20%	9%	4%
	Both	64	58%	22%	16%	5%
Work Secondary	Before	47	74%	17%	2%	6%
	Both	18	72%	22%	6%	
Education Secondary	Before	12	92%	8%		
	Both	3	67%		33%	
Other Secondary	Before	39	72%	15%	8%	5%
	Both	16	56%	31%		13%
Work-based Subtour	Before	22	77%	5%		14%
	Both	18	83%	11%		6%
		717				
		71%				
		19%				
		6%				
		4%				
Total	Total		71%	20%	6%	4%

Table 18: Classification model for number of stops after primary destination

Classes			Distributions of Number of Stops After Primary Destination			
Tour Purpose / Priority	**Tour Stops**	**Tours**	**1**	**2**	**3**	**4+**
Work Primary	After	350	69%	21%	6%	4%
	Both	174	66%	22%	9%	3%
Education Primary	After	58	59%	17%	17%	7%
	Both	22	77%	9%	9%	5%
Other Primary	After	106	69%	19%	8%	4%
	Both	64	55%	23%	14%	3%
Work Secondary	After	62	71%	23%	2%	5%
	Both	18	89%	6%	6%	
Education Secondary	After	13	85%	15%		
	Both	3	33%	67%		
Other Secondary	After	41	71%	22%	7%	
	Both	16	69%	25%		6%
Work-based Subtour	After	50	80%	16%	2%	2%
	Both	18	72%	28%		
Total	Total	995	68%	21%	7%	3%

Table 19: Classification model for stop before primary destination departure period *(shaded cells are not possible)*

Classes			Distributions of departure periods for stops before primary destination				
Tour Times	**# Stops**	**Tours**	**Early**	**AM peak**	**Midday**	**PM peak**	**Late**
Early-Midday	1	6		67%	33%		
	2	2	50%	50%			
	3	3			100%		
Early-PM peak	1	3		100%			
AM peak-AM peak	1	13		100%			
AM peak-Midday	1	71		76%	24%		
	2	26		62%	38%		
	3	12		42%	58%		
	4+	35		29%	71%		
AM peak-PM peak	1	153		82%	17%	1%	
	2	66		65%	30%	5%	
	3	27		41%	44%	15%	
	4+	11		9%	91%		
AM peak-Late	1	32		44%	44%	9%	3%
	2	24		46%	38%	12%	4%
	3	6		100%			
Midday-Midday	1	93			100%		
	2	62			100%		
	3	30			100%		
	4+	44			100%		
Midday-PM peak	1	44			91%	9%	
	2	50			84%	16%	
	3	21			76%	24%	
	4+	31			77%	23%	
Midday-Late	1	19			90%	5%	5%
	2	22			73%	23%	4%
	3	12			83%	17%	
	4+	35			49%	34%	17%
PM peak-PM peak	1	25				100%	
	2	2				100%	
PM peak-Late	1	21				52%	48%
	2	14				71%	29%
	3	3				33%	67%
Late-Late	1	30					100%
	2	10					100%
	3	6					100%

Table 20: Classification model for stop after primary destination departure period *(shaded cells are not possible)*

Classes			Distributions of departure periods for stops after primary destination				
Tour Times	**# Stops**	**Tours**	**Early**	**AM peak**	**Midday**	**PM peak**	**Late**
Early-Early	1	1	100%				
Early-AM peak	1	1		50%	50%		
Early-Midday	1	15			53%	27%	20%
	2	6			33%	67%	
	3	6			33%	67%	
Early-PM peak	1	1				100%	
AM peak-AM peak	1	10		70%	20%	10%	
	2	12		33%	58%	1%	8%
	3	9			33%	67%	
	4+	4			100%		
AM peak-Midday	1	86			51%	40%	9%
	2	86			62%	36%	2%
	3	69			48%	46%	6%
	4+	69			67%	20%	13%
AM peak-PM peak	1	225				64%	36%
	2	118				58%	42%
	3	54				52%	43%
	4+	38				71%	29%
AM peak-Late	1	24					100%
	2	10					100%
	3	3					100%
Midday-Midday	1	154			77%	19%	4%
	2	94			67%	32%	1%
	3	45			67%	31%	2%
	4+	50			54%	32%	14%
Midday-PM peak	1	61				61%	39%
	2	44				61%	39%
	3	12				75%	25%
	4+	12				92%	8%
Midday-Late	1	13					100%
	2	12					100%
	3	9					100%
PM peak-PM peak	1	29				79%	21%
	2	10				80%	20%
	3	6				67%	33%
PM peak-Late	1	27					100%
	2	2					100%
Late-Late	1	32					100%
	2	16					100%
	3	6					100%

Model Application

All of the models in this chapter were incorporated into a C++ program with the following structure:

- Read in and store all zone-based land use data and accessibility measures.
- Loop on the person records in the SF county synthetic sample for the appropriate forecast year, after this sample has been updated by applying the Workplace Location model and the Vehicle Availability Model.
- For each person record:
    - Apply the Full Day Pattern model for the person type (worker, student or other). Calculate the probability for each pattern alternative, and use a random Monte Carlo procedure to predict a single pattern. If the "no travel" alternative is predicted, go to the next record.
    - Apply the Primary Tour Time of Day model for the appropriate tour purpose (work, education or other). Calculate the probability for each time period combination, and use a random Monte Carlo draw to predict a single combination.
    - Conditional on the predicted choices, apply the relevant classification models (Tables 13 to 20), each using a Monte Carlo procedure.
    - Write the output as a series of tours, each with:
        - The purpose
        - The type (primary, secondary or work-based)
        - The number of trip segments within each half-tour
        - The time period in which each trip segment begins
- Print summary information across the sample, to use in validation and calibration.

APPENDIX A. Working adult full day pattern choice model: final calibrated model

Summary Statistics	
Observations	2170
Final log-likelihood	-5450.1
Rho-squared (const)	.023
Rho-squared (0)	.305
Variable	**Coefficient**
Work primary tour pattern utility	
- Age 25-34	2.716
- No car in household	2.528
- Less than 1 car per adult in household	.543
- Total employment within 15 minutes by car in PM peak (000)	.0324
- Constant	18.58
Work tour intermediate stop utility	
- No kids in household	-.405
- Female, kids under 5	.318
- Couple, non-worker in household	-.414
- No car in household	-.375
- Retail + service emp within 15 minutes by car in PM peak (000)	.00957
- Retail + service employment within half mile (000)	-.0313
- Retail + service employment within half mile of work (000)	-.0174
- Stop before constant	-1.088
- Stop after constant	-0.191
- Stops both ways constant	1.341
Work-based sub-tour utility	
- Income under $30,000	-.609
- No car in household	-.981
- Less than 1 car per adult in household	-.747
- Retail + service employment within half mile of work (000)	.0239
- Constant	-2.086
- Combine with stop before work	-1.559
- Combine with stop after work	-0.943
- Combine with stops both ways	-0.966
Other primary tour pattern utility	
- Part time worker	4.601
- No car in household	1.718
- Retail + service emp within 15 minutes by car in off-peak (000)	0.696
- Constant	10.167

Other tour intermediate stop utility		
- No car in household	-.485	-1.6
- Less than 1 car per adult in household	-.508	-2.2
- No kids in household	-.339	-1.5
- Retail + service emp within 15 minutes by car in off-peak (000)	.0197	1.9
- Retail + service employment within half mile (000)	-.1195	-1.6
- Stop before constant	-1.570	-4.1
- Stop after constant	-1.198	-3.3
- Stops both ways constant	1.496	4.0
Secondary tours utility		
- Single adult in household	.535	4.1
- Part time worker	.732	4.1
- Age 25-34	.338	3.0
- No car or no license	-.782	-4.5
- Retail + service emp within 15 minutes by car in off-peak (000)	.0114	3.3
- One with a work tour constant	-1.562	-14.8
- One with a work tour and subtour constant	.458	3.2
- Two with a work tour constant	-3.506	-19.6
- Two with a work tour and subtour constant	.441	1.5
- One with an "other" primary tour constant	-0.895	-5.8
- Two with an "other" primary tour constant	-1.853	-7.7
Logsums		(vs.1.0)
- Across all travel alternatives	.358	4.8
- All alternatives within each primary purpose	.246	7.5

APPENDIX B. Student/child full day pattern choice model: final calibrated model

Summary Statistics	
Observations	571
Final log-likelihood	-1121.8
Rho-squared (const)	.044
Rho-squared (0)	.390
Variable	**Coefficient**
Education primary tour pattern utility	
- Age 5-11	1.103
- Age 12-15	1.099
- Age 16-19	1.046
- Age 20-24	.952
- Age 25-34	2.199
- Constant	3.387
Education tour intermediate stop utility	
- Age 5-11	-.726
- Age 12-15	-.719
- Age 16-19	-.552
- Stop before constant	-1.825
- Stop after constant	-1.097
- Stops both ways constant	1.457
Other primary tour pattern utility	
- Female with children under 5	1.018
- Retail + service emp within 15 minutes by car in PM peak (000)	.0125
- Less than 1 car per adult in household	-0.4909
- Constant	2.096
Other tour intermediate stop utility	
- No kids in household	.732
- Stop before constant	-1.910
- Stop after constant	-1.399
- Stops both ways constant	.585
Secondary tours utility	
- Male, single adult in household	1.116
- Income over $60,000	1.704
- Age 20 or less	-1.243
- No car in household	-.473
- One with an education tour constant	-1.117
- One with an education tour and stops both way	-1.531
- Two with an education tour constant	-1.348
- One with an "other" primary tour constant	-.693
- Two with an "other" primary tour constant	-1.520
Logsums	
- Across all travel alternatives	.337

APPENDIX C. Other adult full day pattern choice model: final calibrated model

Summary Statistics	
Observations	729
Final log-likelihood	-1223.8
Rho-squared (const)	.025
Rho-squared (0)	.345
Variable	**Coefficient**
Primary tour pattern utility	
- No kids in household	.493
- Constant	-.530
Primary tour intermediate stop utility	
- Less than 1 car per adult in household	-.303
- No kids in household	.324
- Age 65 or over	-.279
- Retail + service emp within 15 minutes by car in off-peak (000)	.00714
- Retail + service employment within half mile (000)	-.109
- Stop before constant	-1.039
- Stop after constant	-0.808
- Stops both ways constant	.233
Secondary tours utility	
- Age 25-34	1.030
- Age 65 or over	.379
- No car in household	-1.360
- Less than 1 car per adult in household	-.754
- One with an "other" primary tour constant	-.650
- One with an "other" primary tour with stops both ways	.536
- Two with an "other" primary tour constant	-1.936
- Two with an "other" primary tour with stops both ways	1.035

APPENDIX D. Work primary tour time of day choice model: final calibrated model

Summary Statistics	
Observations	1729
Final log-likelihood	-2486.8
Rho-squared vs. Constants	.0751
Rho-squared vs. 0	.4689
Variable	**Coefficient**
Early period utilities	
- Early-Early constant	-6.034
- Early-AM peak constant	-5.069
- Early-PM peak constant	-2.721
- Early-Late constant	-4.834
- AM peak-AM peak constant	-5.671
Early-Midday utility	
- Constant	-2.387
- Secondary tours in pattern	.889
- Stop after work	1.130
AM peak-Midday utility	
- Constant	-2.377
- Part time worker	2.122
- Secondary tours in pattern	.629
- Stop after work	2.088
AM peak-PM peak utility	
- 2+ secondary tours in pattern	-1.244
- Work-based subtour in pattern	.724
- Stop after work	.826
- Female	.375
- Couple, with non-working adult in household	.242
AM peak-Late utility	
- Constant	-1.861
- Age under 35	.638
- Income over $60,000	.882
- Secondary tours in pattern	-1.435
- Stop before work	.568
- Work-based subtour in pattern	1.192
Midday-Midday utility	
- Constant	-3.899
- Part time worker	2.760
- Secondary tours in pattern	.859
- Stop after work	2.173

Variable	Coefficient	T-statistic
Midday-PM peak utility		
- Constant	-1.027	-5.4
- Part time worker	1.346	4.4
- No intermediate stops	-.668	-3.4
Midday-Late utility		
- Constant	-1.900	-11.1
- Part time worker	1.201	3.3
Late period utilities		
- PM peak-PM peak constant	-10.0	Fixed
- PM peak-Late constant	-3.004	-13.8
- Late-Late constant	-2.654	-12.5
- Age under 20	1.560	2.4
- Part time worker	1.726	3.8
Accessibility variables (included in all utilities)		
- Total employment within 15 minutes by auto, outbound period (000)	.00234	2.4
- Total employment within 15 minutes by auto, return period (000)	.00130	1.9
- Total employment within 30 minutes by transit, outbound (000)	.00081	0.9
- Total employment within 30 minutes by transit, return period (000)	.00010	0.2

APPENDIX E. Education primary tour time of day choice model: final calibrated model

Summary Statistics	
Observations	411
Final log-likelihood	-436.9
Rho-squared (const)	.1356
Rho-squared (0)	.6075
Variable	**Coefficient**
Early period utilities	
- Early-Early constant	-10.0
- Early-AM peak constant	-10.0
- Early-Midday constant	-5.488
- Early-PM peak constant	-10.0
- Early-Late constant	-10.0
- AM peak-AM peak constant	-4.348
AM peak-Midday utility	
- Age under 20	1.663
AM peak-Late period utilities	
- AM peak-PM peak constant	.341
- AM peak-Late constant	-2.890
- Secondary tours in pattern	-1.618
- Age 5-11	.751
Midday-Midday utility	
- Constant	-2.302
- Secondary tours in pattern	1.135
- Stop after school	1.458
Midday-Late period utilities	
- Midday-PM peak constant	-1.687
- Midday-Late constant	-3.441
- Age 25-34	1.837
- No intermediate stops	-.878
Late period utilities	
- PM peak-PM peak constant	-10.0
- PM peak-Late constant	-3.556
- Late-Late constant	-7.163
Accessibility variables (included in all utilities)	
- Service employment within 15 minutes by auto, outbound period (000)	.07000
- Service employment within 15 minutes by auto, return period (000)	.02032
- Service employment within 30 minutes by transit, outbound per. (000)	.01271
- Service employment within 30 minutes by transit, return period (000)	0

APPENDIX F. Other primary tour time of day choice model: final calibrated model

Summary Statistics	
Observations	667
Final log-likelihood	-1116.4
Rho-squared (const)	.0593
Rho-squared (0)	.3820
Variable	**Coefficient**
Early period utilities	
- Early-Early constant	-10.0
- Early-AM peak constant	-10.0
- Early-Midday constant	-4.078
- Early-PM peak constant	-10.0
- Early-Late constant	-10.0
AM peak-early period utilities	
- AM peak-AM peak constant	-2.227
- AM peak-Midday constant	-1.125
- No intermediate stops	-.519
- Age under 16	1.296
- Non-working adult with kids	.722
AM peak – PM peak utility	
- AM peak-PM peak constant	-2.557
AM peak-late period utilities	
- AM peak-Late constant	-3.736
- Age under 16	2.664
Midday-Midday utility	
- Age over 65	.969
Midday-PM peak utility	
- Constant	-1.351
Midday-Late utility	
- Constant	-3.033
- Stop before primary destination	1.577
PM peak-PM peak utility	
- Constant	-2.504
- No intermediate stops	.790
- Secondary tours in pattern	.865
PM peak-Late utility	
- Constant	-1.689
- Secondary tours in pattern	.786
Late-Late utility	
- Constant	-2.555
- Secondary tours in pattern	.877
- No intermediate stops	1.582
- Age under 35	.702
- Full time worker	.551
Accessibility variables (included in all utilities)	
- Retail + service emp. within 15 minutes by auto, outbound period (000)	.00500
- Retail + service emp. within 15 minutes by auto, return period (000)	.00304
- Retail + service emp. within 30 minutes by transit, outbound per. (000)	.00500
- Retail + service emp. within 30 minutes by transit, return period (000)	0

APPENDIX G. Files for Running the Tour Generation/Time of Day Models

TAZDATA.DAT - The zonal data file. 1738 records in space-delimited format.

ACCESS.DAT - The accessibility variable data file. 766 records in space-delimited format.

TOURGEN.CPP, TOURGEN.EXE - the tour generation/time of day model code and executable. It uses the two zonal input files above, plus VEHAVL.OUT, the output from the vehicle availability application. It creates TOURGEN.OUT, which has a record for each tour.

It also creates TOURGEN.SUM for comparing to MTC trip tables. There are seven records:

- home-work trips
- work-home trips
- home-education trips
- education-home trips
- home-other trips
- other-home trips
- non-home-based trips

Each record has five values:

- Trips in the Early period
- Trips in the AM peak period
- Trips in the Midday period
- Trips in the PM peak period
- Trips in the Late period