TIME OF DAY MODELING PROCEDURES FOR IMPLEMENTATION IN FSUTMS
Final Report

Research Center
Florida Department of Transportation
605 Suwannee Street, MS 30
Tallahassee, FL 32399-0450

Submitted by
Ram M. Pendyala, Ph.D.
Principal Investigator
Department of Civil and Environmental Engineering
University of South Florida, Tampa, FL 33620

In Collaboration with
Cambridge Systematics, Inc.
Gannett Fleming, Inc.
The Corradino Group

Contract No. BC353, RPWO #8
2002

Acknowledgements

The project team is grateful to the members of the Statewide Model Task Force for their technical guidance and advice throughout the course of this research project. The project team thanks Mr. Robert G. McCullough, P.E. and Terrence Corkery of the Systems Planning Office for their help in coordinating this research effort with other ongoing model development projects in the state.

Disclaimer

The contents of this report do not necessarily reflect the official views or policies of the Florida Department of Transportation or its constituent divisions. This report does not constitute a standard, specification, or regulation.

Table of Contents

Approaches to Time of Day Modeling

CHAPTER I

This chapter provides an overview of the various methods used for time-of-day modeling. In addition, the chapter summarizes the various critical issues and advantages and disadvantages associated with the different methods.

OBJECTIVE

- Obtain peak hour or peak period traffic volumes, transit ridership, and/or travel times from travel models, in addition to daily model outputs.

Basic Method

- Factoring daily trips to obtain peak hour or period trips at some stage in the 4-step process.
- Factors may be fixed or may vary based on geography, levels of congestion, or demographic or trip characteristics.

Peak/Off-Peak Period Definitions

- 2 periods – peak vs. off-peak
- 3 periods – a.m. peak, p.m. peak, off-peak
- 4 periods - a.m. peak, p.m. peak, mid-day, overnight
- 5 periods - a.m. peak, p.m. peak, mid-day, night, early morning
- Use of shoulder periods?

Possible Approaches

- After trip assignment
- Between mode choice and assignment
- Between trip distribution and mode choice
- Between trip generation and distribution

TIME OF DAY MODELING AFTER TRIP ASSIGNMENT

Approach

- Run daily 4-step model, factor volume outputs to obtain peak hour/period volumes.

Advantages

- Simplest, quickest method to apply (e.g. use K and D factors as many areas in Florida are doing).
- Accounts for different peaking/directionality characteristics in different subregions/ roadways.
- Allows for the possibility of link-based peak spreading (but not trip based peak spreading or time of day choice).

Disadvantages

- Daily equilibrium assignment is performed for period that is not homogeneous—speeds vary greatly over an average weekday (i.e. assignments are based on daily speeds, which are not very meaningful).
- Insensitive to future changes in land use or composition of traffic (through vs. local).
- Peaking is unrelated to congestion levels—application of fixed factors to forecast year daily volumes may result in unrealistically high peak volumes.

Figure 1 shows how the post-trip assignment time of day modeling procedure works within the context of the four-step modeling process.

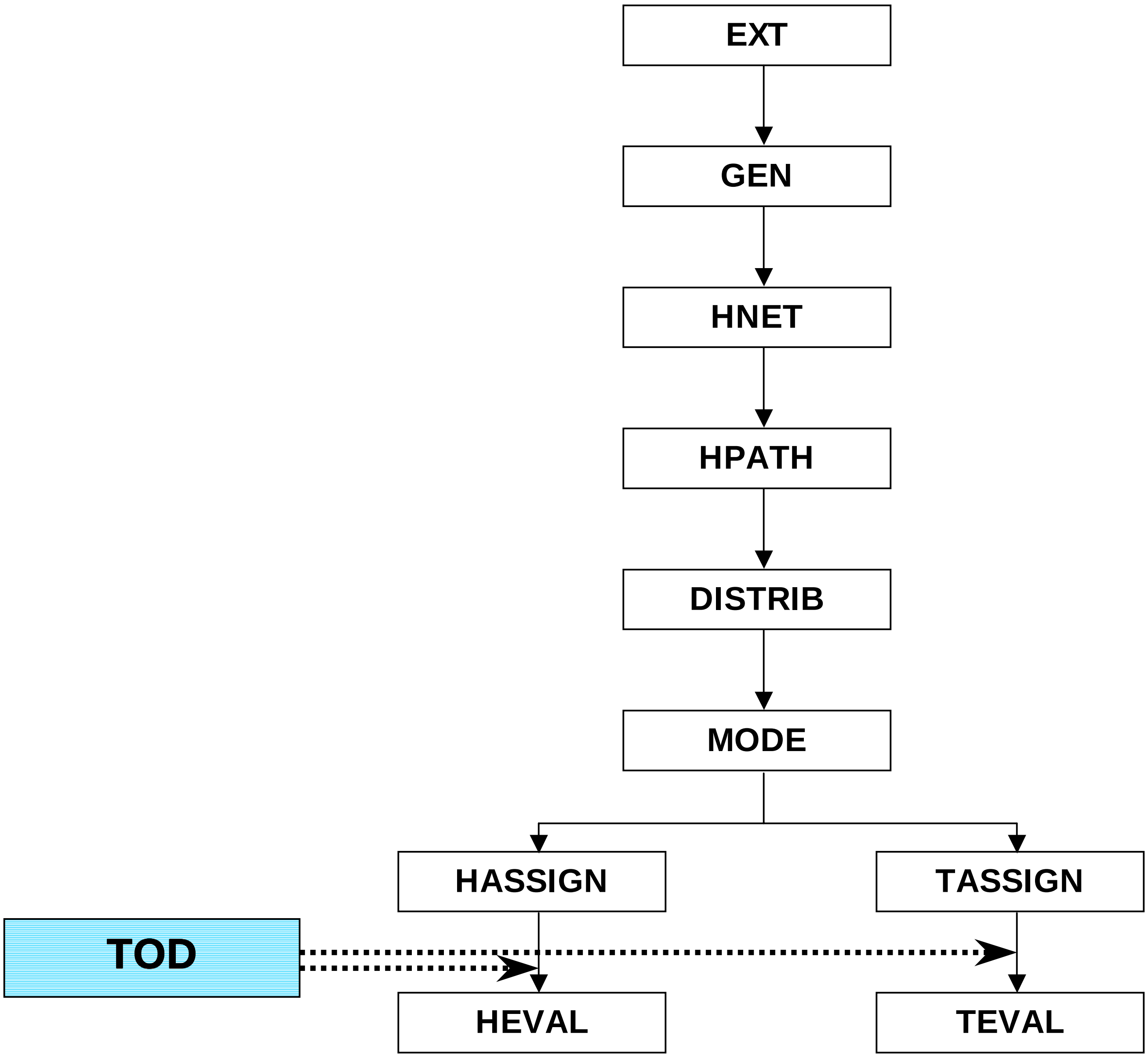


Figure 1. Post-Trip Assignment Time of Day Modeling Procedure

TIME OF DAY MODELING BETWEEN MODE CHOICE AND TRIP ASSIGNMENT

Approach

- Run trip generation, distribution, and mode choice on a daily basis, factor trip tables by purpose and mode to obtain peak hour/period trip tables, assign trip tables for each period to appropriate networks.

Advantages

- Simple method to apply—TRANPLAN trip table manipulation functions, factors derived from surveys, calibrated to time of day counts.
- Assignments can be done for relatively homogeneous periods (speeds within a peak or off-peak period vary much less than daily speeds).
- Mode can be considered in time of day factoring—transit could have explicitly different peaking characteristics than auto.
- Allows for the possibility of trip-based or link-based peak spreading, or time of day choice (this assumes factors are not fixed).

Disadvantages

- Mode choice and trip distribution are still performed using daily speeds.
- Applying a single set of regional factors causes inaccuracies due to different peaking characteristics across the region, but it is difficult to derive subregional factors.
- Peaking is not directly related to congestion levels—assigning trip tables based on the application of fixed factors to forecast year daily trip tables could result in unrealistically high peak volumes.
- This problem could be mitigated by using feedback; however, the feedback process is complicated when assignment travel time outputs are peak/off-peak but distribution/ mode choice travel time inputs are daily.

Figure 2 shows how the post-mode choice time of day modeling procedure works within the context of the four-step modeling process.

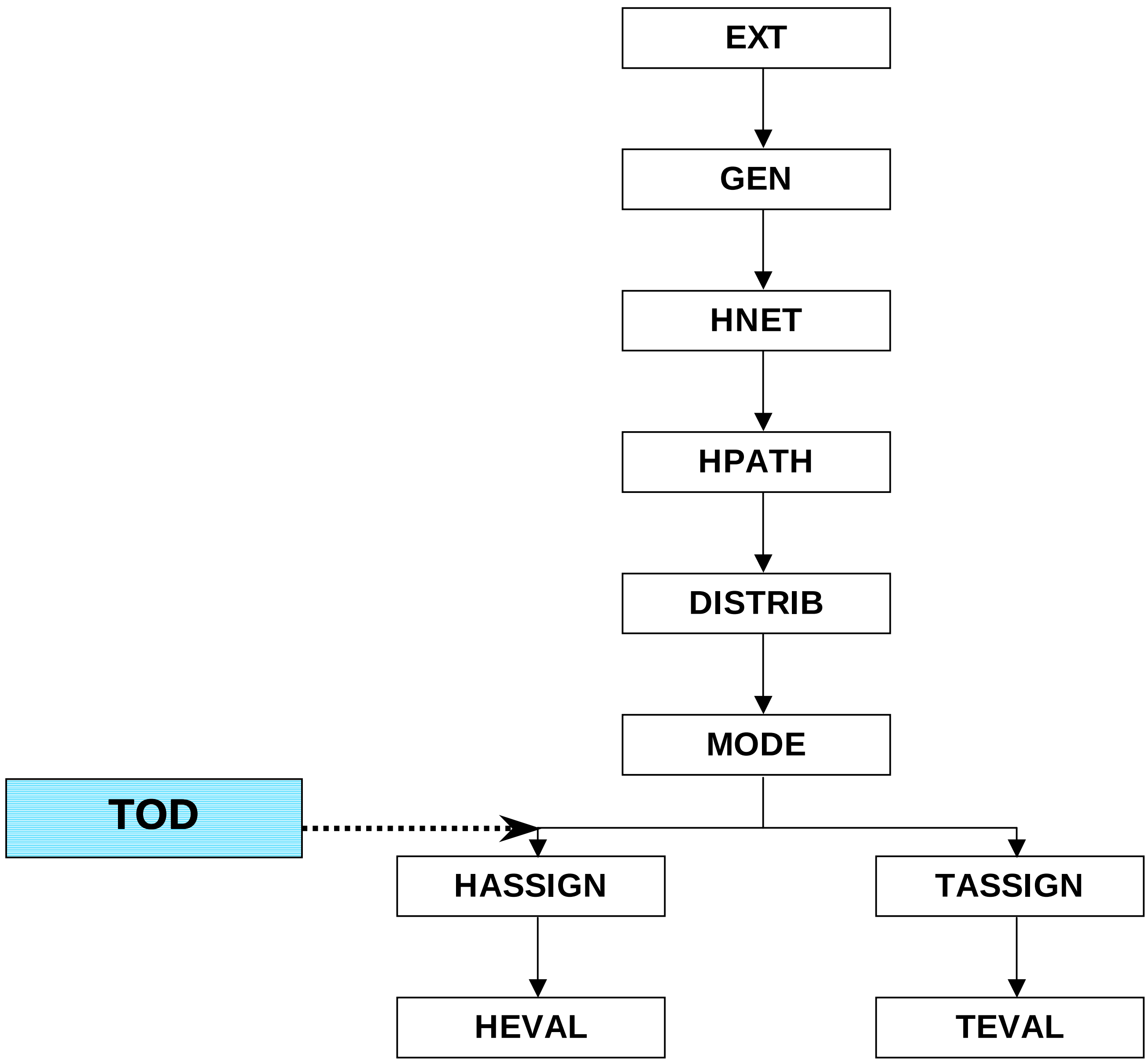


Figure 2. Post-Mode Choice Time of Day Modeling Procedure

TIME OF DAY MODELING BETWEEN TRIP DISTRIBUTION AND MODE CHOICE

Approach

- Run trip generation and distribution on a daily basis, factor person trip tables by purpose to obtain peak hour/period trip tables, perform mode choice and assignment for each period using appropriate networks.

Advantages

- Assignments can be done for relatively homogeneous periods (speeds within a peak or off-peak period vary much less than daily speeds).
- Mode choice (but not distribution) is performed for peak/off-peak periods using appropriate networks.
- Allows for the possibility of trip-based or link-based peak spreading, or time of day choice (this assumes factors are not fixed).

Disadvantages

- Trip distribution still performed using daily speeds.
- Applying a single set of regional factors causes inaccuracies due to different peaking characteristics across the region, but it is difficult to derive subregional factors.
- Difficult to justify using inconsistent procedures between trip distribution and mode choice procedures—distribution uses daily speeds, mode choice uses peak/off-peak speeds.
- Peaking is not directly related to congestion levels—assigning trip tables based on the application of fixed factors to forecast year daily trip tables could result in unrealistically high peak volumes.
- This problem could be mitigated by using feedback; however, the feedback process is complicated when assignment travel time outputs are peak/off-peak but distribution/ mode choice travel time inputs are daily.

Figure 3 shows how the post-trip distribution time of day modeling procedure works within the context of the four-step modeling process.

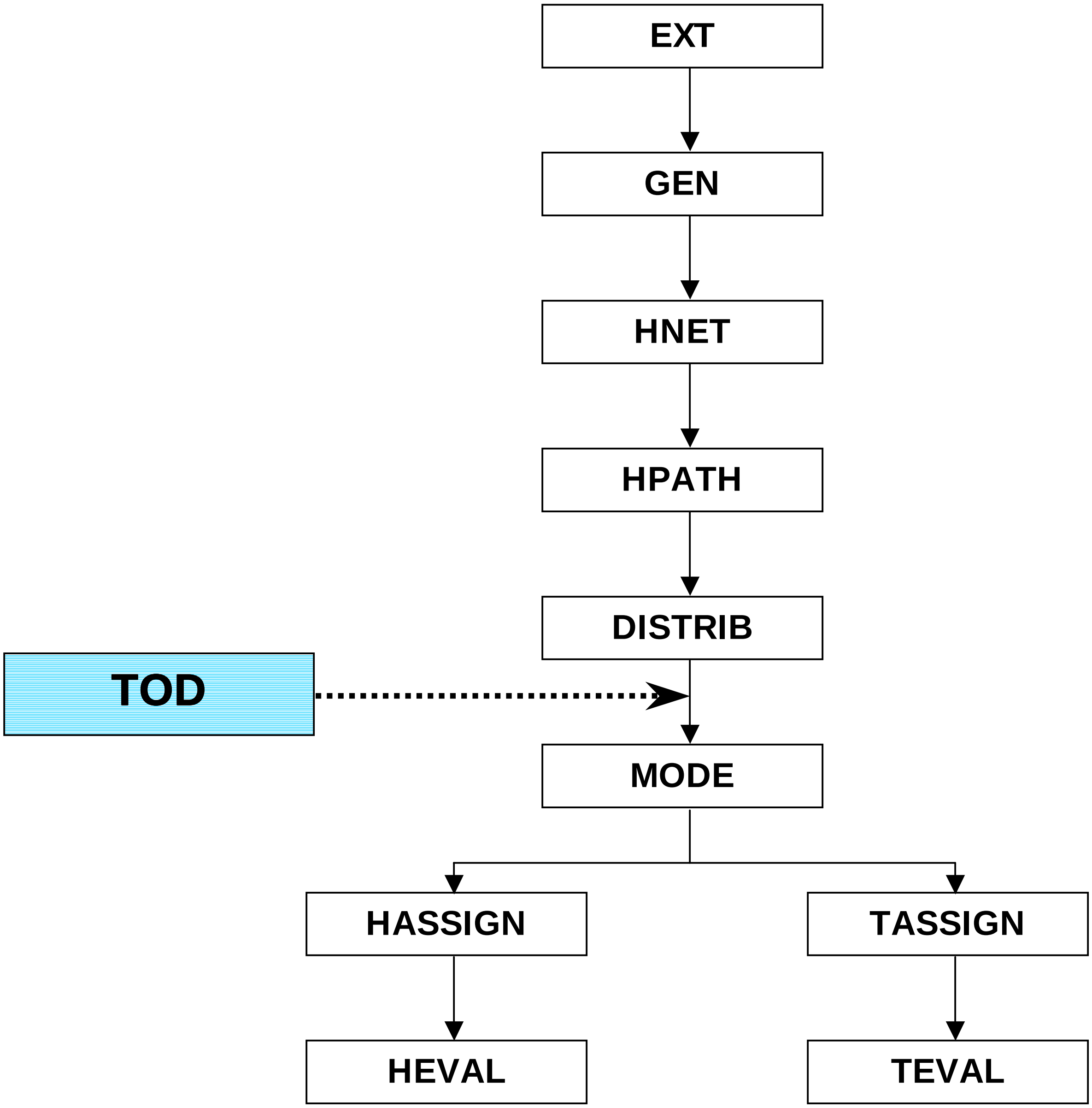


Figure 3. Post-Trip Distribution Time of Day Modeling Procedure

TIME OF DAY MODELING BETWEEN TRIP GENERATION AND TRIP DISTRIBUTION

Approach

- Run trip generation on a daily basis, factor trip ends by purpose to obtain peak hour/period trip ends, perform trip distribution, mode choice, and assignment for each period using appropriate networks.

Advantages

- Assignments can be done for relatively homogeneous periods (speeds within a peak or off-peak period vary much less than daily speeds).
- Mode choice and trip distribution are performed for peak/off-peak periods using appropriate networks, consistent with the trip assignment approach.
- Allows for the possibility of trip-based or link-based peak spreading, or time of day choice (this assumes factors are not fixed).
- The use of feedback is facilitated since assignment travel time outputs and inputs to trip distribution and mode choice are all for the same peak/off-peak periods.

Disadvantages

- Applying a single set of regional factors causes inaccuracies due to different peaking characteristics across the region, but it is difficult to derive subregional factors.
- Peaking is not directly related to congestion levels—assigning trip tables based on the application of fixed factors to forecast year daily trip tables could result in unrealistically high peak volumes. This problem could be mitigated by using feedback.
- If time of day choice is used, zone-to-zone measures of congestion cannot be considered since factors are applied to trip ends, not trip tables.

Figure 4 shows how the post-trip generation time of day modeling procedure works within the context of the four-step modeling process.

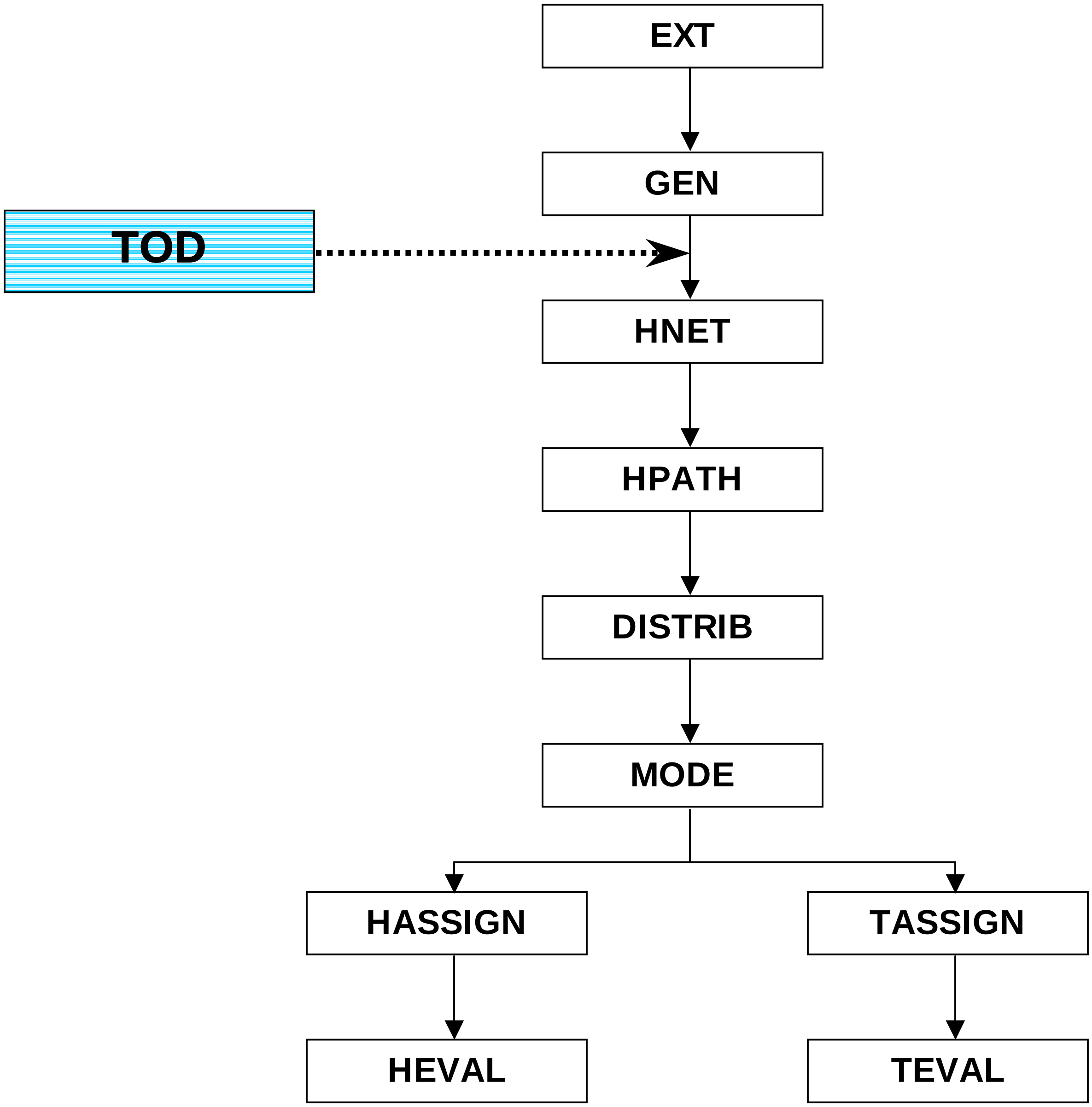


Figure 4. Post-Trip Generation Time of Day Modeling Procedure

PEAK SPREADING APPROACHES

Peak spreading approaches constitute more advanced time of day modeling procedures that are intended to capture the peak spreading effects of congestion. The different peak spreading approaches are:

- Spreading within the peak period
- Spreading outside the peak period, but peak periods remain fixed (time of day choice)
- Redefinition of peak periods based on congestion

Spreading Within the Peak Period

There are two methods that address spreading within the peak period.

- Link-based approaches (post-assignment)
- Trip-based approaches (pre-assignment)

Link-Based Peak Spreading

Approach

- Obtain peak period assignments, estimate relationships between v/c ratios and ratio of peak hour/peak period percentages, apply to peak period link volumes from assignment.

Advantages

- Relatively simple method to apply (spreadsheet or simple program); peaking-congestion relationships can be estimated from time of day count information.
- Good foundation for approach; relationship between congestion and peak spreading is well documented.

Disadvantages

- Procedure is insensitive to many factors affecting peak spreading, including trip purpose and length.
- Resulting peak hour volumes among links may not be consistent (i.e. volume entering a node may not equal volume leaving the node).
- Addresses neither spreading of trips outside the peak period nor the redefinition of peak periods over time.

Trip-Based Peak Spreading

Approach

- Obtain peak period trip tables, estimate relationships between ratio of peak hour/peak period percentages and other variables such as trip purpose and length, apply to peak period trip tables prior to peak hour assignment.

Advantages

- Good foundation for approach; relationship between peak spreading and other variables is well documented.

Disadvantages

- Procedure has not been tested using congestion as a variable.
- Addresses neither spreading of trips outside the peak period nor the redefinition of peak periods over time.

Spreading Outside the Peak Period (Time of Day Choice)

Approach

- When using time of day modeling procedure between mode choice and assignment, apply a model that relates the percentage of trips in the peak period to variables such as congestion, trip length, geography, and socioeconomic variables. Apply the resulting percentages on a zone-to-zone basis to the person trip tables by purpose and mode that are outputs from mode choice, and run assignments for peak and off-peak periods.

Advantages

- The effects of congestion on peak spreading can be explicitly considered.
- Assignments can be done for relatively homogeneous periods (speeds within a peak or off-peak period vary much less than daily speeds).
- Mode can be considered in time of day factoring—transit could have explicitly different peaking characteristics than auto.
- Procedure has been tested in San Francisco Bay Area for home to work trips

Disadvantages

- Mode choice and trip distribution are still performed using daily speeds.

- The feedback process is complicated when assignment travel time outputs are peak/off-peak but distribution/ mode choice travel time inputs are daily.
- Has not been tested for non-work trips.

Redefinition of Peak Periods Based on Congestion

- One could define peak periods based on congestion levels, and therefore redefine them for each forecast year scenario.
- Many complexities are associated with this concept:
  - Peak periods are different in different parts of the region.
  - Defining peak periods requires knowing demand levels at different hours of the day, information which current models do not provide.
  - Relationships between daily demand and specific hours at which congestion occurs are unclear.
- No prior research into this concept.
- Benefits could be significant, but work on this concept should wait until time of day modeling structure is in place.

ISSUES AND CONSIDERATIONS IN TIME OF DAY MODELING

Data Needs

- Surveys – Household surveys are required unless models are transferred (see below). Transit surveys are useful in helping to examine peaking differences by trip purpose but cannot be used to derive time of day factors because of selection bias.
- Traffic counts – Need counts by hour of the day; need for screenlines, external stations.
- Speeds – Existing procedures have not been validated using speed information—should this be done?
- Transit ridership – Need transit ridership information by hour of the day for calibration.

- Transit service information – Need information on differences in transit operations (headways, fares, speeds, express service, stop patterns, etc.)

Transferability of Time of Day Factors

- If models could be transferred, the need for survey data could be reduced.
- Although there is evidence that peaking characteristics are similar among different areas, no formal research has been done (though it is underway).
- There has been little work nationally or in Florida on time of day modeling in smaller urban areas.

Variations in Peaking in Different Parts of the Region

- Peaking can vary significantly around the region. The timing and duration of peak periods can be very different from one facility to another.
- However, in modeling, there needs to be a consistent definition of the peak periods for the entire region. The overall peak periods for the region should be used for analysis, as defined by survey data and counts.
- If factors for fixed peak periods do not vary within the region, there will be major roadways where the peak period volumes by direction do not match observations.

Changes in Peaking Over Time

- Time of day factors are generally developed from survey data and traffic and transit counts. These factors are based on base year data only and do not vary over time, even if they vary geographically within the region.
- Many factors that affect peaking, however, do change over time, including demographics, land use, and levels of congestion. These factors are considered in fixed time of day factors only to the extent that they affect trip purposes and distribution.
- A time of day choice model is the only way to account for these factors that change over time.

DEFINING TIME PERIODS

The selection of the number of time periods (into which the day is divided) is also a very crucial parameter in the development and implementation of time of day modeling procedures. Figures 5 through 8 show how the various time periods may be defined. In general:

- Number of periods used ranges from two to five
- Using more time periods provides greater accuracy because each period is homogeneous
- Using more time periods entails need for more data for model development/validation (also, longer model run times)
- Selection of time periods should be based on:
    - analysis needs
    - data available
    - nature of area

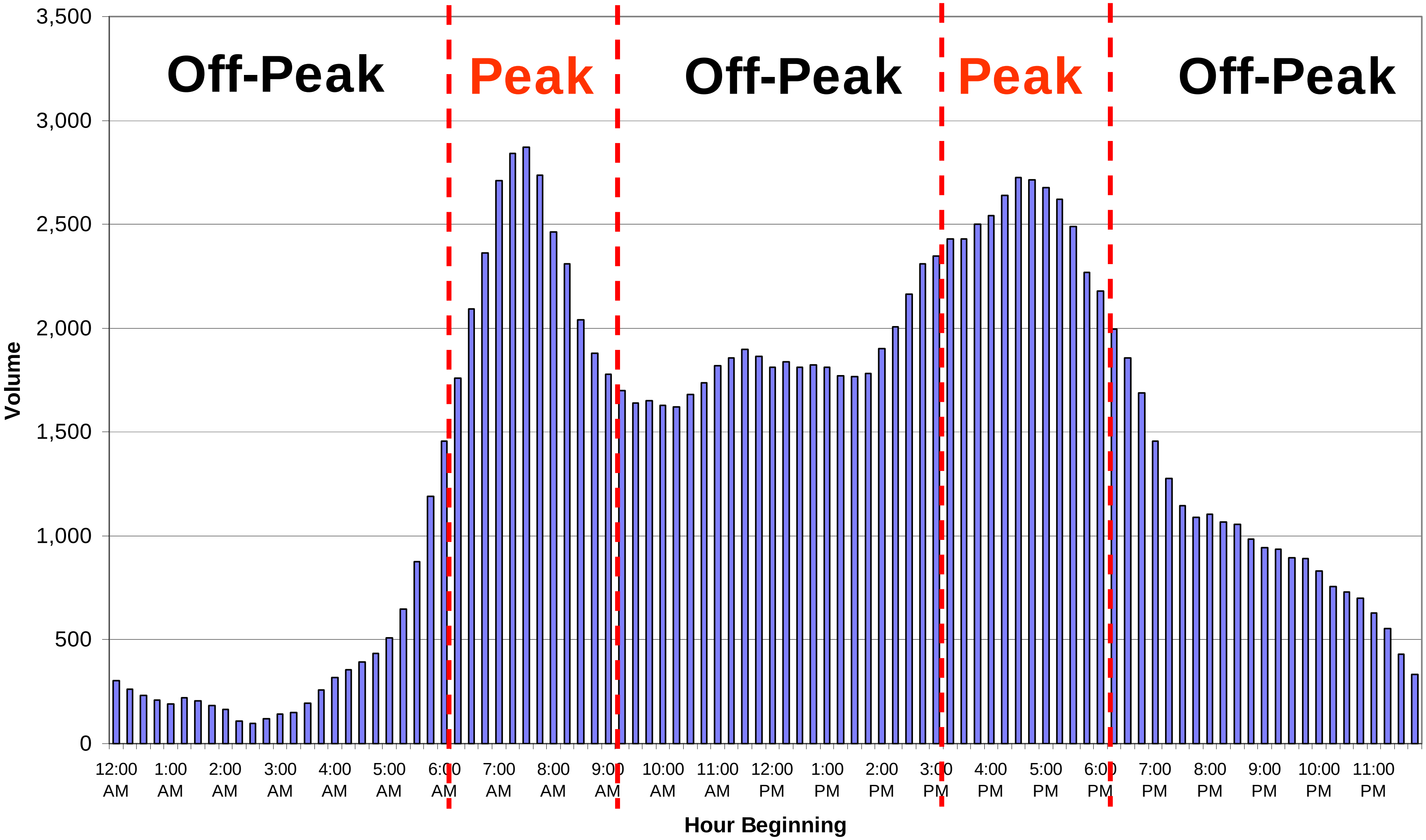


Figure 5. Two Period Time of Day Split

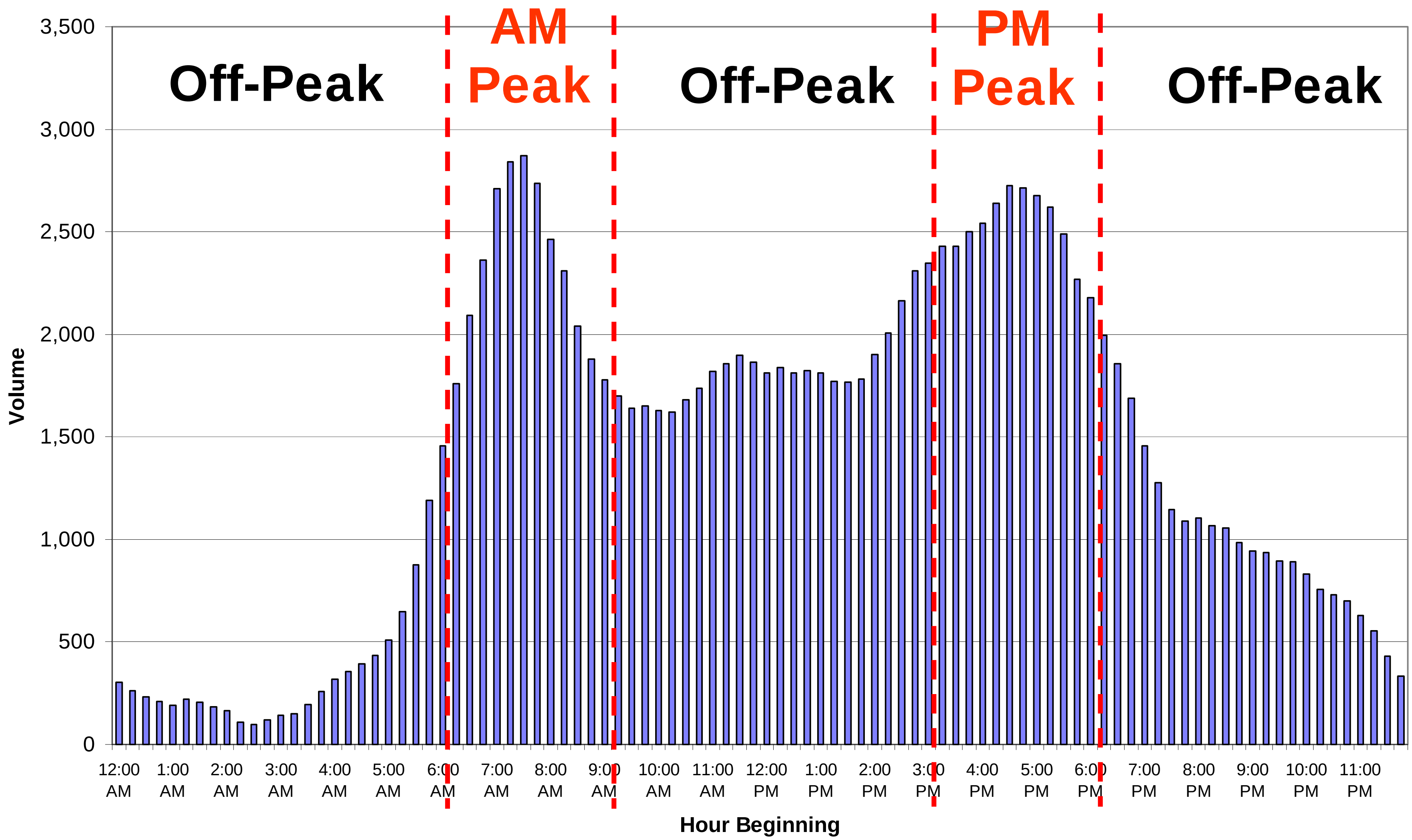


Figure 6. Three-period Time of Day Split

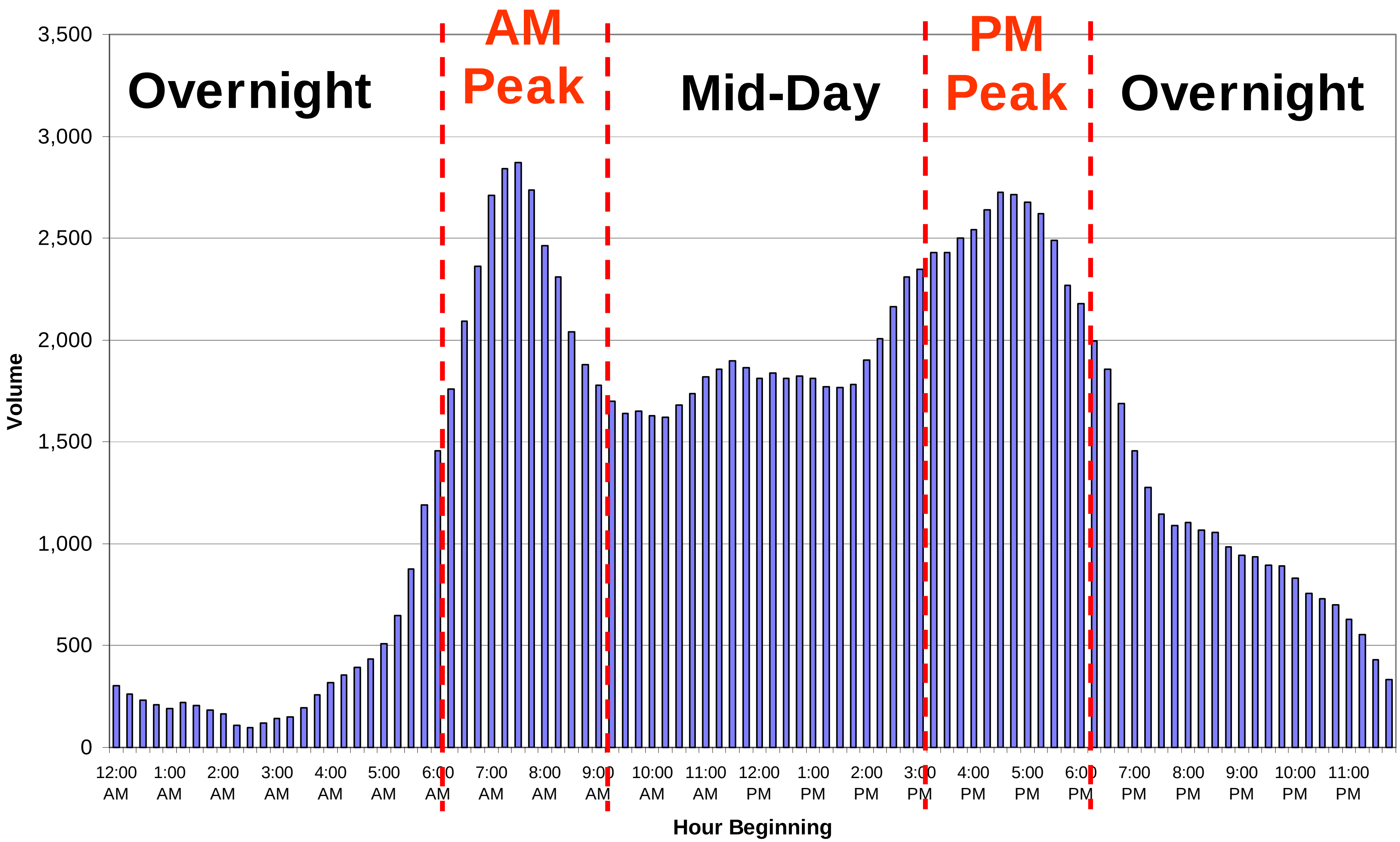


Figure 7. Four-period Time of Day Split

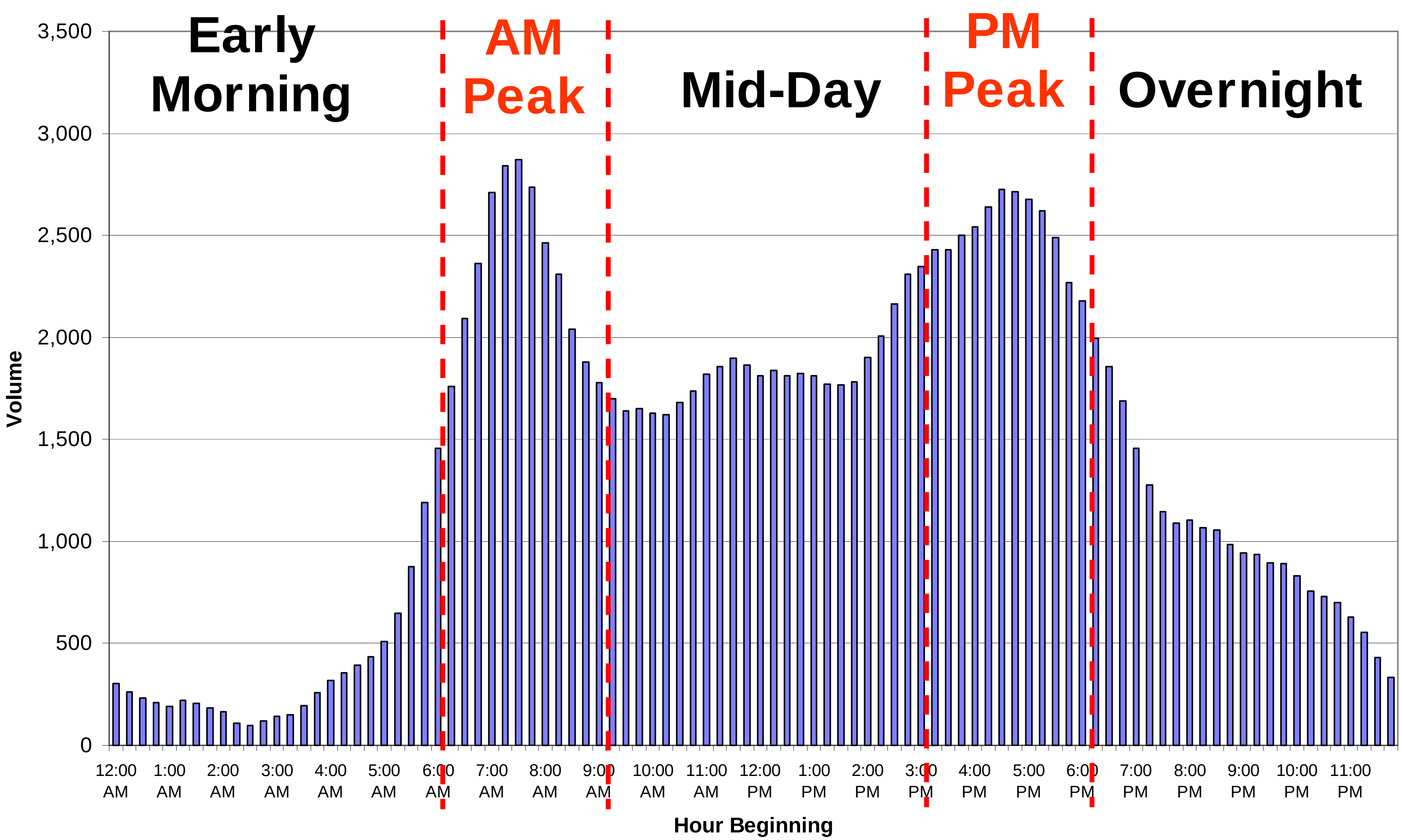


Figure 8. Five-period Time of Day Split

Analysis of Time of Day Distributions of Travel

CHAPTER II

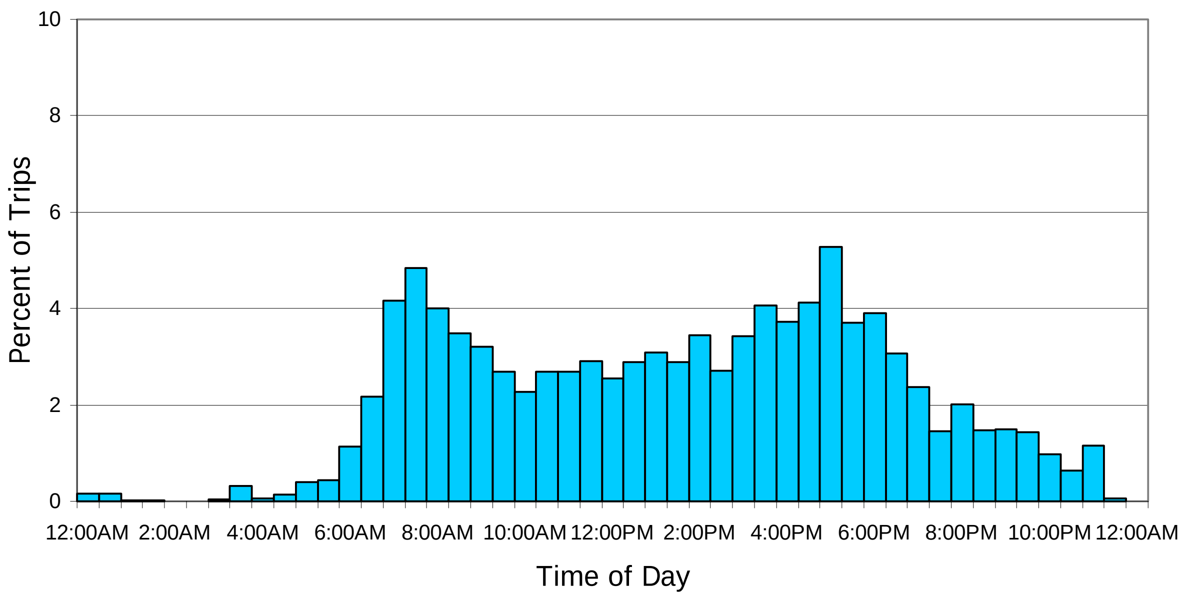
INTRODUCTION

This chapter provides an analysis of time of day distributions of travel. The project team has analyzed time of day distributions of travel by purpose for two Florida data sets, namely, the 1996 Tampa Bay household travel survey and the 1999 Southeast Florida Travel Characteristics Study. In general, the time of day distributions are found to follow expected patterns. The time of day factors and choice models developed in this study are based on these distributions and their correlation to socio-economic variables and system level-of-service variables.

TIME OF DAY DISTRIBUTIONS IN TAMPA BAY

Figure 1. All Trips

(N=13188508)



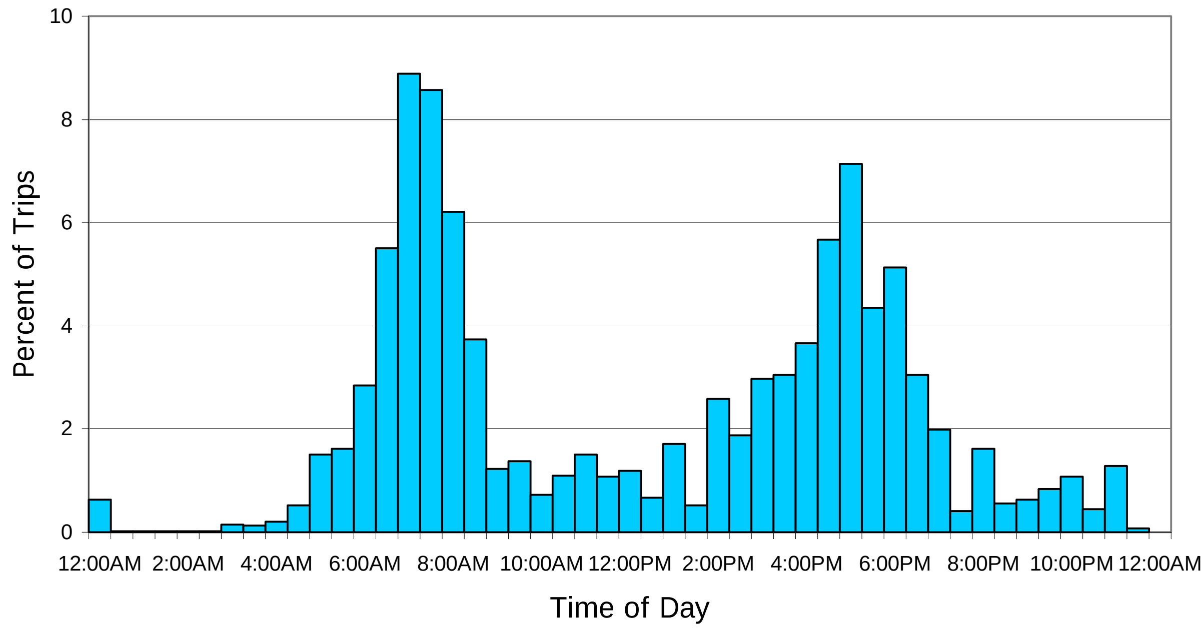


Figure 2. Home Based Work Trips
(N=3352408)

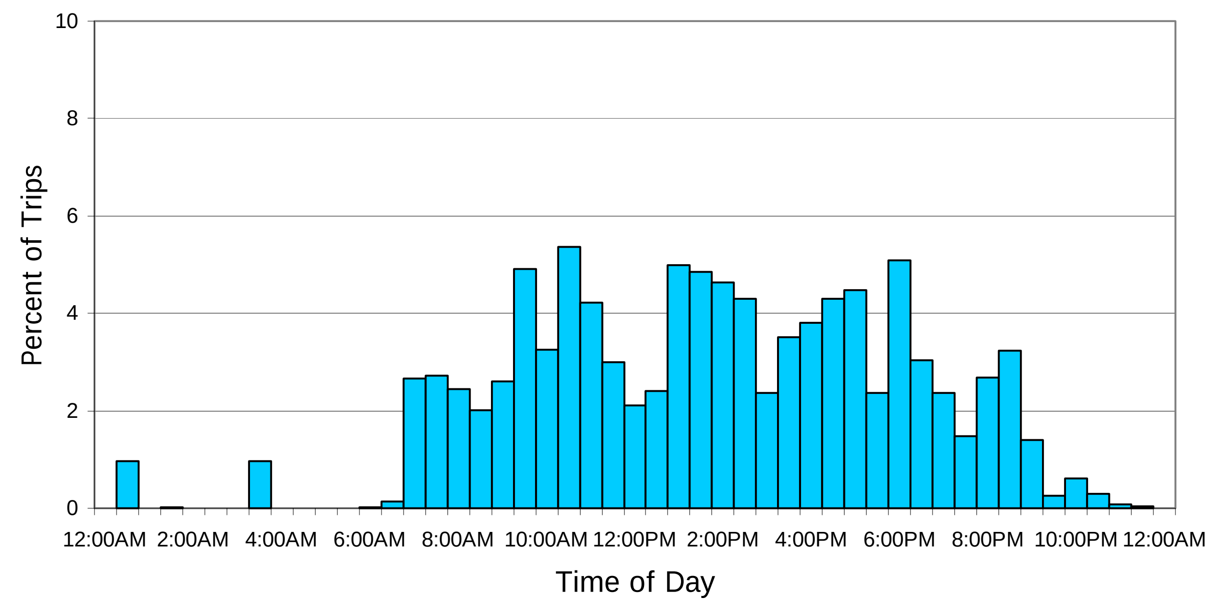


Figure 3. Home Based Shopping/Errand Trips
(N=2167800)

Figure 4. Home Based Social Recreation Trips
(N=634814)

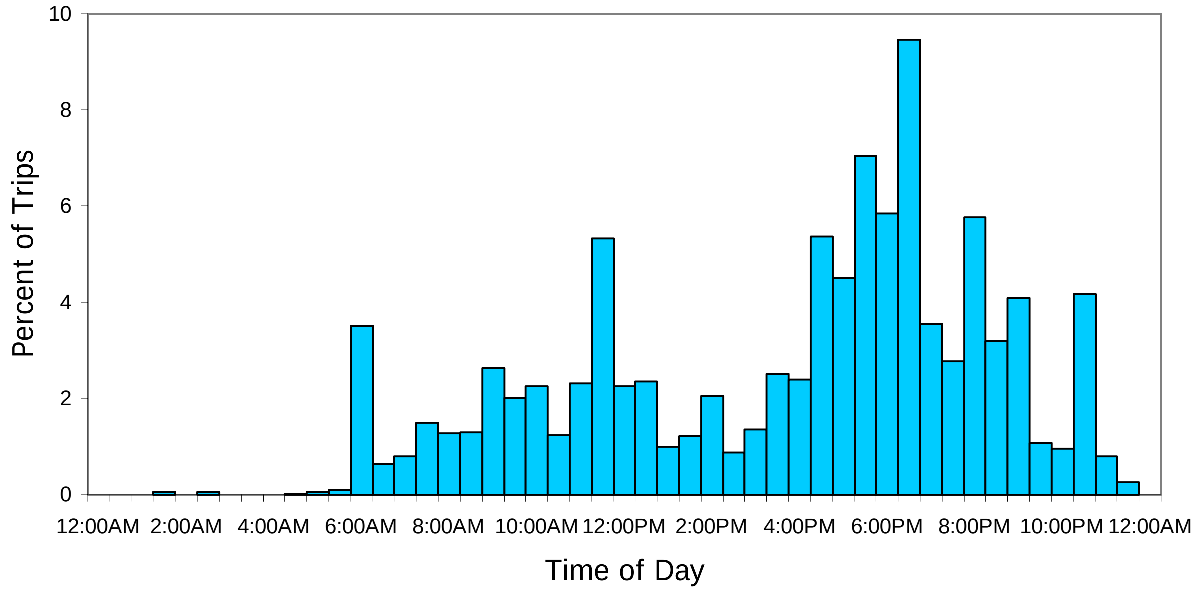
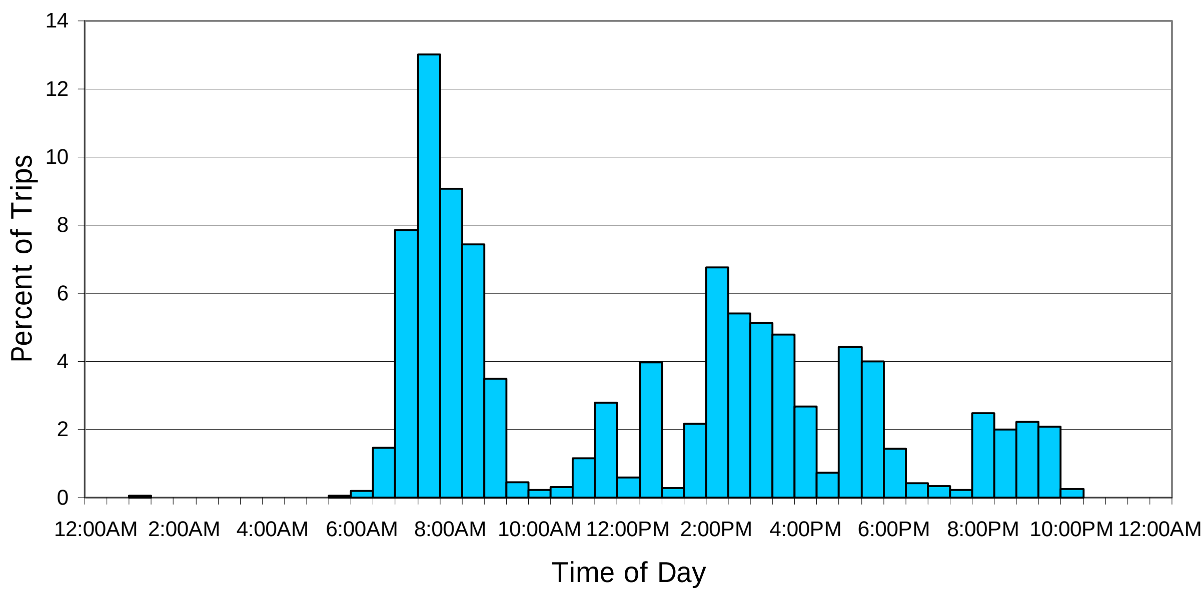


Figure 5. Home Based School Trips
(N=1251115)



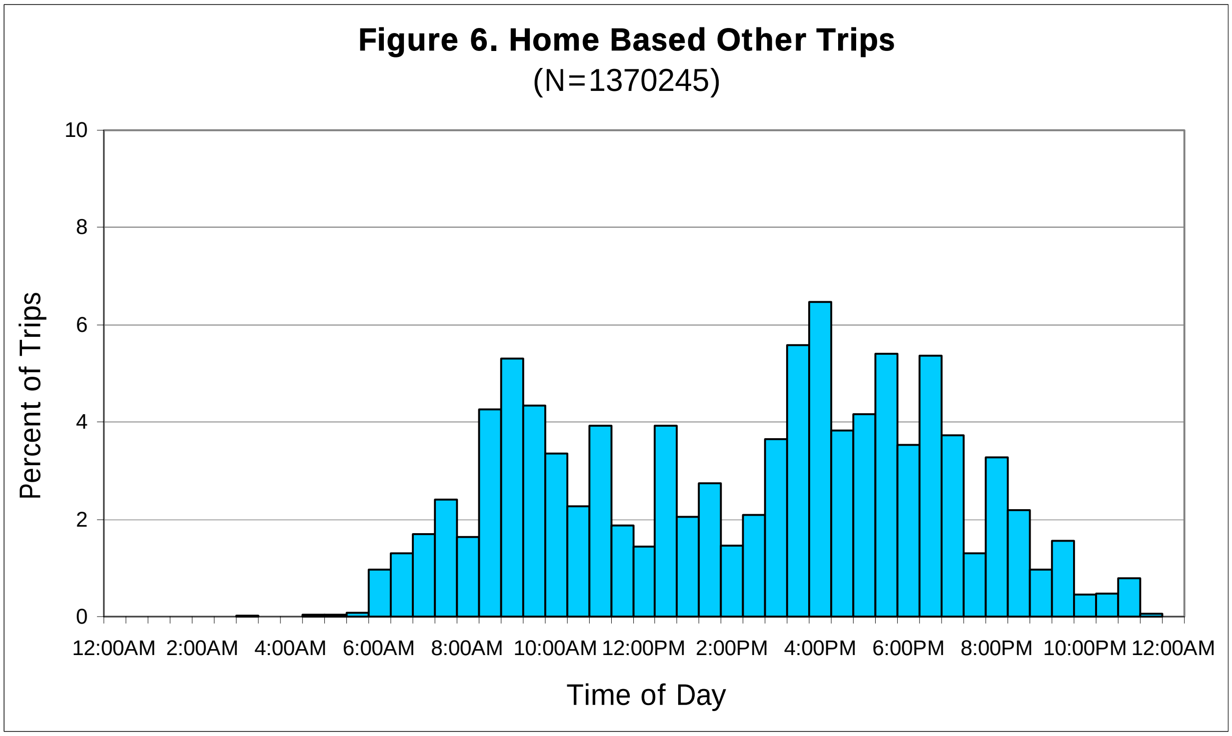


Figure 6. Home Based Other Trips
(N=1370245)
Percent of Trips
10
8
6
4
2
0
12:00AM
2:00AM
4:00AM
6:00AM
8:00AM
10:00AM
12:00PM
2:00PM
4:00PM
6:00PM
8:00PM
10:00PM
12:00AM
Time of Day

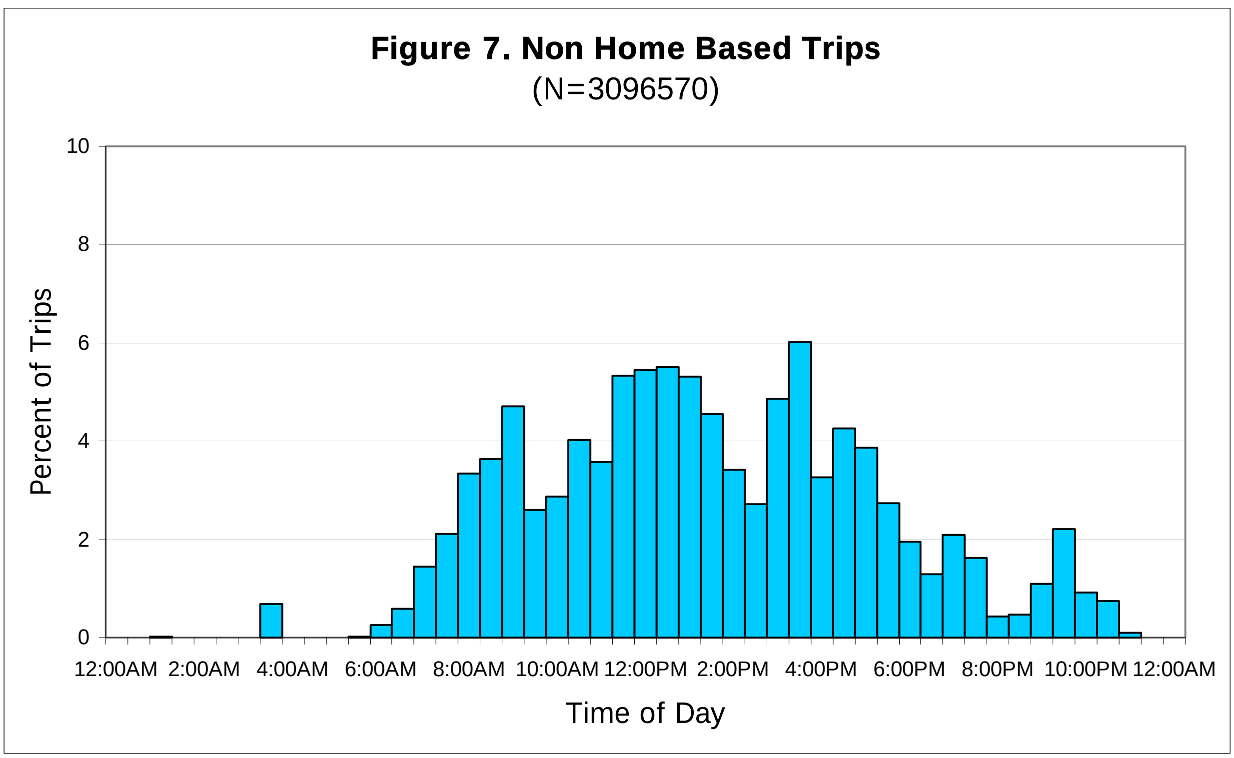


Figure 7. Non Home Based Trips
(N=3096570)
Percent of Trips
10
8
6
4
2
0
12:00AM
2:00AM
4:00AM
6:00AM
8:00AM
10:00AM
12:00PM
2:00PM
4:00PM
6:00PM
8:00PM
10:00PM
12:00AM
Time of Day

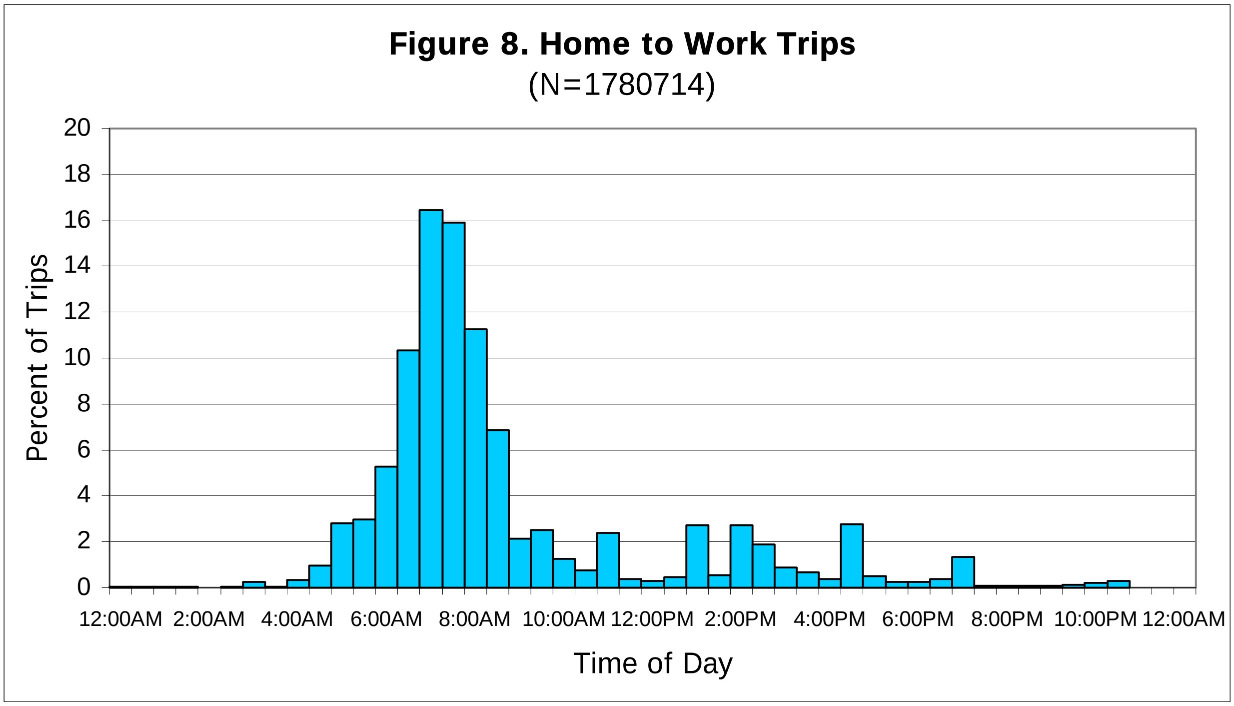


Figure 8. Home to Work Trips
(N=1780714)
20
18
16
14
12
10
8
6
4
2
0
Percent of Trips
12:00AM
2:00AM
4:00AM
6:00AM
8:00AM
10:00AM
12:00PM
2:00PM
4:00PM
6:00PM
8:00PM
10:00PM
12:00AM
Time of Day

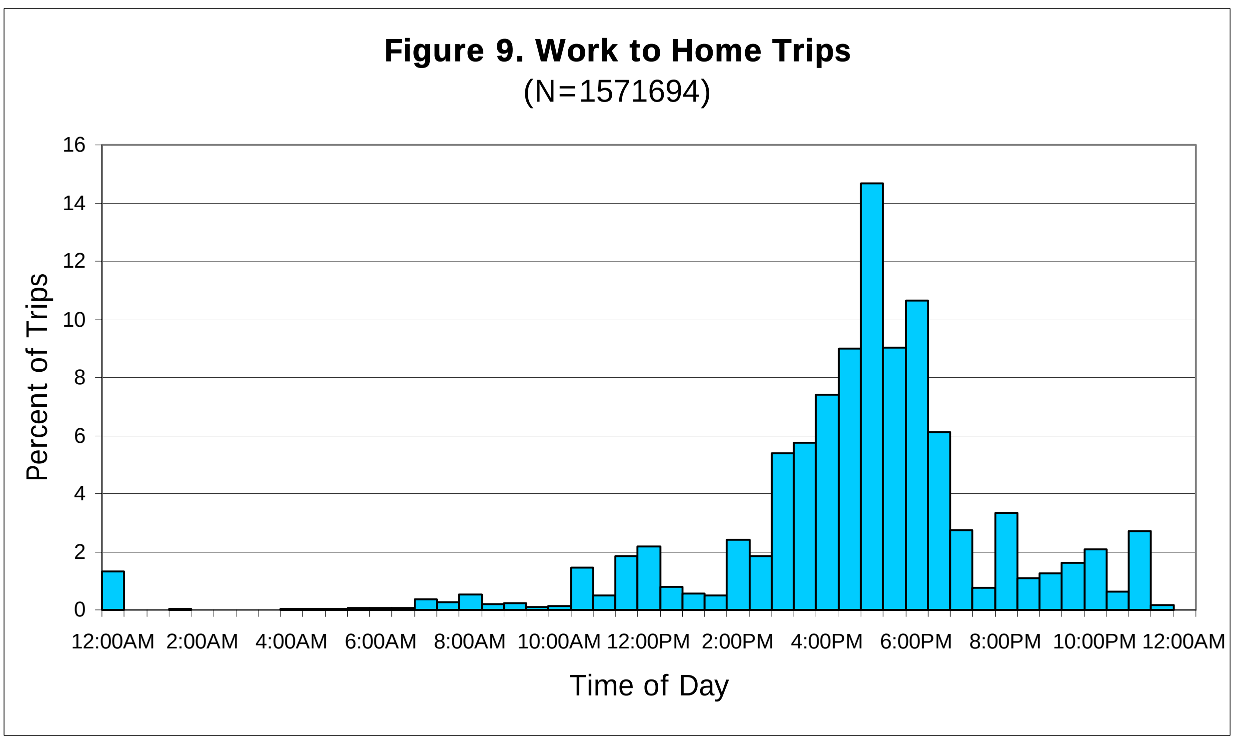


Figure 9. Work to Home Trips
(N=1571694)
16
14
12
10
8
6
4
2
0
Percent of Trips
12:00AM
2:00AM
4:00AM
6:00AM
8:00AM
10:00AM
12:00PM
2:00PM
4:00PM
6:00PM
8:00PM
10:00PM
12:00AM
Time of Day

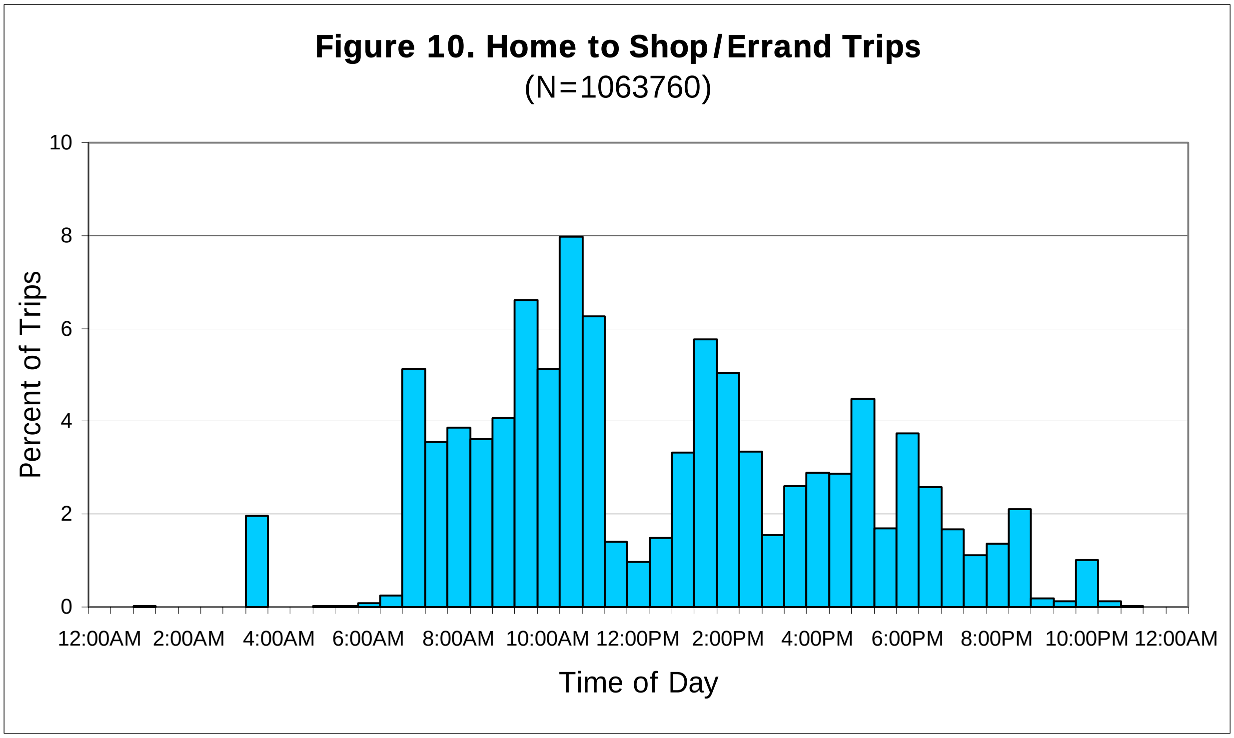


Figure 10. Home to Shop/Errand Trips
(N=1063760)
10
8
6
4
2
0
Percent of Trips
12:00AM 2:00AM 4:00AM 6:00AM 8:00AM 10:00AM 12:00PM 2:00PM 4:00PM 6:00PM 8:00PM 10:00PM 12:00AM
Time of Day

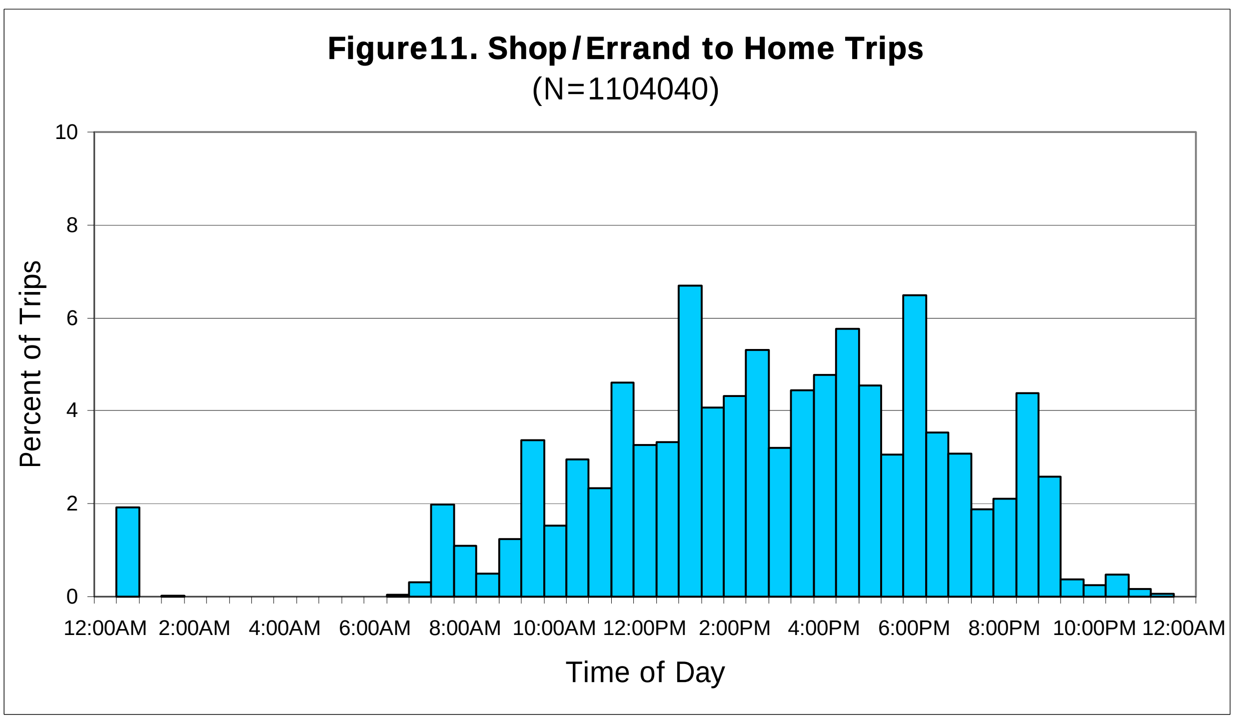


Figure11. Shop/Errand to Home Trips
(N=1104040)
10
8
6
4
2
0
Percent of Trips
12:00AM 2:00AM 4:00AM 6:00AM 8:00AM 10:00AM 12:00PM 2:00PM 4:00PM 6:00PM 8:00PM 10:00PM 12:00AM
Time of Day

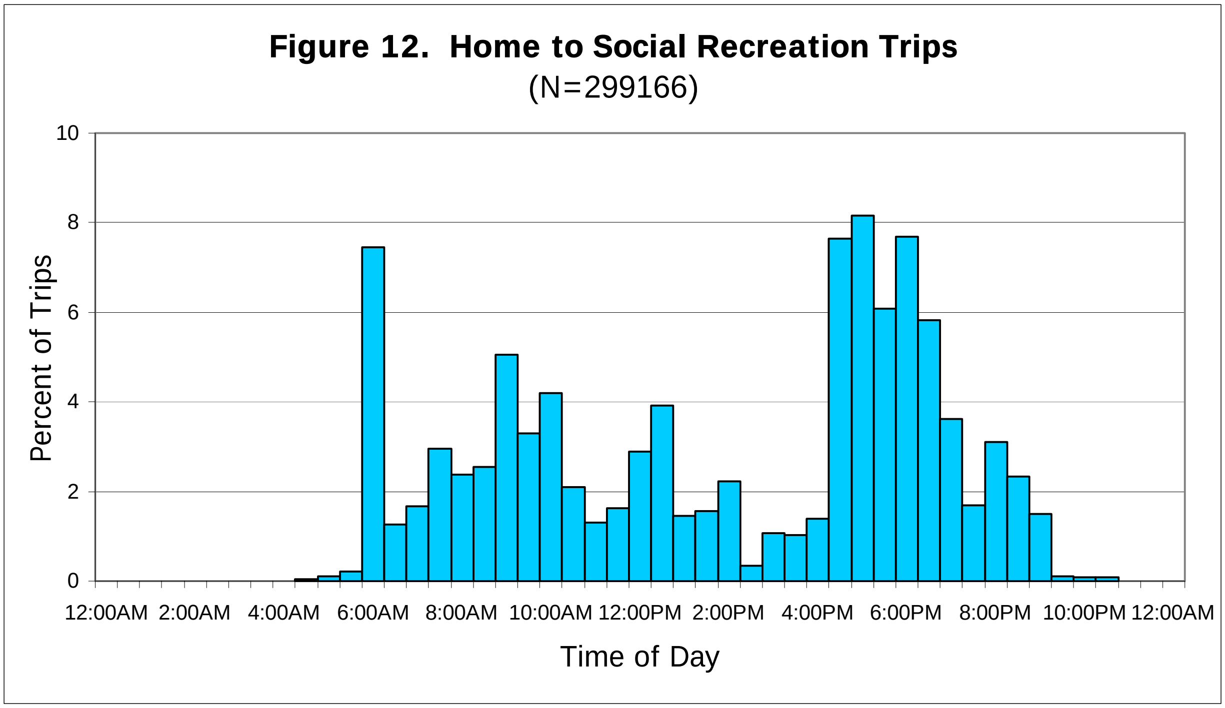


Figure 12. Home to Social Recreation Trips
(N=299166)
Percent of Trips
0
2
4
6
8
10
12:00AM
2:00AM
4:00AM
6:00AM
8:00AM
10:00AM
12:00PM
2:00PM
4:00PM
6:00PM
8:00PM
10:00PM
12:00AM
Time of Day

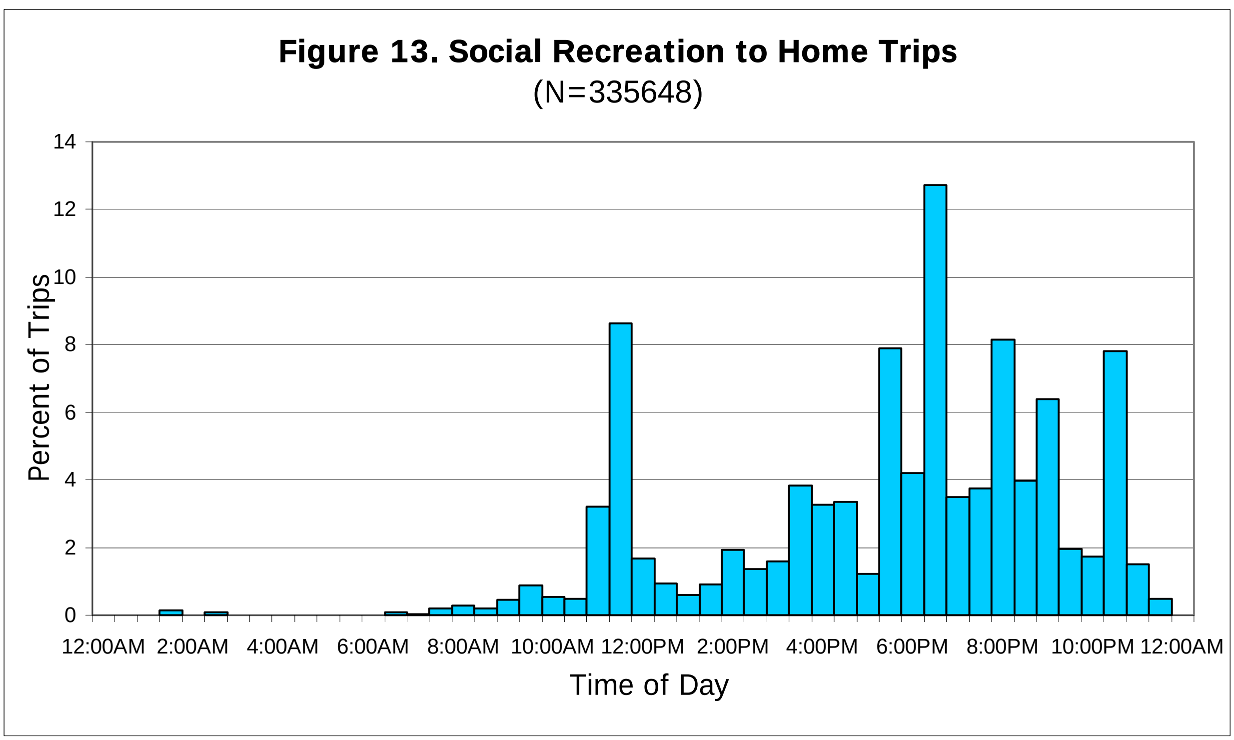


Figure 13. Social Recreation to Home Trips
(N=335648)
Percent of Trips
0
2
4
6
8
10
12
14
12:00AM
2:00AM
4:00AM
6:00AM
8:00AM
10:00AM
12:00PM
2:00PM
4:00PM
6:00PM
8:00PM
10:00PM
12:00AM
Time of Day

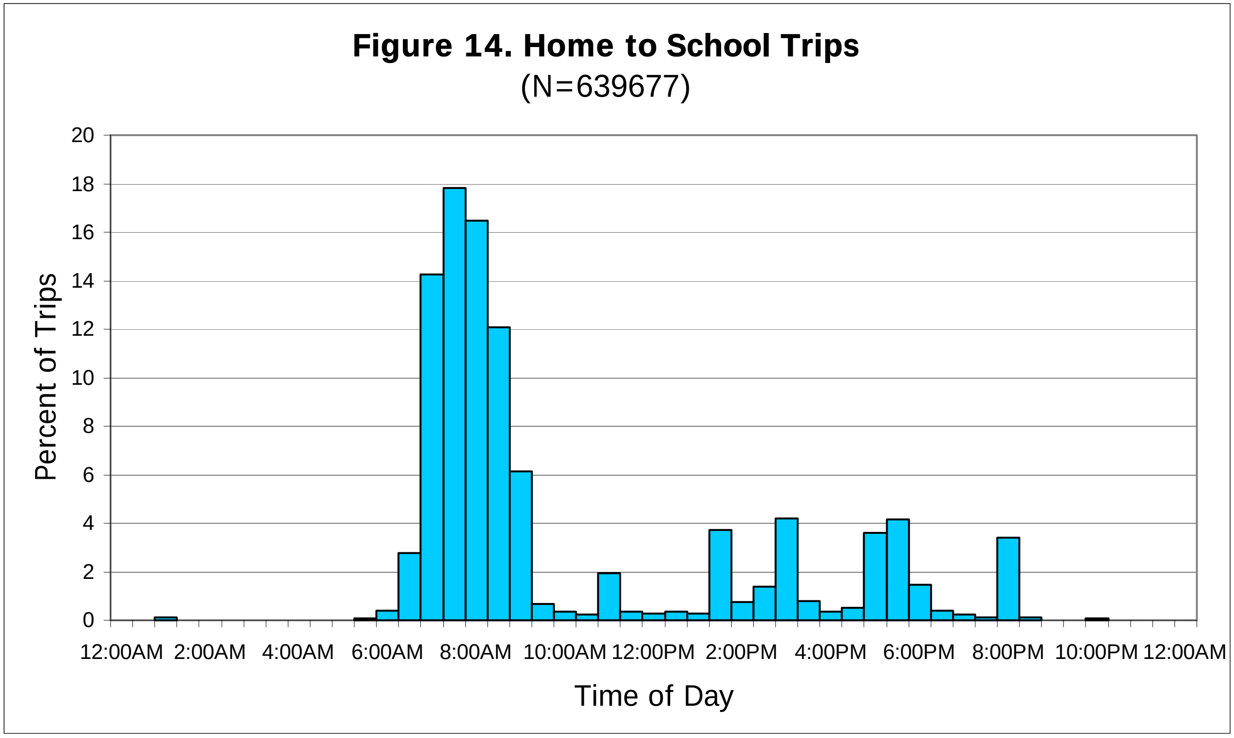


Figure 14. Home to School Trips
(N=639677)
Percent of Trips
20
18
16
14
12
10
8
6
4
2
0
12:00AM 2:00AM 4:00AM 6:00AM 8:00AM 10:00AM 12:00PM 2:00PM 4:00PM 6:00PM 8:00PM 10:00PM 12:00AM
Time of Day

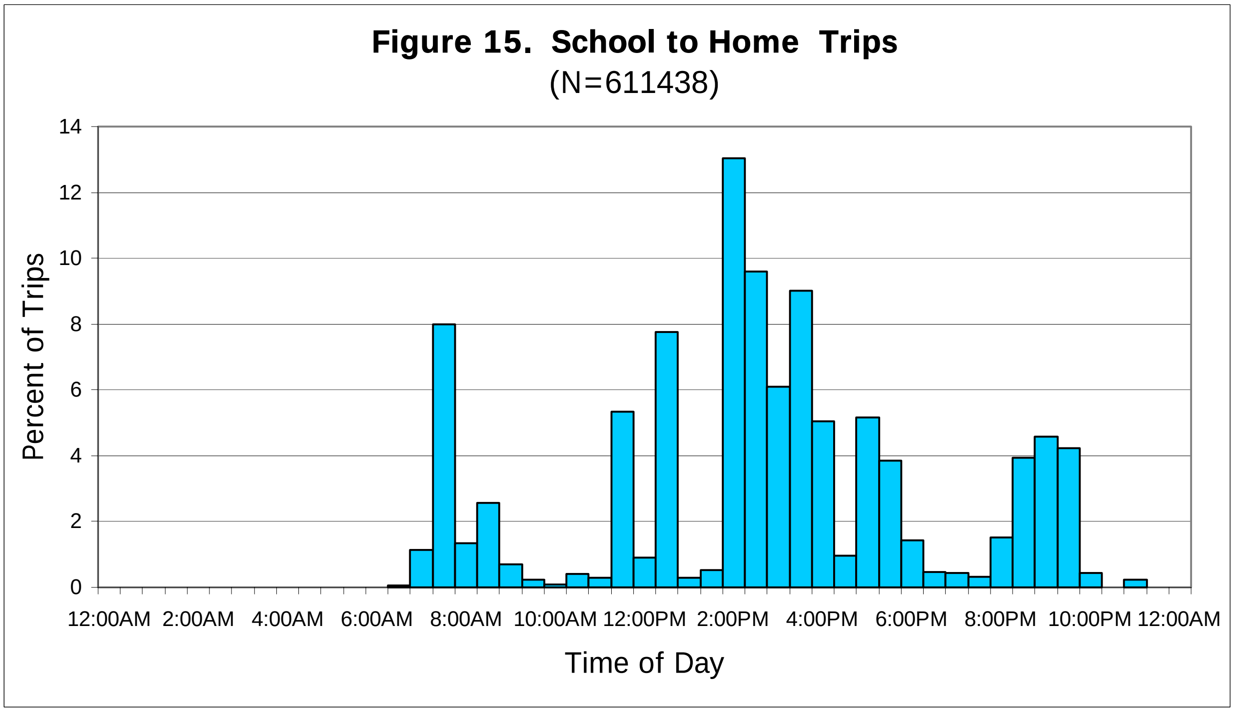


Figure 15. School to Home Trips
(N=611438)
Percent of Trips
14
12
10
8
6
4
2
0
12:00AM 2:00AM 4:00AM 6:00AM 8:00AM 10:00AM 12:00PM 2:00PM 4:00PM 6:00PM 8:00PM 10:00PM 12:00AM
Time of Day

Figure 16. Home to Other Trips
(N=780884)

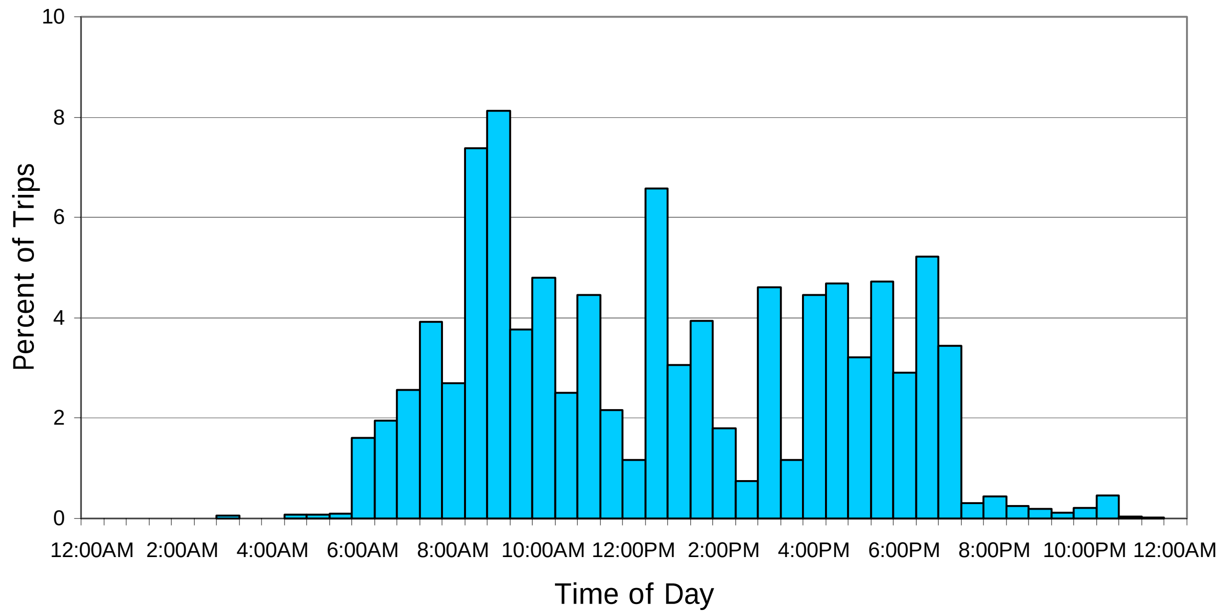
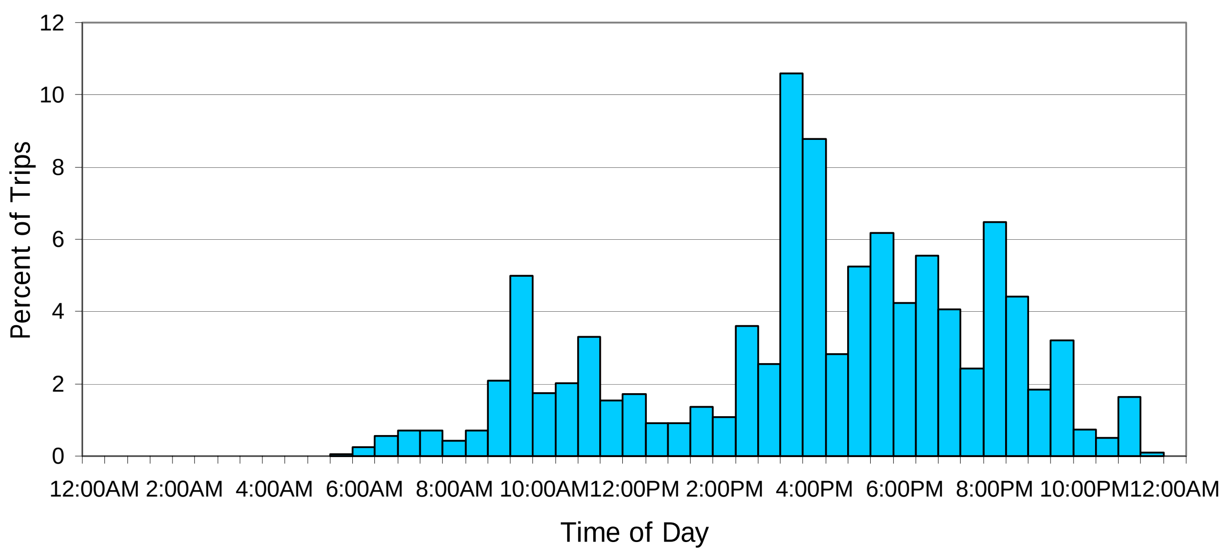


Figure 17. Other to Home Trips
(N=689361)



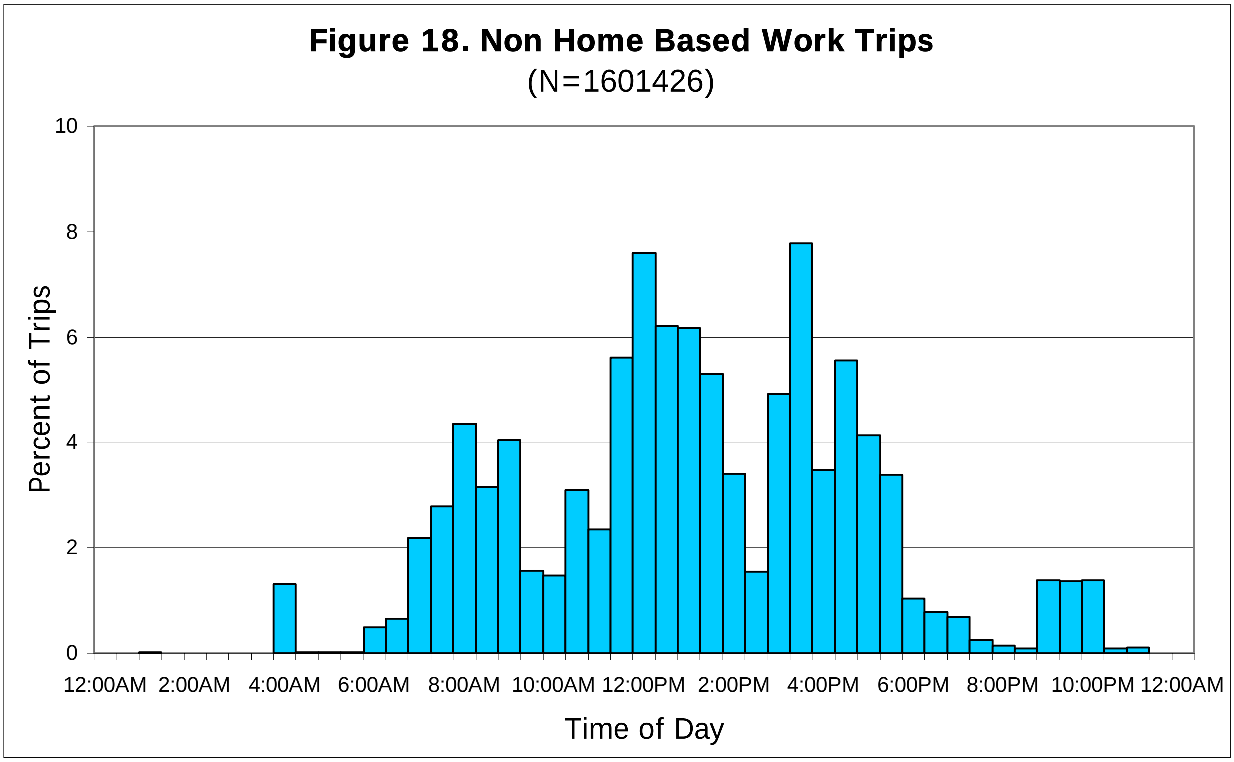


Figure 18. Non Home Based Work Trips
(N=1601426)
Percent of Trips
0
2
4
6
8
10
12:00AM
2:00AM
4:00AM
6:00AM
8:00AM
10:00AM
12:00PM
2:00PM
4:00PM
6:00PM
8:00PM
10:00PM
12:00AM
Time of Day

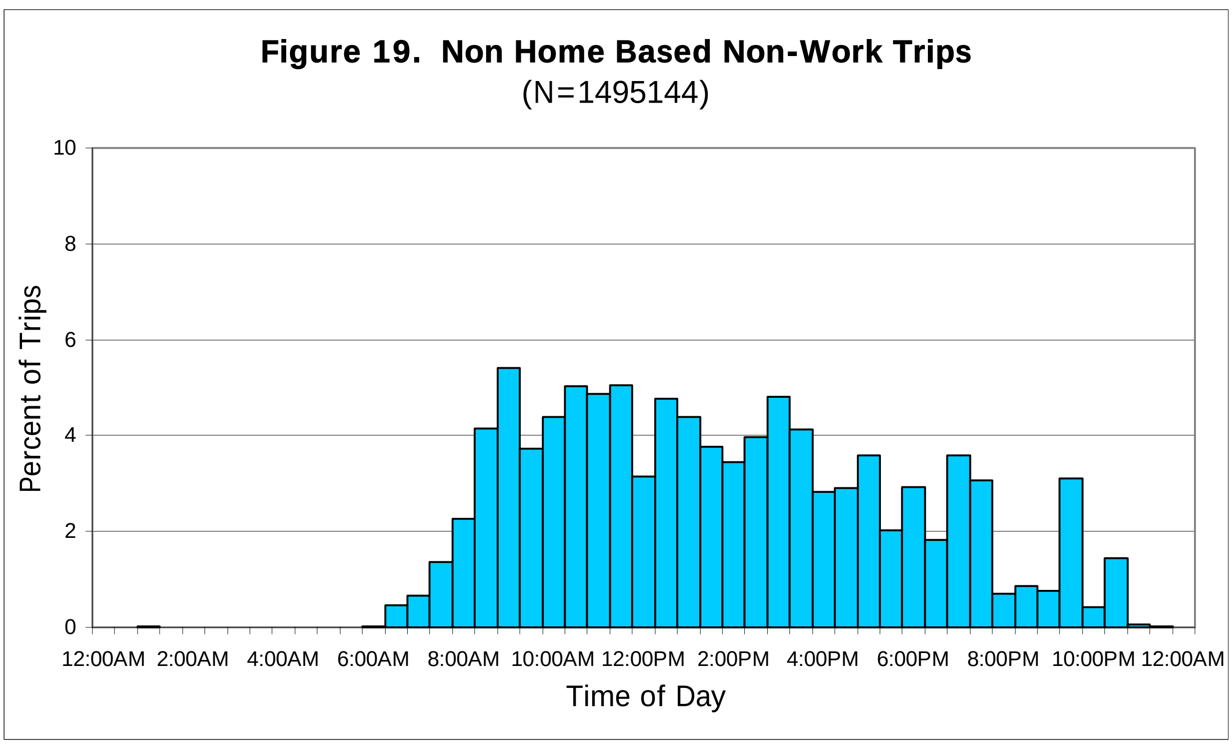
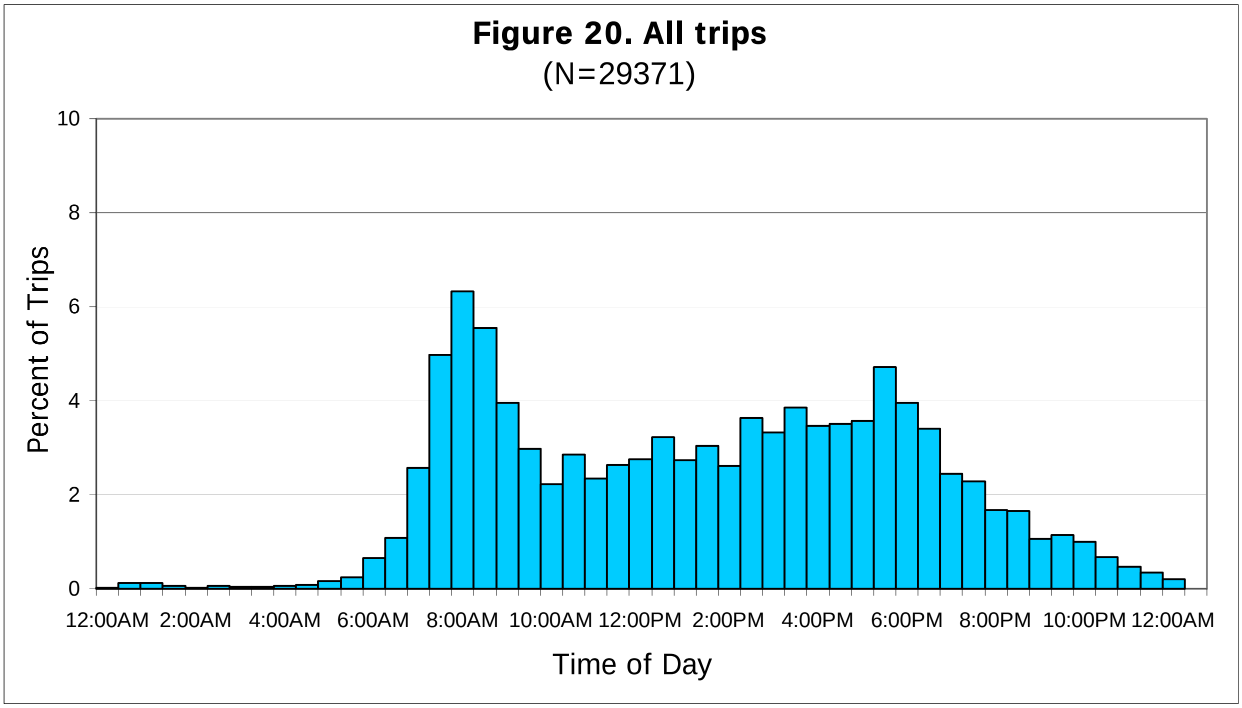


Figure 19. Non Home Based Non-Work Trips
(N=1495144)
Percent of Trips
0
2
4
6
8
10
12:00AM
2:00AM
4:00AM
6:00AM
8:00AM
10:00AM
12:00PM
2:00PM
4:00PM
6:00PM
8:00PM
10:00PM
12:00AM
Time of Day

TIME OF DAY DISTRIBUTIONS IN SE FLORIDA



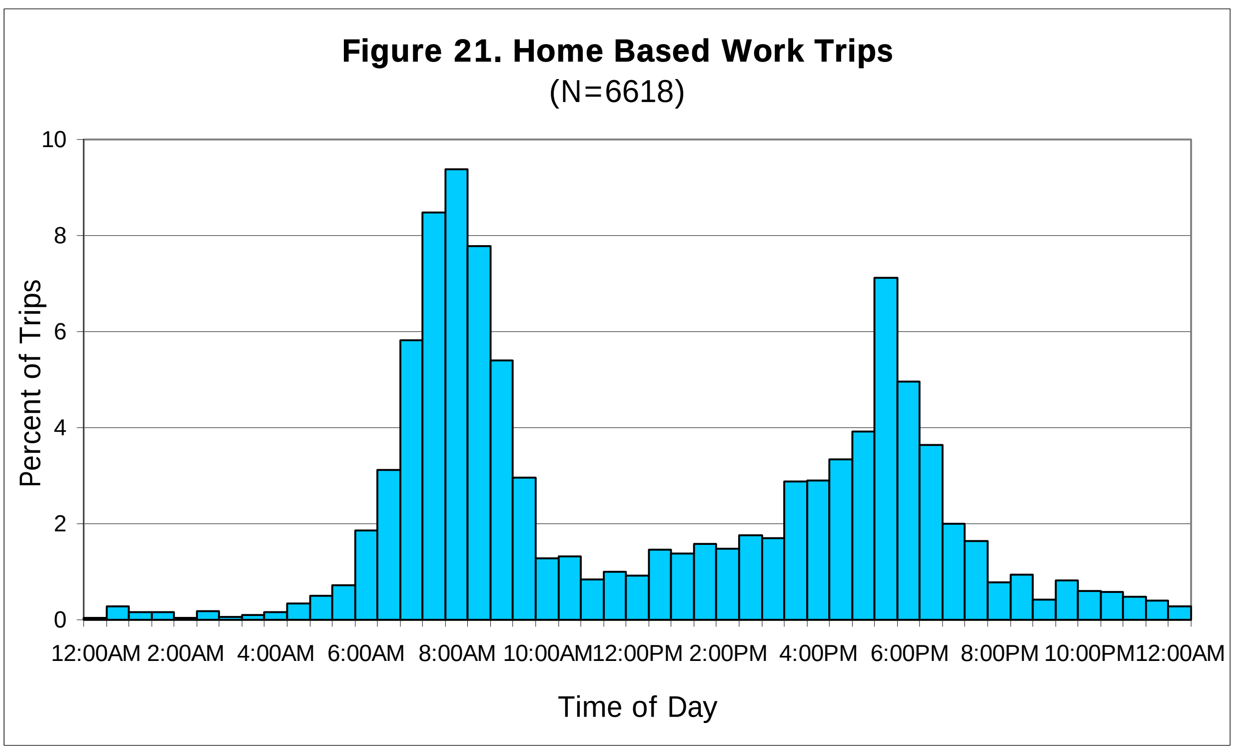


Figure 22. Home Based Shopping Trips
(N=2277)

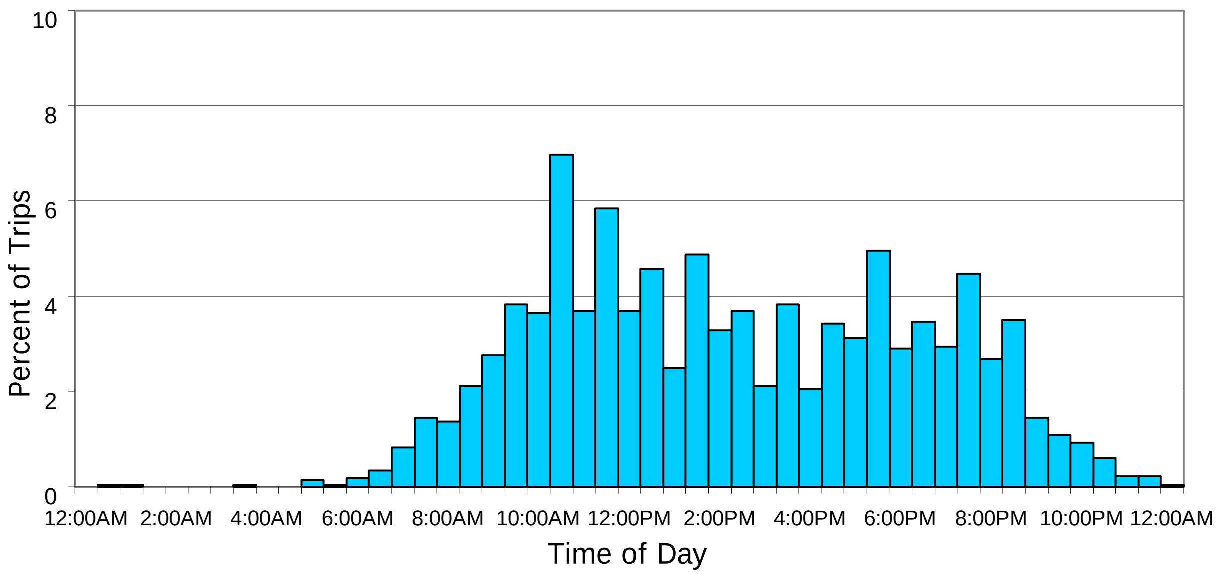
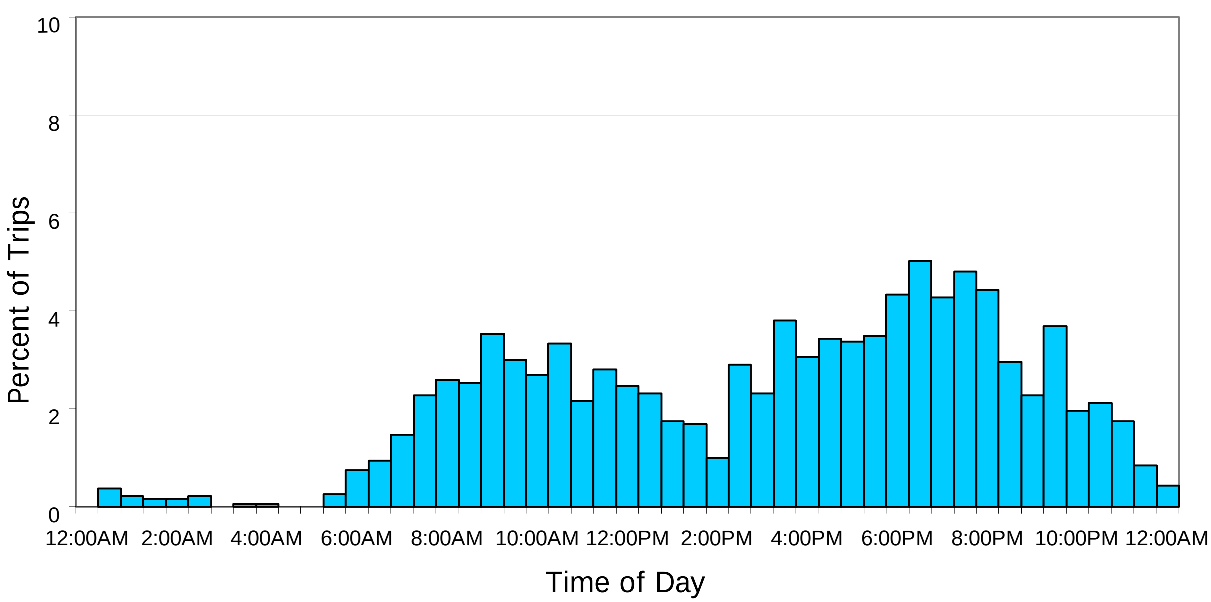


Figure 23. Home Based Social Recreation Trips
(N= 1895)



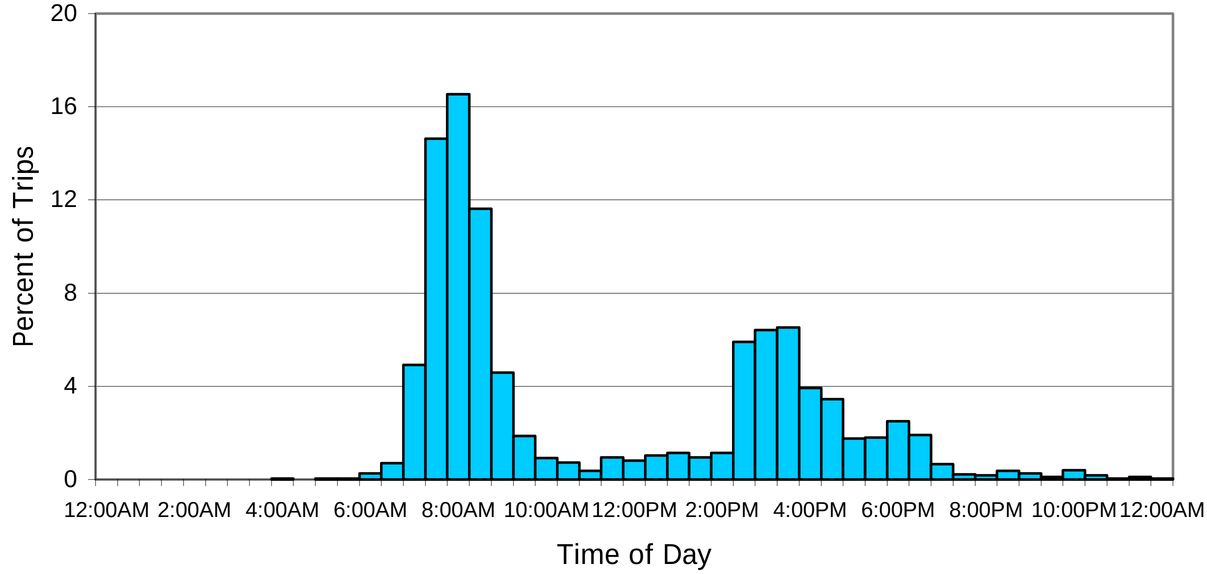


Figure 24. Home Based School Trips
(N=2727)

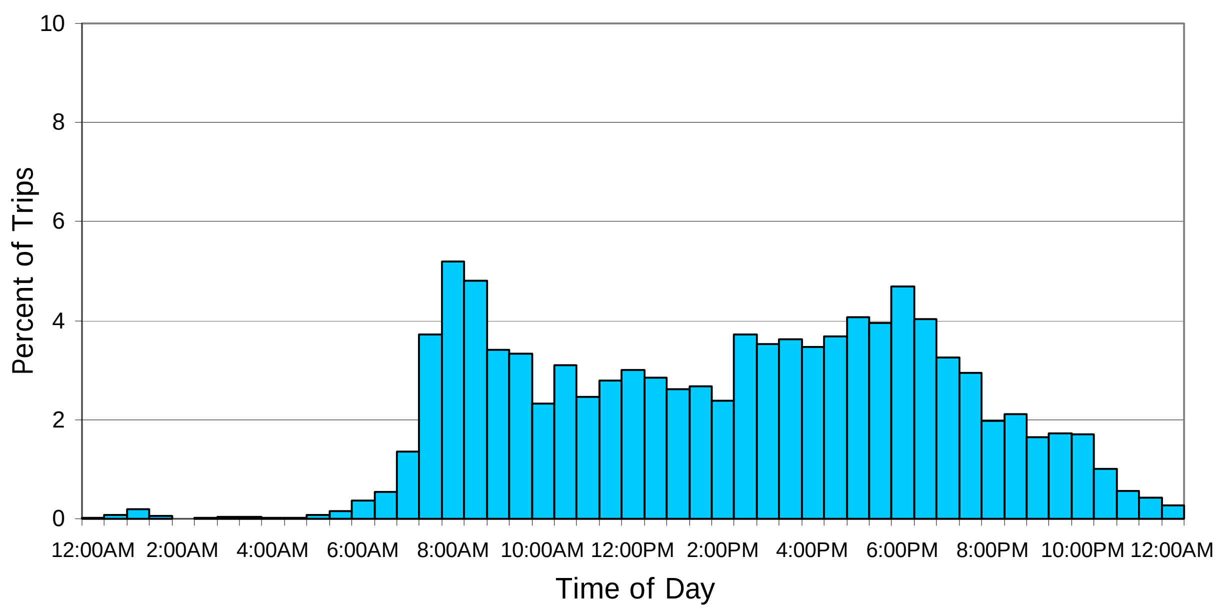


Figure 25. Home Based Other Trips
(N=8078)

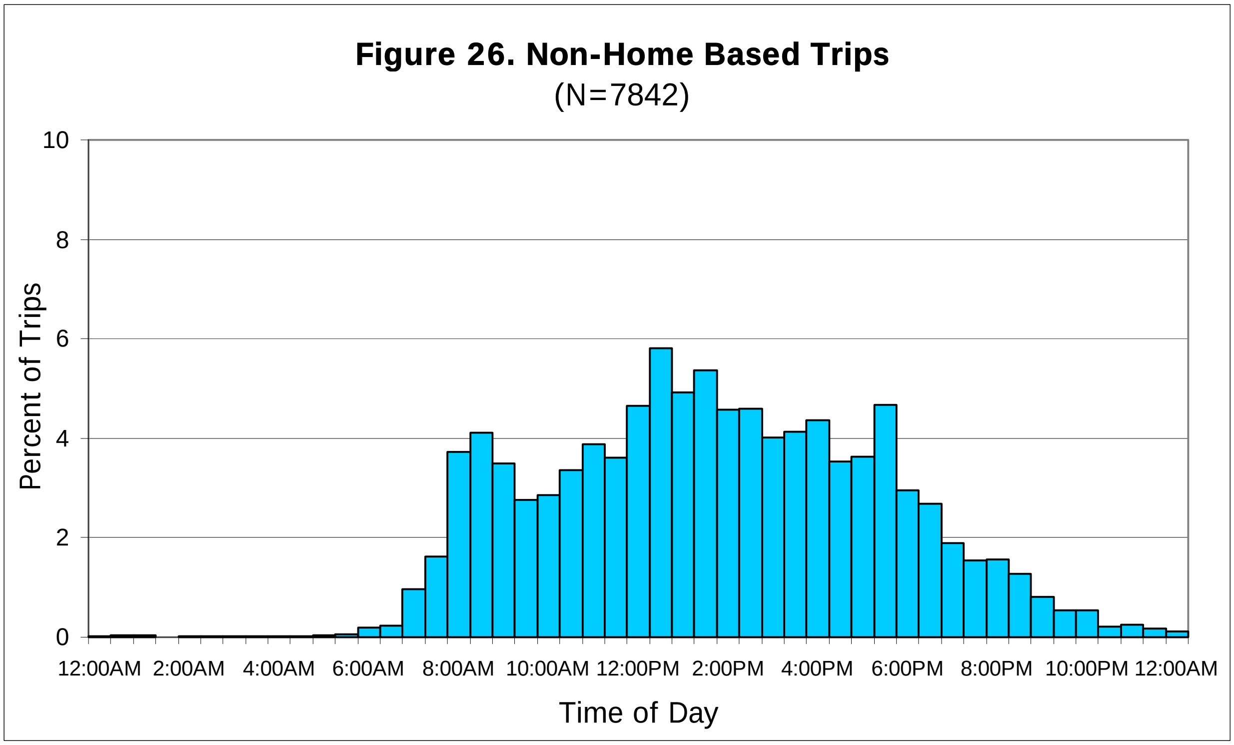


Figure 26. Non-Home Based Trips
(N=7842)
10
8
6
4
2
0
Percent of Trips
12:00AM 2:00AM 4:00AM 6:00AM 8:00AM 10:00AM 12:00PM 2:00PM 4:00PM 6:00PM 8:00PM 10:00PM 12:00AM
Time of Day

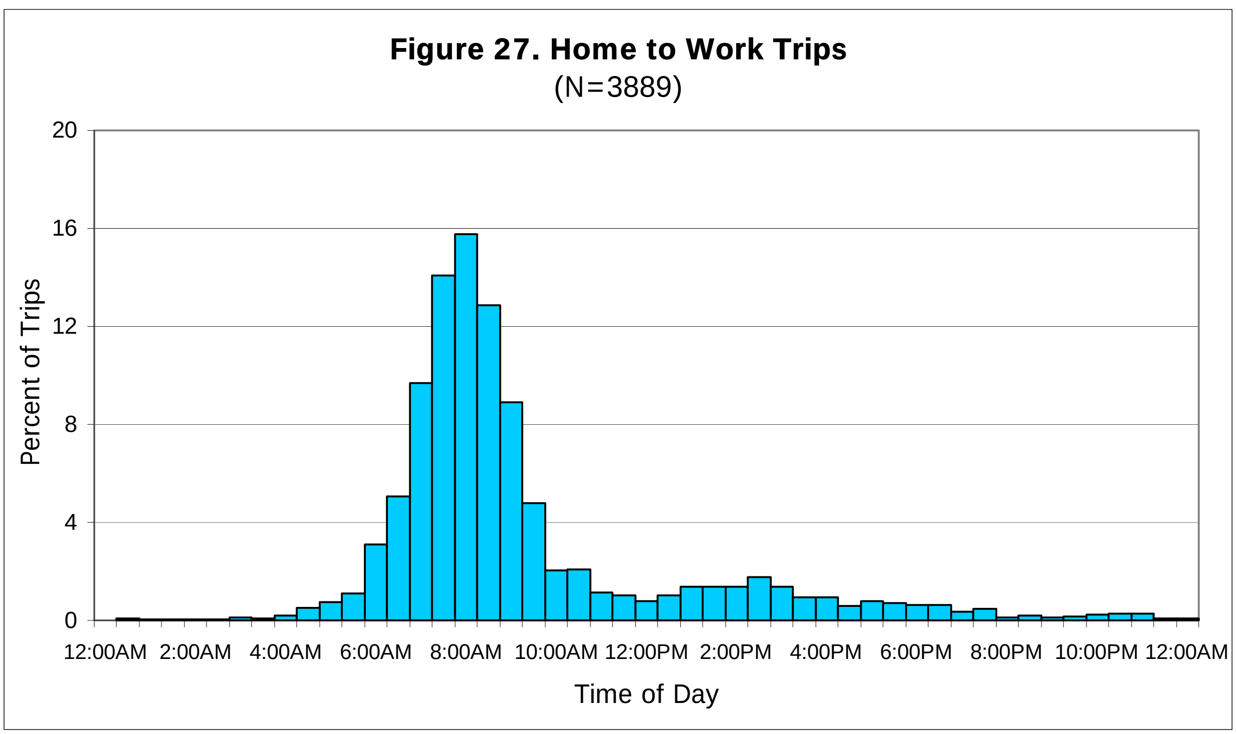


Figure 27. Home to Work Trips
(N=3889)
20
16
12
8
4
0
Percent of Trips
12:00AM 2:00AM 4:00AM 6:00AM 8:00AM 10:00AM 12:00PM 2:00PM 4:00PM 6:00PM 8:00PM 10:00PM 12:00AM
Time of Day

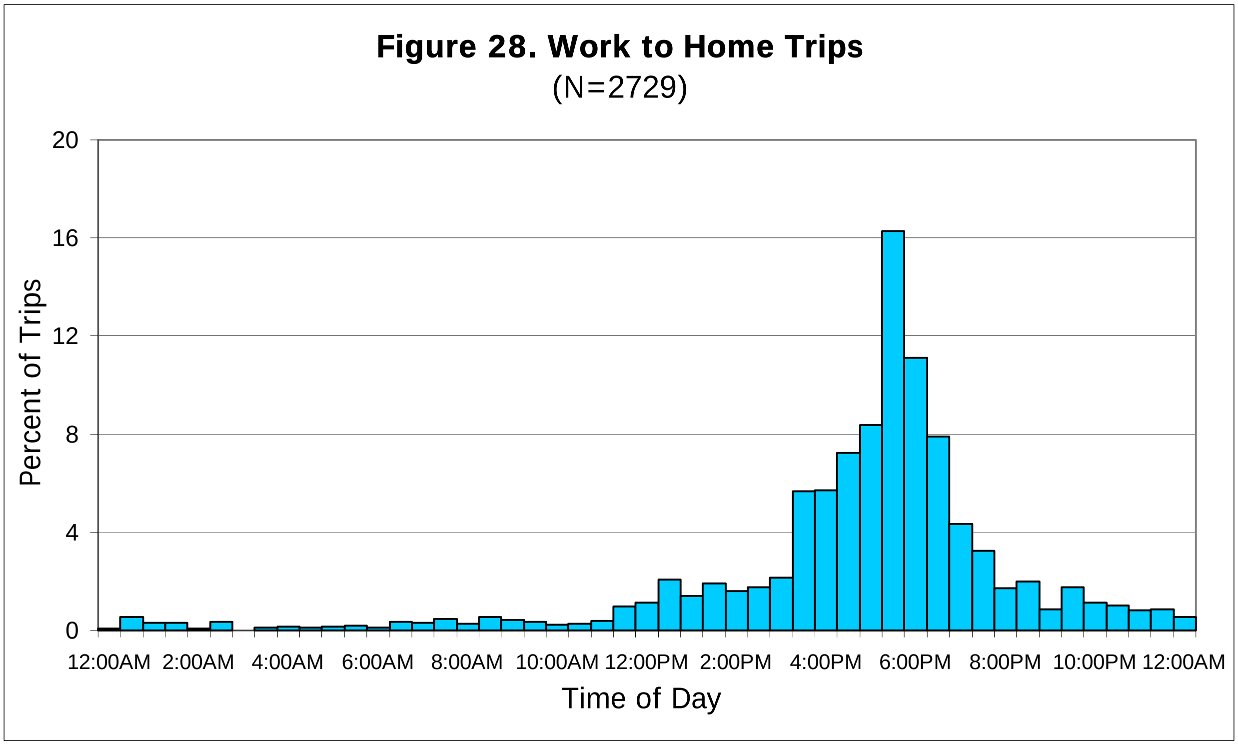


Figure 28. Work to Home Trips
(N=2729)
20
16
12
8
4
0
Percent of Trips
12:00AM 2:00AM 4:00AM 6:00AM 8:00AM 10:00AM 12:00PM 2:00PM 4:00PM 6:00PM 8:00PM 10:00PM 12:00AM
Time of Day

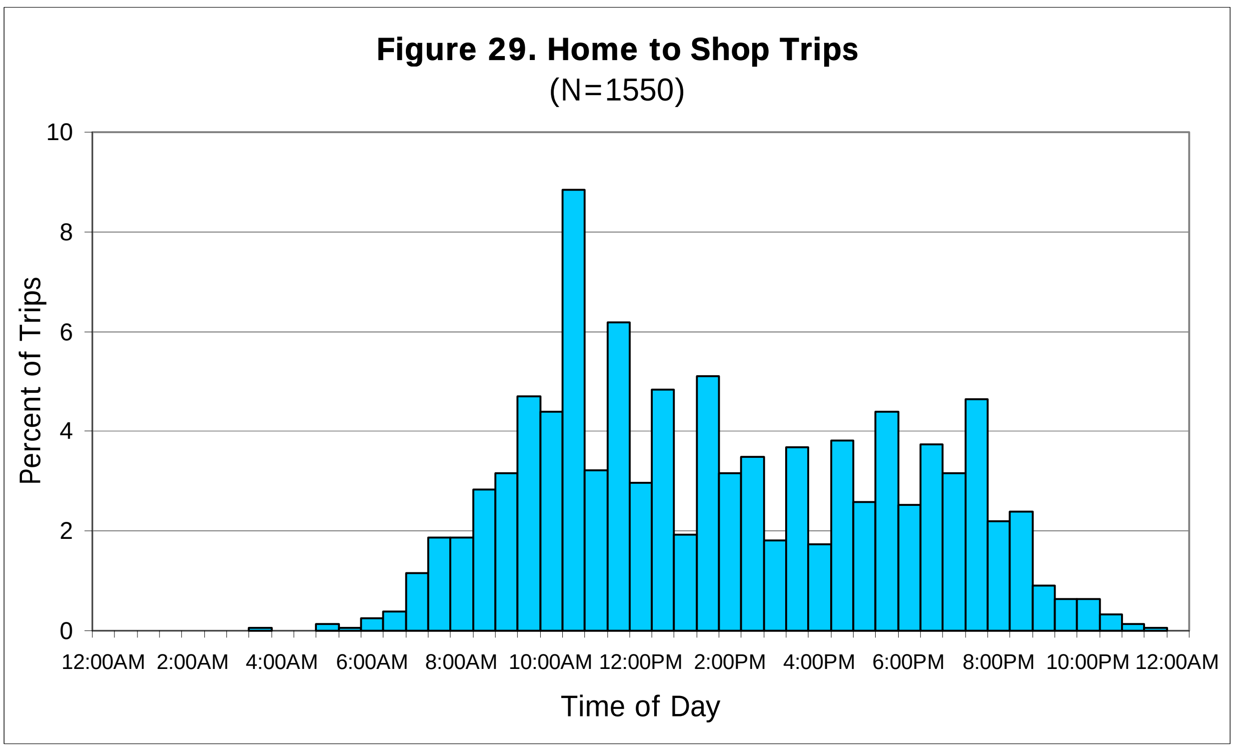


Figure 29. Home to Shop Trips
(N=1550)
10
8
6
4
2
0
Percent of Trips
12:00AM 2:00AM 4:00AM 6:00AM 8:00AM 10:00AM 12:00PM 2:00PM 4:00PM 6:00PM 8:00PM 10:00PM 12:00AM
Time of Day

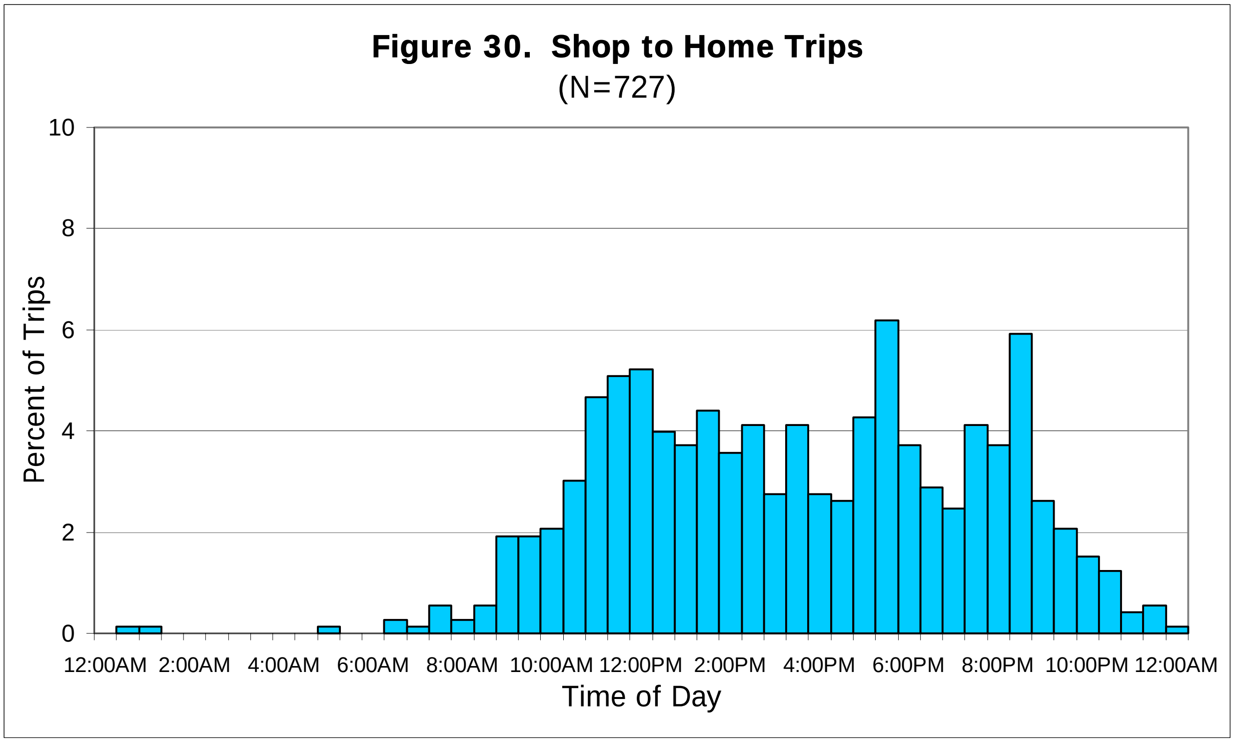


Figure 30. Shop to Home Trips
(N=727)
Percent of Trips
0
2
4
6
8
10
12:00AM
2:00AM
4:00AM
6:00AM
8:00AM
10:00AM
12:00PM
2:00PM
4:00PM
6:00PM
8:00PM
10:00PM
12:00AM
Time of Day

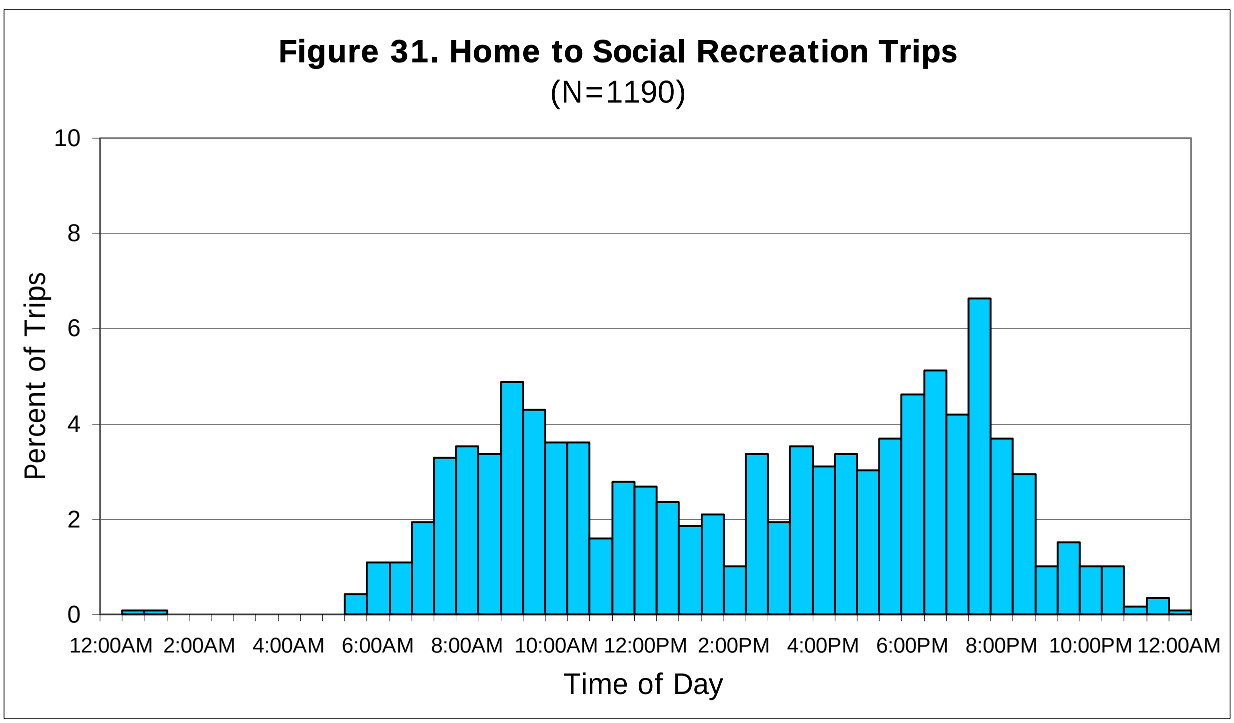


Figure 31. Home to Social Recreation Trips
(N=1190)
Percent of Trips
0
2
4
6
8
10
12:00AM
2:00AM
4:00AM
6:00AM
8:00AM
10:00AM
12:00PM
2:00PM
4:00PM
6:00PM
8:00PM
10:00PM
12:00AM
Time of Day

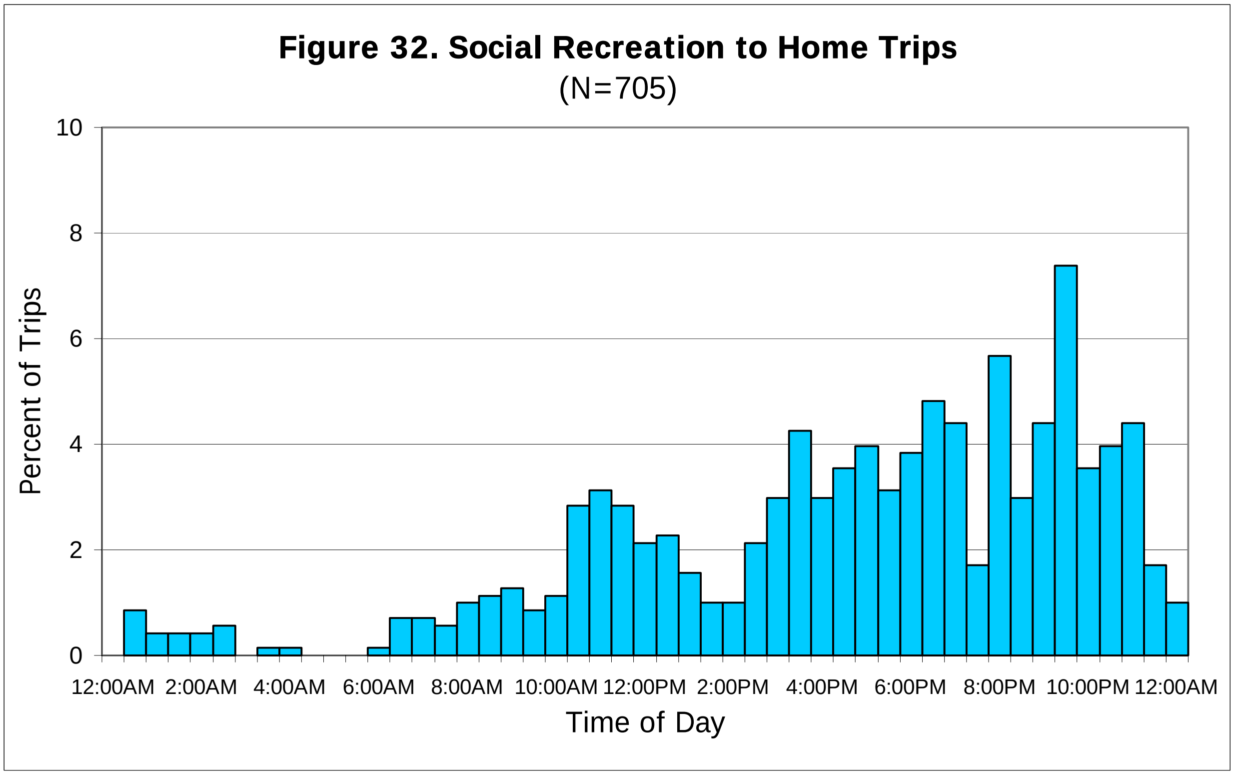


Figure 32. Social Recreation to Home Trips
(N=705)
Percent of Trips
10
8
6
4
2
0
12:00AM 2:00AM 4:00AM 6:00AM 8:00AM 10:00AM 12:00PM 2:00PM 4:00PM 6:00PM 8:00PM 10:00PM 12:00AM
Time of Day

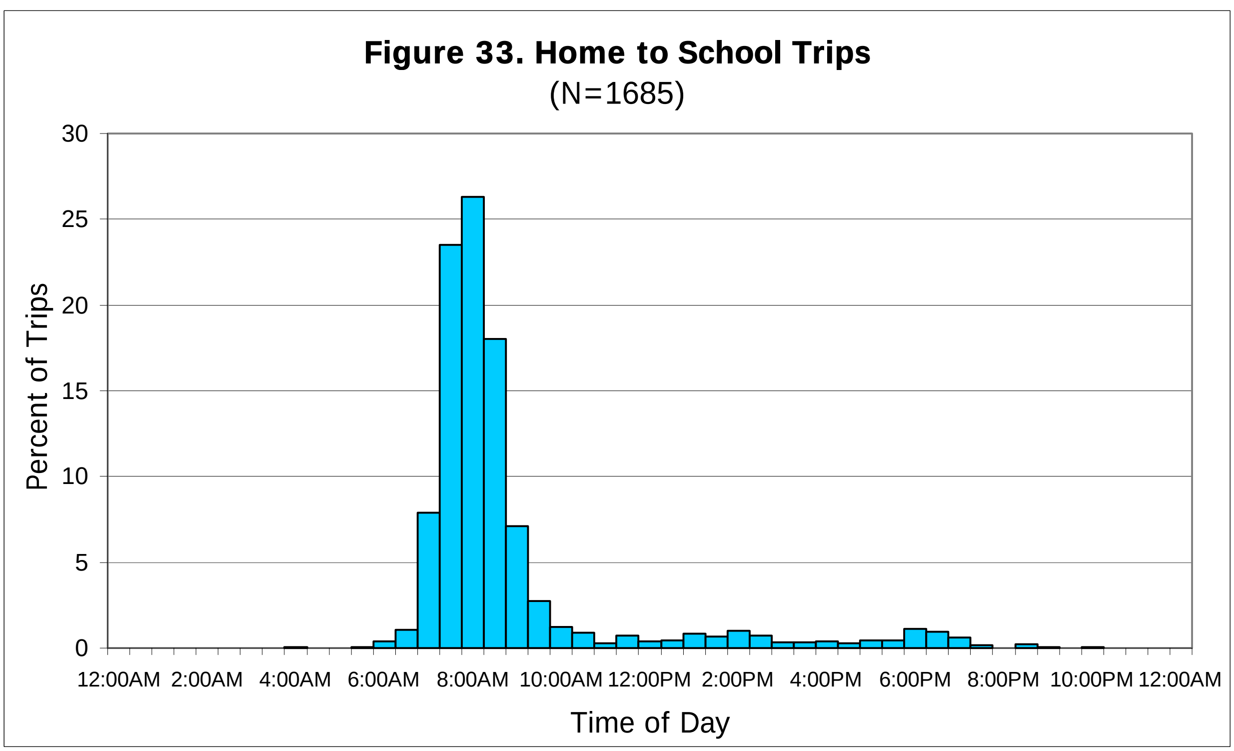


Figure 33. Home to School Trips
(N=1685)
Percent of Trips
30
25
20
15
10
5
0
12:00AM 2:00AM 4:00AM 6:00AM 8:00AM 10:00AM 12:00PM 2:00PM 4:00PM 6:00PM 8:00PM 10:00PM 12:00AM
Time of Day

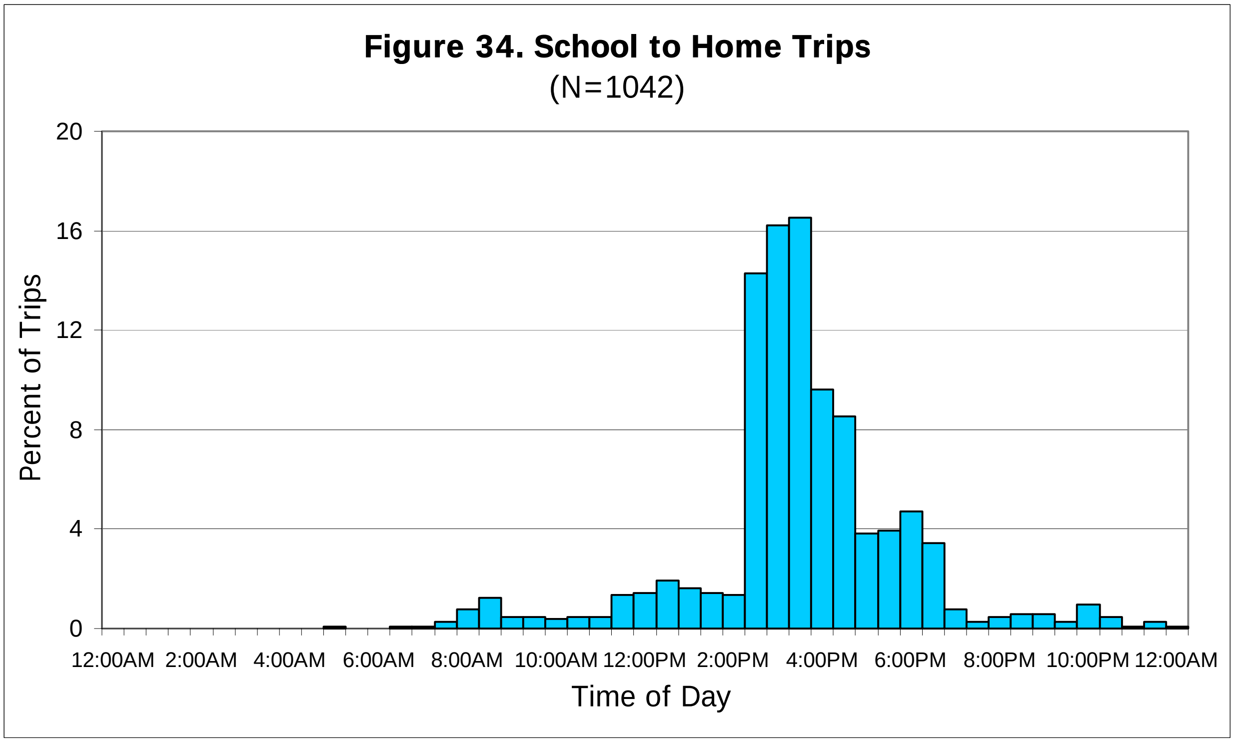


Figure 34. School to Home Trips
(N=1042)
Percent of Trips
20
16
12
8
4
0
12:00AM
2:00AM
4:00AM
6:00AM
8:00AM
10:00AM
12:00PM
2:00PM
4:00PM
6:00PM
8:00PM
10:00PM
12:00AM
Time of Day

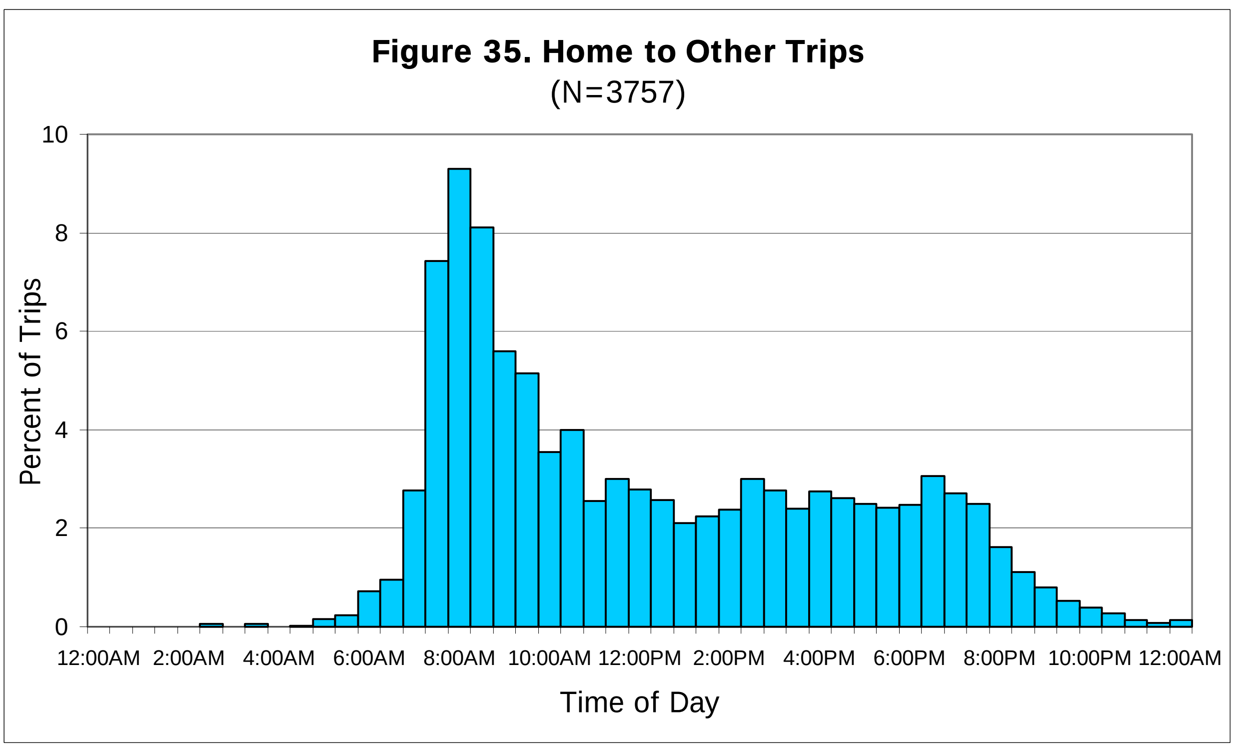


Figure 35. Home to Other Trips
(N=3757)
Percent of Trips
10
8
6
4
2
0
12:00AM
2:00AM
4:00AM
6:00AM
8:00AM
10:00AM
12:00PM
2:00PM
4:00PM
6:00PM
8:00PM
10:00PM
12:00AM
Time of Day

Figure 36. Other to Home Trips
(N=4321)

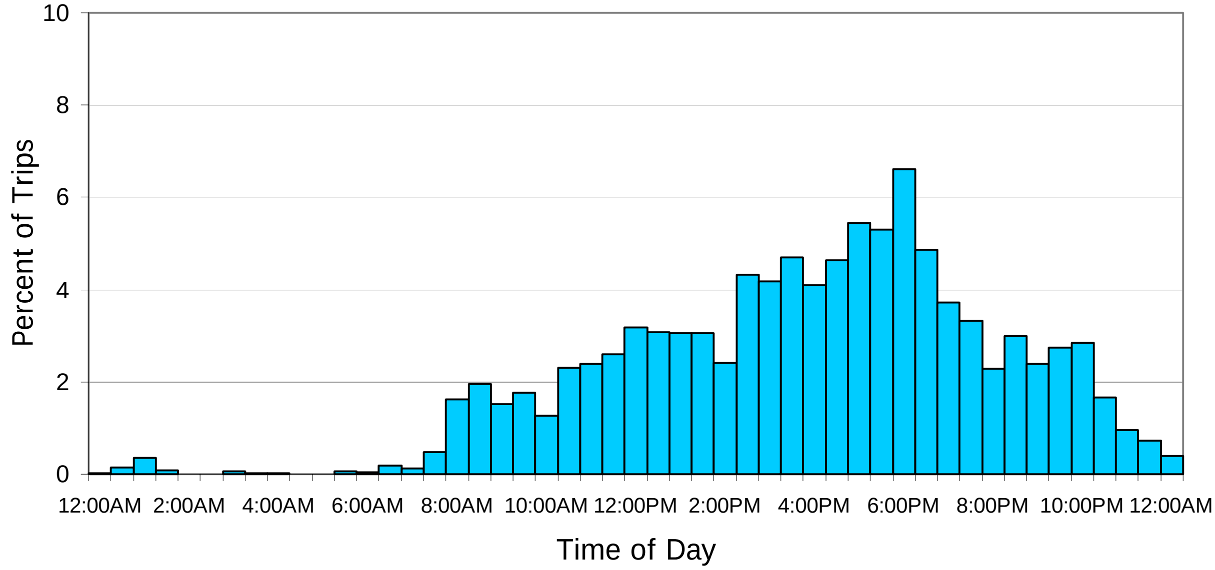
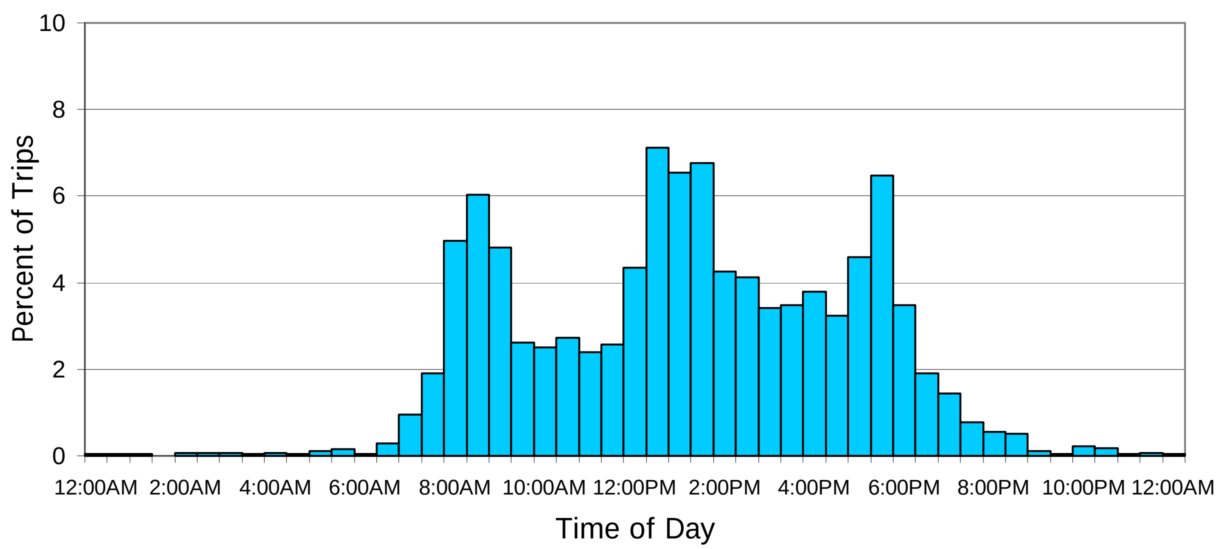
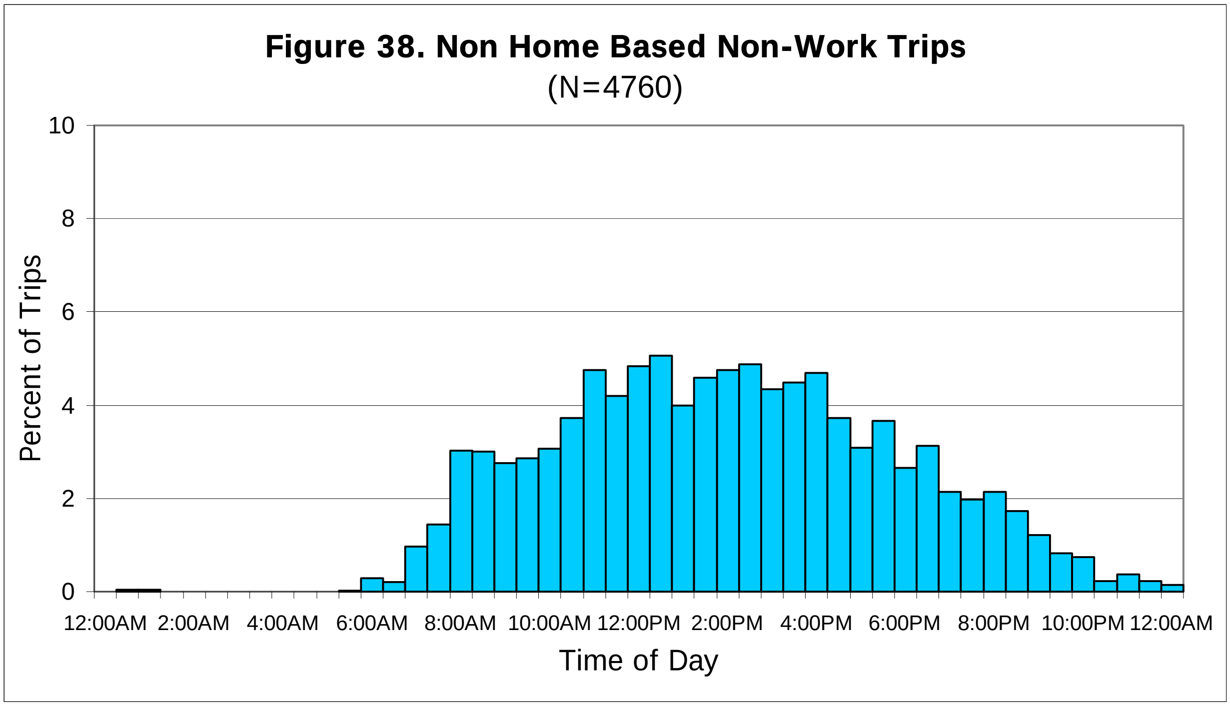


Figure 37. Non Home Based Work Trips
(N=2722)





The time of day distributions presented in this chapter form the basis for the development of time of day factors that may be applied following the trip distribution step within the four-step process. Time of day factors developed using these distributions for the Tampa Bay area and the Jacksonville area are presented in subsequent technical chapterranda.

Time of Day Modeling Procedure: Jacksonville

CHAPTER III

INTRODUCTION

This chapter provides an overview of the time of day modeling procedure that was recently implemented in Jacksonville, Florida. A time of day modeling approach for the Jacksonville Urban Area Transportation Study (JUATS) travel model system was developed and tested by Cambridge Systematics for the Jacksonville Transportation Authority (JTA). This approach was based on the existing daily JUATS model and has been applied by the JTA in their Major Investment Study (MIS). This chapter documents the time of day modeling process and its results. The chapter was authored by Thomas Rossi and Nazrul Islam of Cambridge Systematics, key partners on this project.

TECHNICAL APPROACH

The time of day model for Jacksonville was developed using the following process:

- Evaluation of data sources available to develop and apply the time of day model;
- Definition of a.m. and p.m. peak periods;
- Development of time of day factors by trip purpose;
- Model application; and
- Model validation.

Each stage of the model development effort was reviewed by a technical steering committee coordinated by JTA. The committee included staff from JTA, Florida Department of Transportation, District 2, The Jacksonville Metropolitan Planning Organization, and their consultants including Reynolds, Smith, and Hills, Inc.

In theory, factors to convert daily trips to peak and off-peak period trips could be applied after trip generation, trip distribution, or mode choice. Each alternative has distinct advantages and drawbacks. Application of factors after trip generation is equivalent to having separate trip generation models for each time period. This method would be the simplest to apply; this would mean applying separate trip distribution and mode choice model applications for each time period for each trip purpose. This method also allows for separate highway and transit level of service (travel time) estimates for each time period to be used in trip distribution, mode choice, and assignment. The major drawback to this method is that it would not provide for the possibility of using level of service variables or, more importantly, chosen mode as possible factors in the time of day for trips. In addition, the computation time for this method is higher than if time of day factors were applied later.

Application of factors after trip distribution would allow for the use of some level of service variables in the allocation of daily trips to time periods. This method would require the application of only a single trip distribution model for each purpose, but would require three mode choice model applications for each purpose. It also would not provide for the use of chosen mode in the allocation. An additional drawback is that trip distribution would not consider level of service differences by time period, i.e., peak congestion would not directly affect trip distribution. Perhaps the most serious consequence is that the trip distribution models would be applied on a daily basis while the assignments are performed for each time period. Given these concerns, the disadvantages seem to outweigh the benefits of this period, compared to the application of factors after trip generation.

Application of factors after mode choice would allow for the fullest range of factors in the time of day allocation of daily trips, including chosen mode. However, both the trip distribution and mode choice models would be applied at the daily level, meaning peak and off-peak period level of service characteristics could not be applied directly to trips made in those periods.

JTA had decided that the application of factors after mode choice seemed to be the best alternative for their analysis needs. Therefore, the time of day factors are applied to person trips by mode and purpose, following the application of the mode choice model. Trip assignments are run for the a.m. and p.m. peak periods by mode and were validated using a.m. and p.m. peak period counts for highway facilities and the JTA transit system.

TRIP PURPOSES

There are three internal trip purposes used in the JUATS model system: home based work, home based non-work, and non-home based. For the time of day modeling approach, the two home based trip purposes must be further categorized by direction: from home (production to attraction) or to home (attraction to production). Non-home based trips are always defined in the JUATS model system as the production end of the trip being the trip origin. The resulting trip purposes used in the time of day analysis are as follows:

- Home-based work - production-to-attraction;
- Home-based work - attraction-to-production;
- Home-based other - production-to-attraction;
- Home-based other - attraction-to-production; and
- Non-home-based.

DATA SOURCES FOR MODEL DEVELOPMENT

The main data source used in both defining the peak periods and in developing the factors to allocate daily trips by mode and purpose to the three time periods is the Jacksonville household travel survey of 1994. The household survey contained trip data from 611 households in the Jacksonville area. The survey data were expanded using weighting factors that ensure that the survey data set is reflective of the household characteristics—in this case number of vehicles and housing type—in the survey area. The data were used to define the peak periods and to develop factors to convert daily person trips by mode and purpose to person trips by mode, purpose, and time period by direction. The time period for each trip was defined as the period into which the midpoint of the trip fell.

Traffic count data by fifteen minute increment were provided to JTA by the Florida Department of Transportation, District 2 for about 600 locations. These counts were taken in 1998. The count data were used for two purposes. First, the data were used to develop time of day factors for external stations. Second, the data were used to validate the time of day model results. The percentage of traffic occurring in each peak period was computed by direction (where available) for each count location. These percentages provided a basis for comparison to model results, as described later in this chapter.

It should be noted that at the time the time of day models were validated, the count data had been available for only about two weeks, and the information to geographically reference the count data had been available for only one week. All of the count data had not been processed, and so some of the validation results must be regarded as preliminary.

DEFINITION OF PEAK PERIODS

To determine appropriate peak periods for Jacksonville, data from the household survey were analyzed. Based on this analysis, the a.m. peak period was defined as 7:00 to 9:00 and the p.m. peak period as 3:30 to 6:30. The off-peak period is represented by all other hours of the day, including midnight to 7:00 a.m., 9:00 to 3:30 p.m. and 6:30 p.m. to midnight.

DEVELOPMENT OF TIME OF DAY FACTORS

This section presents the time of day factors to convert daily person trip tables by mode for each purpose into trips by mode, purpose, and direction for the a.m. peak, p.m. peak, and remainder of day periods. As discussed previously, the a.m. peak period has been defined as 7:00 to 9:00 and the p.m. peak period as 3:30 to 6:30.

Internal Auto Trips

The best source for data on trip peaking is a local household travel survey, and the Jacksonville survey provides such information. Auto trip factors for each time period were computed by vehicle occupancy level (drive alone, two person carpool, and three or more person carpool). Table 1 presents the percentages of trips by time period, purpose, and direction (for home based trips) computed from the household travel survey data. These factors were used in dividing the daily auto person trip tables by vehicle occupancy level into trip tables for the a.m. peak, p.m. peak, and off-peak periods.

Table 2 presents the averages of the auto trip factors compared to time of day factors from seven other urban areas, normalized to match the peak periods proposed for the Jacksonville model system. There are some differences among the areas, but overall they show fairly similar peaking patterns. As Table 2 shows, the computed factors for Jacksonville compare favorably to factors for other urban areas.

Transit Trips

Table 3 shows the factors estimated for transit trips. These factors were developed to match information on total ridership by time of day, which was provided by JTA. Factors for each trip purpose were estimated by examining time of day factors from other areas. Although few U.S. urban areas have developed time of day factors for transit trips, three such areas were identified: Portland, Sacramento, and Tampa (although Tampa's factors were not derived from their local household travel survey). The factors from these three areas are shown for comparison purposes in Table 3.

Table 1. Proposed Jacksonville Time of Day Factors for Auto Trips

A.M. Peak	Drive Alone	2 Person Carpool	3+ Person Carpool
HBW H-W	29.4%	24.8%	14.7%
HBW W-H	1.1%	0.0%	0.0%
HBNW H-O	6.2%	10.2%	15.5%
HBNW O-H	2.3%	1.4%	0.5%
NHB	8.6%	8.7%	3.5%

P.M. Peak	Drive Alone	2 Person Carpool	3+ Person Carpool
HBW H-W	1.1%	4.1%	7.3%
HBW W-H	26.7%	31.5%	14.7%
HBNW H-O	7.9%	8.7%	11.3%
HBNW O-H	12.9%	11.3%	16.7%
NHB	25.2%	16.8%	19.5%

Table 2. Comparison of Jacksonville Auto Time of Day Factors to Other Urban Areas

A.M. Peak	Jacksonville	Baltimore	Denver	Miami	Philadelphia	Portland	Sacramento	Tampa	Average
HBW H-W	28.9%	18.2%	20.8%	22.2%	33.0%	25.1%	27.0%	22.5%	24.1%
HBW W-H	1.0%	1.9%	0.2%	1.1%	0.9%	0.6%	1.0%	1.2%	1.0%
HBNW H-O	8.6%	18.2%	4.7%	8.1%	14.8%	5.1%	8.2%	8.9%	9.7%
HBNW O-H	1.8%	3.2%	0.4%	1.3%	1.0%	1.8%	1.6%	1.6%	1.6%
NHB	8.2%	14.2%	1.7%	5.3%	8.5%	4.2%	6.4%	7.7%	6.9%

P.M. Peak	Jacksonville	Baltimore	Denver	Miami	Philadelphia	Portland	Sacramento	Tampa	Average
HBW H-W	1.4%	6.3%	3.6%	1.6%	2.4%	3.2%	3.2%	2.5%	3.2%
HBW W-H	27.0%	18.5%	32.8%	24.9%	30.2%	33.0%	26.3%	28.1%	27.7%
HBNW H-O	8.5%	7.9%	12.7%	10.8%	8.8%	9.3%	8.9%	9.1%	9.6%
HBNW O-H	12.8%	16.8%	15.5%	10.8%	15.4%	14.9%	13.0%	14.8%	14.4%
NHB	22.6%	14.1%	14.5%	16.0%	10.0%	11.5%	23.7%	12.9%	14.7%

Table 3. Recommended Jacksonville Transit Time of Day Factors Compared to Other Urban Areas

	Transit Factors					Auto Factors
A.M. Peak	**Jacksonville**	**Portland**	**Sacramento**	**Tampa**	**Average**	**Jacksonville**
HBW H-W	21.6%	31.8%	40.6%	22.1%	31.5%	28.7%
HBW W-H	0.0%	0.3%	0.0%	0.8%	0.3%	1.0%
HBNW H-O	3.1%	1.4%	10.8%	3.8%	5.3%	8.7%
HBNW O-H	0.0%	0.0%	0.0%	0.8%	0.3%	1.8%
NHB	3.1%	0.0%	33.5%	4.5%	12.7%	8.3%

P.M. Peak	**Jacksonville**	**Portland**	**Sacramento**	**Tampa**	**Average**	**Jacksonville**
HBW H-W	0.7%	1.2%	0.0%	1.0%	0.7%	1.5%
HBW W-H	27.5%	35.0%	46.5%	29.5%	37.0%	27.3%
HBNW H-O	6.9%	6.5%	15.4%	1.0%	7.6%	8.4%
HBNW O-H	9.6%	10.8%	17.6%	5.0%	11.1%	12.6%
NHB	13.8%	26.5%	14.6%	6.0%	15.7%	22.6%

External Vehicle Trips

External trips include three types of trips:

- Trips originating in the study area destined for someplace outside the study area (internal-external);
- Trips originating outside the study area destined for someplace inside the study area (external-internal); and
- Trips traveling through the study area with an origin and destination outside the region (external-external).

The household survey provides only limited information on external travel (i.e. only trips made by area residents) and provides no information on external-external travel. Based on traffic counts from five external stations, time of day factors were estimated for internal-external and external-internal trips. The a.m. peak period factor was estimated at 15.37 percent and the p.m. peak period factor at 23.67 percent. Information from the Southeast Regional Planning Model and Tampa Bay Regional Planning Model, as well as the traffic counts, were used to develop factors for external-external trips. The a.m. peak factor was estimated at 13.6 percent, and the p.m. peak factor at 20.0 percent for external-external trips in the JUATS model.

Commercial Vehicle Trips

Since local data were not available from which time of day factors for truck trips could be developed, the factors used in the Southeast Regional Planning Model and Tampa Bay Regional Planning Model were analyzed. Based on this information, it was determined that factors of 20.0 percent of daily truck travel for the a.m. peak period and 23.6 percent for the p.m. peak period should be used in Jacksonville.

TIME OF DAY MODEL APPLICATION

Model Application Procedures

As discussed in the first section, the time of day factors are applied to person trip tables after the mode choice model is run. The trip generation, distribution, and mode choice models are all applied at the daily level. Factors are applied to person trip tables by mode and purpose, following the application of the mode choice model. A set of simple TRANPLAN matrix manipulation functions was developed to perform these conversions. The JUATS mode choice model scripts have been updated to apply the time of day factors. Highway and transit trip assignments are executed following the revised mode choice/time of day programs. Minor revisions were also required to the model scripts for trip distribution and highway and transit assignment. All revised model scripts are shown in the Appendix.

Model Validation

Highway Validation

There are a variety of validation tests to evaluate the reasonableness of a highway assignment. These tests include comparison of the assignment results to:

- Estimates of vehicle miles traveled (VMT), vehicle hours traveled (VHT), and average speeds by time period;
- Traffic counts on screenlines defined for the JUATS model; and
- Traffic counts on key highway links.

The results of these comparisons for the base year model assignments, with time of day, are shown in Tables 4, 5, and 6 respectively.

In evaluating the time of day assignment results, it should be recognized that the daily model would be expected to result in better validation statistics than the peak period models for two reasons:

1. The daily model has higher volume roads, which provide better percentage comparisons than lower volume roads; and
2. The daily model has significantly more roads with traffic counts, which improves screenline and error estimates.

The model validation results are summarized in the following subsections.

VMT, VHT, and Average Speeds

As shown in Table 4, regionally the two hour a.m. peak period volumes and VMT are consistently about 15 percent of daily totals. The percentage of daily VHT is slightly higher, reflecting the fact that the a.m. peak period is more congested than the average daily condition. This is also reflected by the lower average speed during the a.m. peak period. Volumes and VMT are also consistent in the three hour p.m. peak period, averaging about 21 percent of daily totals. Average speeds are also lower in the p.m. peak period than for the average daily condition. Off-peak volumes and VMT are about 64 percent of the daily totals, and speeds are higher than the average daily conditions. These results are reasonable and intuitive.

The average daily volumes and VMT as computed by summing the three time periods in the new time of day model are very close to the results from the original daily model. Total VHT is slightly lower, which makes sense. Because the original daily model assignments are run using a peak conversion factor (CONFAC) reflective of a peak hour, it would be expected that the addition of a true off-peak period comprising 60 percent of travel would increase overall daily speeds somewhat.

Screenline Volumes

The available count data were used to estimate the a.m. peak period and p.m. peak period percentage of daily traffic for each screenline. These percentages were compared to the a.m. and p.m. peak percentages of daily traffic from the time of day model. These results are shown in Table 5. The screenline comparison shows that the modeled volumes accurately reflect the count volumes and are comparable to the daily assignment results in terms of accuracy at a daily level.

Traffic Counts on Key Highway Links

Two tests were conducted for a selected set of twelve key highway links. For four of the locations, only two-way counts were available; no directional data were provided.

The first test was a comparison of the daily volumes from the time of day model—computed as the sum of the three time periods—to the daily volume estimates from the original daily model. Table 6 shows this comparison. For all twelve locations, the daily volume from the time of day model is close to the volume from the daily model, indicating no significant loss in accuracy in the estimation of daily volumes.

The second test was a comparison of the peak period percentages of daily traffic estimated by the time of day model to the percentages from the traffic counts. As shown in Table 6, with a few exceptions, the comparisons are favorable.

Table 4. Time of Day Model Output Summary

	Daily Model	Sum of Time Periods		AM Peak Period Model		Off-Peak Period Model		PM Peak Period Model	
		Total	% Diff	Total	%	Total	%	Total	%
Total Highway Volume All Links	90,708,920	91,203,329	1%	14,014,229	15%	58,031,416	64%	19,157,684	21%
Average Total Volume	13,996	14,072	1%	2,162	15%	8,954	64%	2,956	21%
Total VMT	23,011,310	23,000,815	0%	3,578,650	16%	14,564,660	63%	4,857,505	21%
Total VHT	795,294	756,403	-5%	127,953	17%	466,035	62%	162,415	21%
Congested Speed (mph)	28.93	30.41	5%	27.97		31.25		29.91	

Table 5. Screenline Summary

Screenline	Daily Count	Daily Model	% Diff	Sum of Time Period Models	% Diff	AM Peak %	Est. AM Peak % from Counts	PM Peak %	Est. PM Peak % from Counts
1	311,970	318,807	2.2%	326,520	4.7%	16%	16%	21%	23%
2	238,542	249,165	4.5%	259,588	8.8%	15%	13%	21%	22%
3	154,652	195,080	26.1%	194,531	25.8%	16%	12%	21%	21%
4	452,852	454,512	0.4%	442,143	-2.4%	16%	13%	22%	22%
5	392,052	412,752	5.3%	421,369	7.5%	15%	13%	21%	22%
6	99,548	113,892	14.4%	114,436	15.0%	15%	14%	21%	19%
7	442,886	389,400	-12.1%	383,251	-13.5%	16%	15%	21%	23%
8	119,996	126,344	5.3%	134,707	12.3%	15%	12%	21%	22%
9	64,682	72,801	12.6%	72,644	12.3%	15%	12%	21%	24%
10	140,004	137,439	-1.8%	137,374	-1.9%	15%	15%	21%	23%
11	188,977	198,195	4.9%	198,291	4.9%	16%	13%	21%	22%
12	313,648	298,813	-4.7%	303,068	-3.4%	15%	15%	21%	21%
13	141,118	139,324	-1.3%	147,442	4.5%	16%	13%	21%	21%
14	140,446	136,253	-3.0%	137,188	-2.3%	16%	13%	21%	20%
15	63,226	63,168	-0.1%	63,201	0.0%	14%	15%	20%	23%
16	55,382	55,415	0.1%	55,337	-0.1%	14%	14%	20%	19%
17	101,212	101,216	0.0%	101,226	0.0%	14%	12%	20%	19%
TOTAL	**3,421,193**	**3,462,576**	**1.2%**	**3,492,316**	**2.1%**	**15%**	**14%**	**21%**	**22%**

Table 6. Time of Day Model Results for Key Highway Network Links

ID	LOCATION	ANODE	BNODE	Sum of Periods	Daily Model	AM peak % Count	AM peak % Model	PM Peak % Count	PM Peak % Model
723889	SR 9 (I-95) 1 MI N OF PECAN PARK RD	1245	2117	25249	25250	13%	15%	14%	18%
723889	SR 9 (I-95) 1 MI N OF PECAN PARK RD	2111	1246	25263	25252	9%	12%	21%	22%
723026	SR 5 0.4 MI N OF PECAN PARK RD (2 Way)	5954	6091	10939	12462	14%	8%	25%	23%
720519	SR 10 AT W CITY LIMITS OF BALDWIN (2 Way)	5513	5514	4278	4283	12%	11%	24%	24%
720140	SR 228 0.3 MI E OF SR 200 (2 Way)	4645	4649	5100	5196	12%	10%	22%	25%
723914	SR 115 AT BRIDGE AT NASSAU-DUVAL LINE	3294	6501	4360	4345	12%	11%	27%	24%
723914	SR 115 AT BRIDGE AT NASSAU-DUVAL LINE	6501	3294	4350	4350	12%	17%	26%	16%
725524	SR 228 AT SOUTH OF HART BRIDGE	2283	2285	19730	21819	16%	12%	29%	29%
725524	SR 228 AT SOUTH OF HART BRIDGE	2466	5577	19763	21205	20%	23%	24%	22%
723170	SR 13 ON ACOSTA BR OVER ST JOHNS RIVER	1230	6260	15217	26916	22%	28%	27%	19%
723170	SR 13 ON ACOSTA BR OVER ST JOHNS RIVER	6260	1230	16635	21125	22%	16%	29%	30%
723172	SR 5 150' S OF MAIN ST BRIDGE (2 Way)	1148	1250	24852	26277	17%	24%	26%	18%
721008	SR 202 E OF GATE PKY W OF ST. JOHN'S BLUFF	2023	3580	36089	35754	23%	21%	18%	17%
721008	SR 202 E OF GATE PKY W OF ST. JOHN'S BLUFF	3581	2027	33634	34077	10%	11%	32%	26%
720946	SR 212 (BEACH BLVD) W OF ST JOHN'S BLUFF	4252	4254	21761	21817	11%	11%	26%	27%
720946	SR 212 (BEACH BLVD) W OF ST JOHN'S BLUFF	4254	4252	19477	23487	16%	22%	19%	17%
720988	SR 10 WEST OF LEE RD.	4458	6103	28656	26820	15%	20%	18%	16%
720988	SR 10 WEST OF LEE RD.	6103	4458	28977	27620	17%	9%	18%	25%
720204	SR 9A NORTH OF ATLANTIC BLVD.	2091	3511	14812	14988	13%	13%	24%	25%
720204	SR 9A NORTH OF ATLANTIC BLVD.	3512	2102	14097	14302	17%	22%	24%	18%
TOTAL	**ALL LOCATIONS IN TABLE**					**16%**	**16%**	**23%**	**24%**

Transit Validation

Table 7 shows a comparison of linked and unlinked transit trips and mode shares for the daily, a.m. peak period, and p.m. peak period models. The sum of the transit trips for the three time periods is very close to the total transit trips from the original daily model. Table 8 shows the modeled percentage of daily transit trips compared to the JTA ridership data. These percentages are very close to the observed ridership data.

Table 7. Mode Choice Model Output Summary

	Daily Model	Sum of Time Periods		AM Peak Period	Off-Peak Period	PM Peak Period
Linked Transit Trips	25,719	25,807	100%	3,483	16,504	5,820
Unlinked Transit Trips	36,150	36,358	101%	4,939	23,174	8,245
Auto Linked Trips	2,611,499	2,611,097	100%	385,048	1,681,595	544,454
Overall Transit Share	1.0%	1.0%		0.9%	1.0%	1.1%

Table 8. Percentage of Daily Transit Trips by Time of Day

	Observed %	Model %
AM Peak Period	14%	13%
Off-Peak Period	63%	64%
PM Peak Period	23%	23%

Time of Day Modeling Procedure: Tampa Bay

CHAPTER IV

INTRODUCTION

This chapter provides an overview of the time of day modeling procedure that is being implemented in the Tampa Bay Regional Planning Model.

PURPOSE

The purpose of this analysis is to determine the peak hour (AM peak and PM peak) and the off peak hour time of day person trip factors for various trip purposes. The idea is to obtain the network parameters by applying these factors across the peak and the off peak periods i.e., across different times of day as opposed to on a daily basis.

CONCEPTUAL OVERVIEW

The following flow chart (Figure 1) describes briefly the conceptual overview of the process.

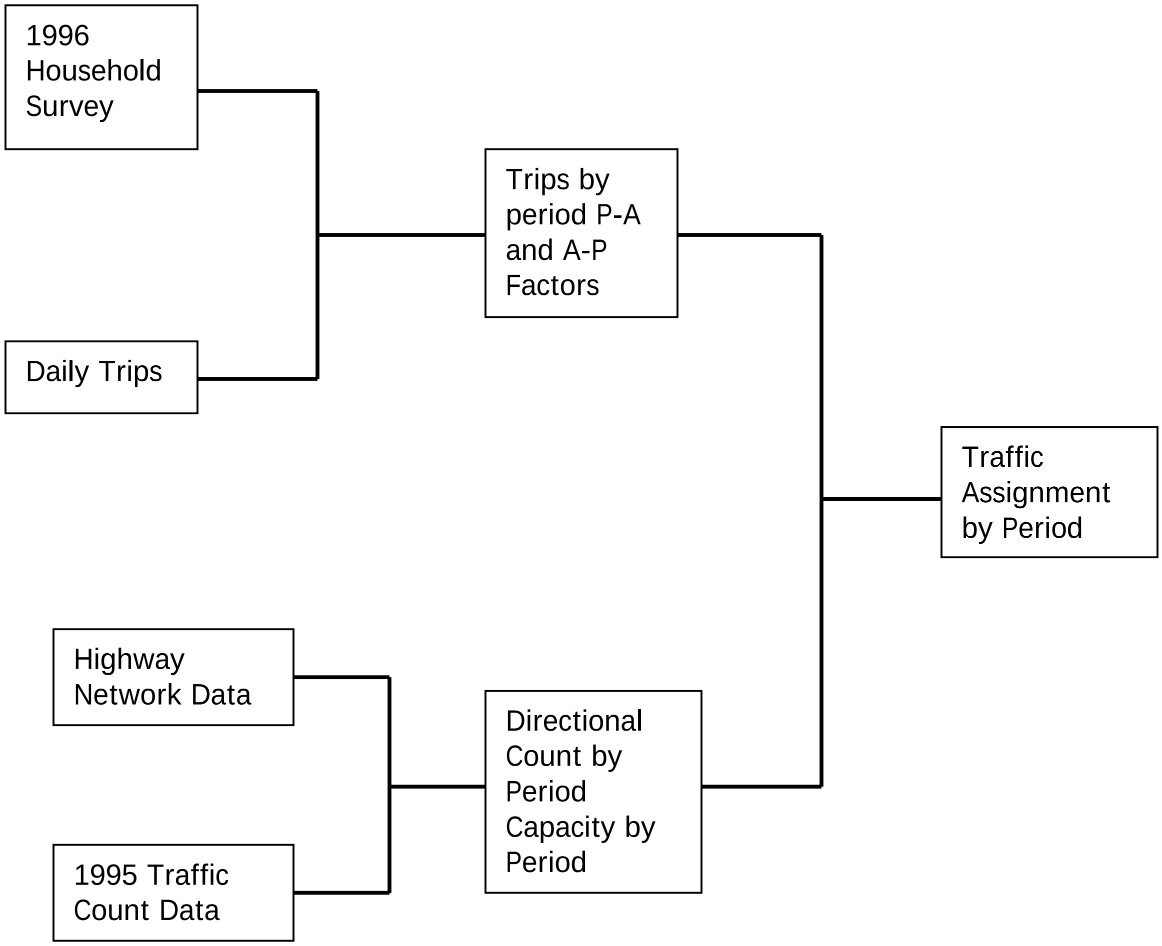


Figure 1. Flowchart For Time of Day Assignment

The 1996 household survey data and the daily trip information were used to generate the P-A (Production to Attractions) and A-P (Attractions to Productions) factors which were applied to obtain the trips by period. The 1995 traffic count data and the highway network data were used to generate directional counts by period and the capacity by period. The trips by period and the directional counts were used to obtain the period assignment. The following sections describe the process in detail.

DATA ORGANIZATION

The input consists of hourly distribution of trip ending time for each of the trip purposes. The output generated from the model was rearranged to get the following tables:

a) Table 1 (T1)=Light Truck + Heavy Truck.
b) Table 2 (T2)=Drive Alone + Taxi + E-I trips.
c) Table 3 (T3)=(A2) + (A3+) + E-E trips.

Three trip tables were generated for each of the AM, PM, and off peak periods. A total of nine tables are generated.

COMPUTATION OF PRODUCTIONS AND ATTRACTIONS

Time of day factors were generated for the Production-Attraction (P-A) trips and Attraction-Production (A-P) trips for the AM, PM, and off peak periods. The computed factors were inputted in the "PROFILE.MAS" file and the model was run to apply the time of day factors and generate the Production-Attraction trips and vice-versa for each of the trip purpose for AM, PM, and off peak periods.

METHODOLOGY

In order to obtain the P-A and A-P trips for the AM, PM, and OFF peak periods the time of day factors are computed for the AM, PM, and OFF peak periods. The AM peak period was 6 AM to 9AM and the peak was 3 PM to 7 PM. The following trip purposes were taken in account:

a) Home Based Work (HBW)
b) Home Based Shopping (HBSH)
c) Home Based Social Recreation (HBSR)
d) Home Based Other (HBO)
e) Non-Home Based (NHB)
f) Truck: These were further classified as light and heavy trucks. Light and heavy trucks were assumed to have the same factors because of the lack enough data.
g) Taxi

h) External-Internal (E-I)
i) External-External (E-E)

The factors for trip purposes HBV, HBSH, HBSR, HBO, and NHB were computed from the hourly Distribution of Trip Ending Time, Tampa Bay Region, 1996. While calculating the factors for Taxi trips it was assumed that they follow the same pattern as the other trip purposes. For taxi trips the weighted average of trip purposes HBW, HBSH, HBSR, HBO, and NHB was used to compute the trip factors. For E-I and E-E trips it was assumed that the factors would be the same for the three peak periods. For E-I and E-E trips the following stations were considered:

a) Station 37 on I-75 @ Hernando/Sumter CL
b) Station 42 on I-75 @ South of I-275 (Manatee)
c) Station114 on I-4 @ west of SR 33 (Polk)

The factors across these three stations were averaged and normalized to get the time of day factors. Table 1 shows the time of day factors for each of the trip purposes. The trip factors were computed using the following equation:

Trip Factor=(Total Traffic During the Peak/Off Peak Period x 100)/(Total Daily Traffic)

Trip purposes HBW, HBSH, HBSR, HBO, and NHB were further distributed into the following categories:

a) DA = Drive alone
b) A2 = Driver with one passenger
c) A3+ = Driver with more than one passenger

As a result of this distribution a total of twenty tables were obtained. Each of the twenty tables was distributed into P-A AM, PM, off peak categories and A-P AM, PM, off peak categories which resulted in a total of 120 tables. The values obtained by the model were cross checked with the expected values. The expected values were computed using a spreadsheet program. The total trips were distributed equally into P-A and A-P trips and the corresponding time of day factors were applied to each trip purpose. The actual values generated by the model were obtained by multiplying the total trips by 0.5 to get the P-A trips and MATRIX TRANSPOSE function was used to get the A-P trips. The MATRIXMANIPULATE function was used to apply the time of day factors for each trip purpose. Tables 2 shows the comparison between the expected and the actual values. The MATRIXMANIPULATE function was used to aggregate these 120 tables into 9 tables as mentioned in the section on data organization.

COMPUTATION OF CONFAC VALUES

Table 3 shows the CONFAC values and the list stations which were considered for computing the CONFAC values. The CONFAC values were computed for the AM, PM, and the off peak periods. The CONFAC values were computed using the following equation:

CONFAC = (Maximum Peak Hour Traffic)/ Total Period Traffic.

Table 1. Time-of-Day Trip Factors

Production-Attraction	AM Peak	PM Peak	Off Peak
HBW	67.44	6.22	26.34
HBSH	10.10	28.11	61.79
HBSR	16.70	41.79	41.51
HBO	46.10	17.41	36.49
NHB	12.84	28.59	58.57
TRUCK	17.86	22.35	59.79
TAXI	20.95	31.72	47.33
E-I	22.33	24.33	53.34
Attraction-Production			
HBW	3.36	66.82	29.82
HBSH	2.89	37.84	59.27
HBSR	2.01	37.49	60.50
HBO	9.27	39.35	51.38
NHB	12.84	28.59	58.57
TRUCK	17.86	22.35	59.79
TAXI	20.95	31.72	47.33
E-I	21.67	32.67	45.66

Table 2. CONFAC Calculations

STATION#	AM PEAK	PM PEAK	OFF PEAK
HILLSBOROUGH			
20	0.47	0.27	0.12
21	0.48	0.34	0.14
62	0.48	0.28	0.15
109	0.40	0.27	0.11
3048	0.45	0.30	0.12
5056	0.42	0.29	0.10
5165	0.41	0.29	0.11
PINELLAS			
34	0.37	0.27	0.12
5181	0.40	0.28	0.13
45	0.45	0.26	0.12
PASCO			
45	0.45	0.28	0.11
5101	0.38	0.26	0.11
6	0.38	0.30	0.14
HERNANDO			
24	0.35	0.29	0.19
12	0.43	0.31	0.12
14	0.51	0.26	0.12
CITRUS			
6	0.44	0.28	0.11
11	0.43	0.31	0.12
INTERSTATES			
84	0.37	0.26	0.09
87	0.36	0.26	0.09
146	0.44	0.30	0.13
4	0.38	0.27	0.10
153	0.38	0.33	0.11
MEAN	0.41	0.28	0.12
STD.DEV	**0.04**	**0.02**	**0.02**

Table 3. Input Time-of-Day Trip Table Factors from Survey

Tampa Bay Regional Planning Model Version 3.3

Production to Attraction	Unadj-Factor	Adj-Factor	Attraction to Production	Unadj-Factor	Adj-Factor
PA Factor HBW AM Peak	0.6744	0.6744	PA Factor HBW AM Peak	0.0336	0.0300
PA Factor HBW PM Peak	0.0622	0.0622	PA Factor HBW PM Peak	0.6682	0.6600
PA Factor HBW Off Peak	0.2634	0.2634	PA Factor HBW Off Peak	0.2982	0.3100
Total	*1.0000*	*1.0000*	Total	*1.0000*	*1.0000*
PA Factor HBSH AM Peak	0.1010	0.0600	PA Factor HBSH AM Peak	0.0289	0.0200
PA Factor HBSH PM Peak	0.2811	0.2200	PA Factor HBSH PM Peak	0.3784	0.3500
PA Factor HBSH Off Peak	0.6179	0.7200	PA Factor HBSH Off Peak	0.5927	0.6300
Total	*1.0000*	*1.0000*	Total	*1.0000*	*1.0000*
PA Factor HBSR AM Peak	0.1670	0.1500	PA Factor HBSR AM Peak	0.0201	0.0200
PA Factor HBSR PM Peak	0.4179	0.4000	PA Factor HBSR PM Peak	0.3749	0.3500
PA Factor HBSR Off Peak	0.4151	0.4500	PA Factor HBSR Off Peak	0.6050	0.6300
Total	*1.0000*	*1.0000*	Total	*1.0000*	*1.0000*
PA Factor HBO AM Peak	0.4610	0.4500	PA Factor HBO AM Peak	0.0927	0.0800
PA Factor HBO PM Peak	0.1741	0.1700	PA Factor HBO PM Peak	0.3935	0.3800
PA Factor HBO Off Peak	0.3649	0.3800	PA Factor HBO Off Peak	0.5138	0.5400
Total	*1.0000*	*1.0000*	Total	*1.0000*	*1.0000*
PA Factor NHB AM Peak	0.1284	0.1000	PA Factor NHB AM Peak	0.1284	0.1000
PA Factor NHB PM Peak	0.2859	0.2500	PA Factor NHB PM Peak	0.2859	0.2500
PA Factor NHB Off Peak	0.5857	0.6500	PA Factor NHB Off Peak	0.5857	0.6500
Total	*1.0000*	*1.0000*	Total	*1.0000*	*1.0000*
PA Factor Lt Trk AM Peak	0.1786	0.1000	PA Factor Lt Trk AM Peak	0.1786	0.1000
PA Factor Lt Trk PM Peak	0.2235	0.1500	PA Factor Lt Trk PM Peak	0.2235	0.1500
PA Factor Lt Trk Off Peak	0.5979	0.7500	PA Factor Lt Trk Off Peak	0.5979	0.7500
Total	*1.0000*	*1.0000*	Total	*1.0000*	*1.0000*
PA Factor Hv Trk AM Peak	0.1786	0.1000	PA Factor Hv Trk AM Peak	0.1786	0.1000
PA Factor Hv Trk PM Peak	0.2235	0.1500	PA Factor Hv Trk PM Peak	0.2235	0.1500
PA Factor Hv Trk Off Peak	0.5979	0.7500	PA Factor Hv Trk Off Peak	0.5979	0.7500
Total	*1.0000*	*1.0000*	Total	*1.0000*	*1.0000*
PA Factor Taxi AM Peak	0.2095	0.2095	PA Factor Taxi AM Peak	0.2095	0.2095
PA Factor Taxi PM Peak	0.3172	0.3172	PA Factor Taxi PM Peak	0.3172	0.3172
PA Factor Taxi Off Peak	0.4733	0.4733	PA Factor Taxi Off Peak	0.4733	0.4733
Total	*1.0000*	*1.0000*	Total	*1.0000*	*1.0000*
PA Factor Occ. E/I AM Peak	0.2233	0.2233	PA Factor Occ. E/I AM Peak	0.2167	0.2167
PA Factor Occ. E/I PM Peak	0.2433	0.2433	PA Factor Occ. E/I PM Peak	0.3267	0.3267
PA Factor Occ. E/I Off Peak	0.5334	0.5334	PA Factor Occ. E/I Off Peak	0.4566	0.4566
Total	*1.0000*	*1.0000*	Total	*1.0000*	*1.0000*
PA Factor E/E AM Peak	0.2233	0.2233	PA Factor E/E AM Peak	0.2167	0.2167
PA Factor E/E PM Peak	0.2433	0.2433	PA Factor E/E PM Peak	0.3267	0.3267
PA Factor E/E Off Peak	0.5334	0.5334	PA Factor E/E Off Peak	0.4566	0.4566
Total	*1.0000*	*1.0000*	Total	*1.0000*	*1.0000*

A Methodology for the Future Year CONFAC

CHAPTER V

The VFACTORS file specifies the value of CONFAC, which is the fraction of the 24-hour trip table that occurs in the peak hour for the purpose of calculating volume/capacity (capacities almost always are stated as hourly volumes).

Empirical evidence shows that as overall congestion grows, the value of CONFAC decreases. The theoretical lower limit for CONFAC is 0.042 (1/24), that is, conditions are equally congested during every hour of the day. The upper limit is 1.00, which would occur when all traffic moves during a single hour (admittedly unlikely). Quick Response values for CONFAC for areas with a population of more than one million are about 0.095. Generally, District 4 models use a value between 0.085 and 0.10.

South Florida models show a tremendous growth in people and traffic for the next 20 years. Thus, it would seem that a reduction in CONFAC should accompany the increase in traffic as drivers try to avoid the worst congestion and the peak spreads. But, in practice, the same value of CONFAC is usually used for future years. So, peak spreading is not accounted for in the models.

Some models developed for other urban areas estimate the percentage of peak-period traffic that occurs in the peak hour with the following equation:

$$P = 1/3 + a \times \exp(b \times [V/C])$$

where

P = Percentage of three-hour peak-period traffic occurring during the peak hour

V/C = Volume-to-capacity ratio during the peak period

a,b = Constant

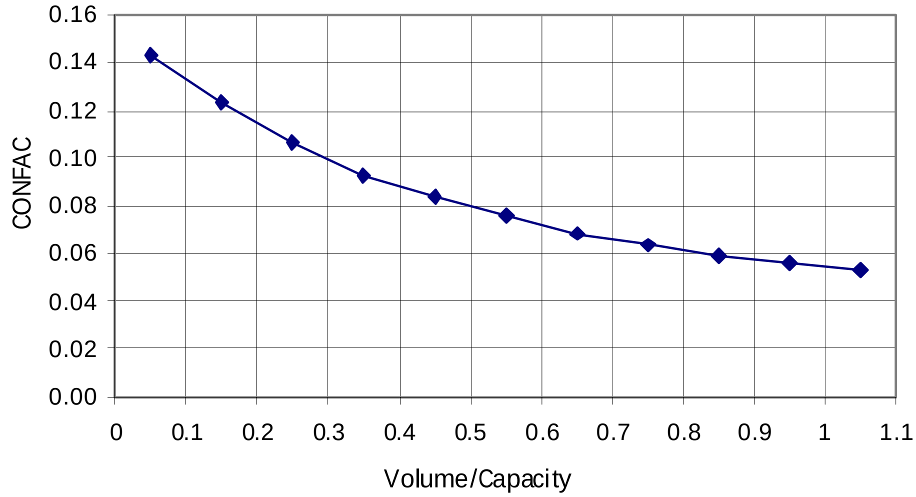
This would seem to be a good model for estimating CONFAC. While an extensive study to compile counts and capacities for calculating the values of "a" and "b" is beyond the time and budget resources of the current project, the following method could be used in a future model update study:

- Postulate that the current value in VFACTORS is correct;
- Postulate that the value for "b" of –2.227 used in other peaking studies is correct;
- Assume CONFAC = (1/24) + a x exp(-2.227 x V/C), where V is daily systemwide capacities (hourly capacity x 24); and,
- For each facility type, calculate the value of "a."

This equation then could be used to estimate the future values of CONFAC from a "trial" future year model application. The figure on the next page shows how CONFAC would vary by volume/capacity for a=0.10. As noted previously, the value of "a" would be calculated from the base year counts and capacities.

An Illustration of CONFAC Varying with Volume-to-Capacity Ratio

SERPM-IV Model Forecast Enhancements



A Methodology for Transit Time of Day Modeling

CHAPTER VI

INTRODUCTION

This chapter provides the a summary of the project team's deliberations regarding the implementation of time of day modeling procedures for transit. This chapter is authored by Tom Rossi and Nazrul Islam of Cambridge Systematics, Inc. who are key partners on the project team. As can be seen in the figure below, transit also exhibits clear temporal patterns in travel demand (ridership). Thus, it is imperative that proper time of day modeling procedures that account for transit are implemented within FSUTMS.

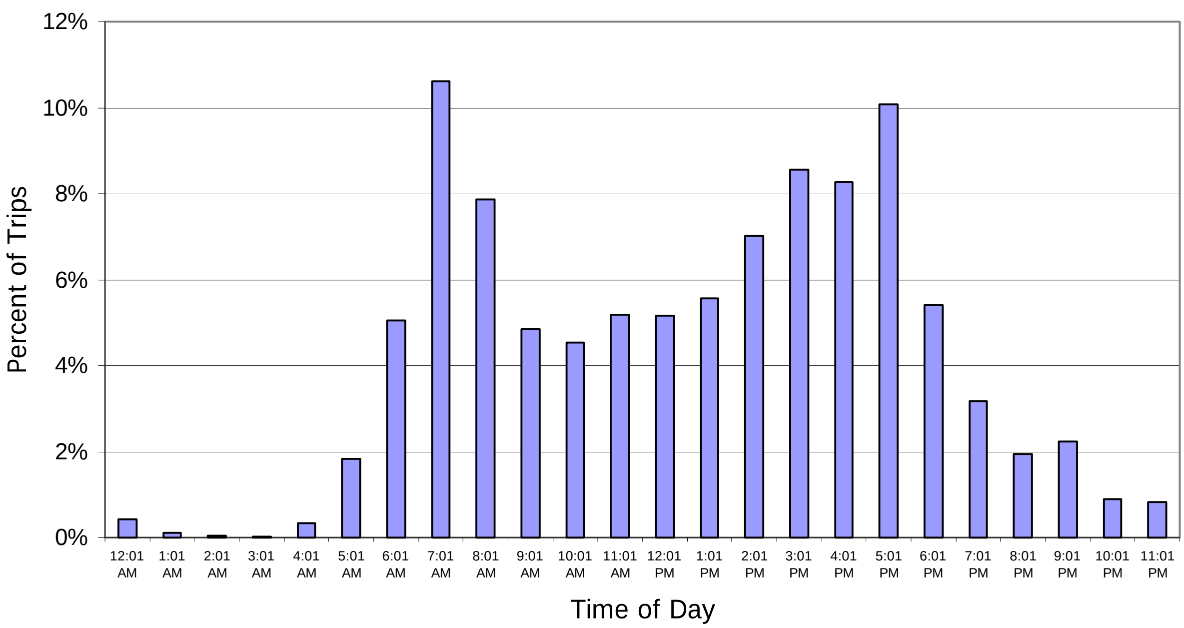


Figure 1. Time of Day Distribution of Transit Trips

BACKGROUND

Following the meeting of October 13, 2000, we have been discussing the issue of how to handle transit in the time of day modeling process within Florida Standard Urban Transportation Model Structure (FSUTMS). In examining how we have handled time of day modeling in the past and how FSUTMS is structured, we now believe that the issue of how to handle transit is more complicated than we did before. Consequently, we have written this chapter to lay out the issues and alternatives and have developed a preliminary recommendation for handling transit. Please note that this differs from the preliminary recommendations discussed at several project meetings.

This chapter discusses the following three items:

- The present FSUTMS modeling procedures and its drawbacks in the time of day modeling procedures related to transit;
- Proposed time of day modeling methods; and
- Our recommendation.

FSUTMS Modeling Procedures and Issues Related to the Time of Day Model Development Process

We are all familiar with the current FSUTMS modeling procedures. After trip generation, FSUTMS employs a gravity model for the trip distribution process. Gravity models are run both in DISTRIB and MODE modules. In the DISTRIB module, the gravity model uses uncongested highway skims to produce daily trips by purpose. Next, in the MODE module, composite impedance highway skims (which include congested highway travel time, travel cost, transit accessibility, etc.) and peak and off-peak transit skims are used to split trips into auto and transit trips. Later, in the assignment stage, the daily highway trips (combined for all purposes) are assigned to a single highway network. The daily work transit trips are assigned to the peak transit network, and the daily non-work trips are assigned to the midday transit network.

The following issues related to the time of day model development are relevant:

- The daily travel demand models do not accurately tools estimate transit demand. For example, the mode choice model is applied at the daily level, which ignores the variations in transit service availability throughout the day.

- In addition, about half of the work trips do not take place during peak periods. Similarly a significant percentage of non-work trips occurs during peak periods. Hence, in the trip distribution process error is introduced when the peak transit skims are applied for work trips and the midday transit skims are applied for non-work trips.
- At the production end of each transit trip, there are three possible modes of access: walk, auto park-n-ride, and auto kiss-n-ride. However, at the attraction end there is only the walk egress mode. Therefore, it is necessary to keep track of the production ends of transit trips. As is normal practice, transit trips are assigned in production-attraction (P-A) format rather than origin-destination (O-D) format, which is more commonly used in highway assignments.
- Another critical issue that needs to be considered is consistency in the path building process among the distribution, mode choice and assignment stages. If the time of day factors were applied after the mode choice, then trip distribution and mode choice would be applied on a daily basis while the assignments are performed for each time period separately. Similarly, if the time of day factors were applied after the trip distribution step, then the trip distribution would be applied on a daily basis while the mode choice and the assignments are performed for each time period separately. As Wade pointed out in October, this could lead to off-peak transit trips for origin-destination pairs that have no off-peak transit service.
- Many existing time of day modeling procedures consider highway travel only. These models do not split transit trips by time periods. For example, the present Southeast Regional Planning Model (SERPM) does not consider time of day for transit, but it does perform highway assignment for a.m. peak, p.m. peak, and off-peak periods separately.

SUMMARY OF PROPOSED METHODS

There are several possible ways to implement the time of day model in the FSUTMS modeling systems. We feel that the three most practical methodologies are the following:

1. <u>Factors after mode choice - highway only.</u> In this method, the transit assignment procedure is not changed. Daily work and non-work trips are assigned to the peak and midday networks respectively. Auto time of day factors are applied after mode choice to create separate peak and off-peak trip tables. These trip tables are assigned to separate peak and

off-peak highway networks. This procedure was applied to the SERPM4 and the TBRPM models and worked well.

This method has several drawbacks. First, the trip distribution, mode choice, and transit assignment models are applied on a daily basis, which means peak period travel characteristics are not directly considered in these modules. Although highway assignment is performed for each time period separately, transit work and non-work trips are assigned to peak and midday networks, respectively. The inconsistencies in path building between trip distribution/mode choice and transit assignment remain.

2. Application of factors after mode choice. In this method trip distribution and mode choice are applied on a daily basis, as in the existing FSUTMS procedures. However, both highway and transit time of day factors are applied after the mode choice module to obtain peak and off-peak period trip tables for the highway and transit modes. Subsequently peak transit trips are assigned to peak transit networks, and off-peak period transit trips are assigned to off-peak networks. The three highway trip tables are then assigned to separate peak and off-peak highway networks. We used this procedure for the JUATS model and it worked very well.

   As in the first method, peak period travel characteristics are not considered in trip distribution and mode choice. However, unlike the first method, the transit trips are factored to the peak and the off-peak periods and assigned accordingly. There remains an inconsistency in path building between trip distribution/mode choice and assignment.

   We considered ways of identifying time of day factors for transit that would account for the lack of off-peak transit service for specific origin-destination pairs and for differences between peak and off-peak levels of services. To properly account for these types of differences, it would seem that a logsum type of combination of peak and off-peak characteristics would have to be included in the time of day model.

There is a question of what transit service characteristics to use as inputs to a daily mode choice model when the trips would be assigned using peak and off-peak period networks. For example, consider the following case:

O-D Pair	Peak Frequency	Off-Peak Frequency
1	30 min	30 min
2	30 min	30 min
3	15 min	No service

For the first O-D pair, the transit service is the same, and so the wait times would be the same for all periods and all trip purposes. For the second pair, however, there would be some trips for which the wait time would be based on a 15-minute headway and others for which the 30-minute headway would be used. This implies that both peak and off-peak wait times should be used as input into the daily mode choice model. A higher percentage of the work trips would experience the 15-minute headway than the non-work trips, and so the way in which peak and off-peak times would be combined would vary by trip purpose. However, this would imply that wait times would be overestimated for peak period trips and underestimated for off-peak trips. This contrasts with the current process used in FSUTMS where peak times are used for work trips and off-peak times for non-work trips, implying that the average wait time is underestimated for work trips and overestimated for non-work trips.

The problem with using an average daily wait time becomes evident when the third O-D pair is considered. The average wait time is going to be based on the 15 minute headway since that is the headway for all transit service that is offered. However, that would imply that transit is more attractive for this O-D pair than for the second pair, even though it is no more attractive in either the peak or off-peak period. This problem might be eliminated by using a logsum-type composite variable, but this would significantly complicate the mode choice process. In this case, transit would be less attractive for the third O-D pair than for the second. The off-peak time of day factor for the third O-D pair would have to be zero.

3. Application of factors after distribution and re-factor after mode choice. In this method, trip distribution is performed on a daily basis as in the previous two methods. However, time of day factors are applied after trip distribution to split daily person trips by purpose into trips by time period. The mode choice module is run separately for each time period, as shown in Figure 2. After running the mode choice module, further time of day factors are applied to the auto and transit trip tables, and separate trip tables by mode, purpose, and time period are developed.

   It is inconsistent that the trip distribution module is applied on a daily basis while mode choice and assignment are performed for each time period separately. However, unlike the first method, the transit trips are factored to the peak and off-peak periods and assigned accordingly. The inconsistencies in path building between mode choice and assignment will be eliminated.

RECOMMENDATION

We have summarized three methods for time of day modeling, all of which have advantages and drawbacks. The first method does not allow for any consideration of time of day for transit trips, and it would be unfortunate to eliminate that possibility. The second method is more complex, requiring logsum-type impedance variables to be developed for all transit service characteristics used as variables in the mode choice model. The third method requires an inconsistency in that trip distribution is performed using daily trips but mode choice is performed using peak and off-peak trips. At this point, we feel that the third method appears to be the best.

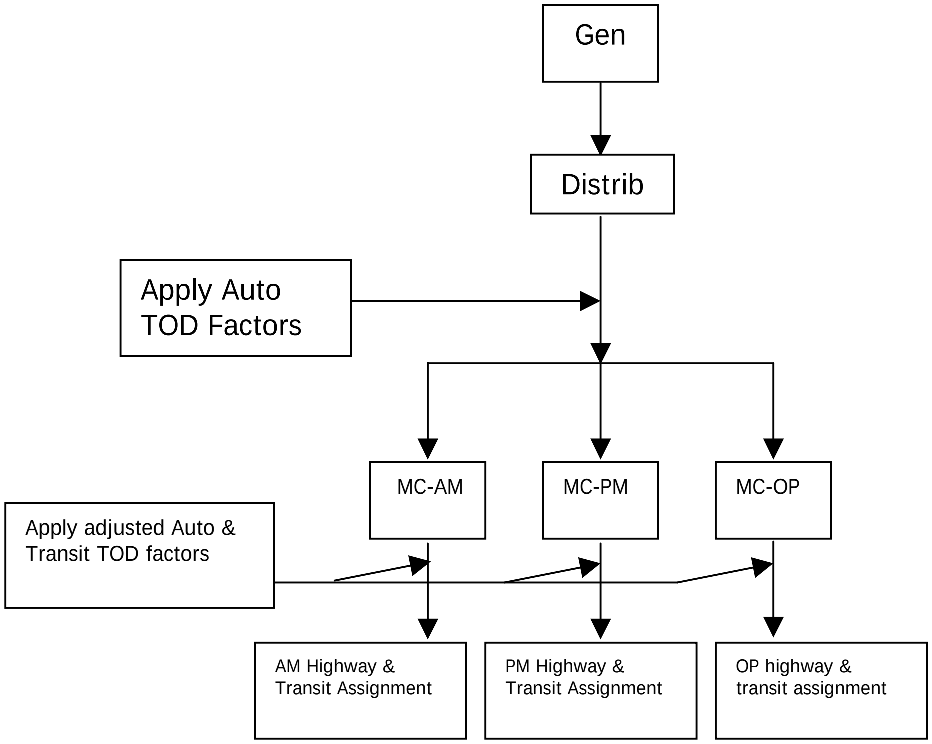


Figure 2. Application of Time of Day Factors After Distribution and Re-factoring After Mode Choice

Time of Day Choice Models

CHAPTER VII

INTRODUCTION

This chapter provides preliminary results from the estimation of time of day choice models. This chapter describes the results of time of day model estimation performed using the Tampa Bay household survey data set. This round of model estimation concentrated on household variables as the data set we received did not yet have transportation level of service data. The primary authors of this chapter are Thomas Rossi and Nazrul Islam of Cambridge Systematics.

DATA SET

The basic data file is composed of 31,465 records, where each record corresponds to a trip. There are 28 fields (variables) for each record. The 28 variables can be classified as:

- 4 identification variables;
- 6 household variables (household size, number of household members of age 16 or more, number of vehicles, dwelling unit type, residence status, and income);
- 3 person variables (age, employment status, and drivers license status);
- 13 trip variables (date, day of week, departure time, ending time, duration, purpose at origin, purpose at destination, and map area origin and destination); and
- 2 weighting factors.

Household and person files were created from the original database file, using the household id variable. The total number of households obtained was 5,349. Not every person in the household file has a record in the person file because the original database reports only the persons that made at least one trip. It should be noted that 97% of the trips in the trip file are private auto trips, and the results of the time of day model estimation are therefore dominated by auto trips.

TRIP PURPOSES

We defined the following trip purposes from the data set:

- Home to work;
- Work to home;
- Home to shop;
- Shop to home;
- Home to education;
- Education to home;
- Home to other (including recreation); and
- Other to home.

We realize that some of the non-work trip purposes are not part of most travel models in Florida, and we may want to combine these trip purposes during later model estimation phases. We also considered defining trip purposes that were part of the journey to work (e.g. home based other as part of a work journey), but this would have required additional processing of the data set. Identification of trips that are part of the journey to work is not currently done in FSUTMS.

Because the model estimation was based only on household variables, we did not define trip purposes for non-home based trips in this round of model estimation.

DEFINITION OF TIME PERIODS

It is necessary to divide the day into distinct time periods to use a discrete choice modeling structure such as logit. During the initial meeting of this project, there was discussion of how many distinct time periods should be considered in time of day modeling and how they should be defined. We recognize that the various trip purposes have different peaking characteristics.

However, since trip assignments must be performed using the same time periods for all trips, it is necessary to define the same periods for all trip purposes.

For this round of model estimation, we defined four time periods:

- Morning peak – 7:15 to 9:15 a.m.
- Mid-day – 9:15 a.m. to 3:15 p.m.
- Afternoon peak – 3:15 to 6:15 p.m.
- Off-peak – 6:15 p.m. to 7:15 a.m.

A trip was defined as being in one of these periods if its temporal midpoint (halfway between the departure and arrival times) fell within the period.

It was necessary to somewhat arbitrarily decide on these definitions. Table 1 shows the percentage of total trips from the survey data set occurring in the peak one, two, and three-hour periods in the morning and afternoon. In the afternoon, it makes sense to use the three-hour period since the third hour has nearly as many trips as the average of the two peak hours. In the morning, the third hour has significantly less travel than the two peak hours, and extending the beginning of the period to 7:30 and the end of the period to 10:30 does not seem intuitive. Thus the two-hour period was chosen for the morning peak and the three-hour period for the afternoon. (Note that the definition of a two-hour morning peak period and a three-hour afternoon peak period is consistent with the time of day structure chosen for Jacksonville.) The mid-day period was chosen as the period between the a.m. and p.m. periods, and the off-peak defined as the remainder of the day.

Table 1. Percentage of Total Trips Occurring in the Peak One, Two, and Three-hour Periods

AM		
Peak 15 min	7:45-8:00	2.4%
Peak hour	7:15-8:15	8.2%
Peak 2 hours	7:15-9:15	15.5%
Peak 3 hours	7:30-10:30	22.1%
PM		
Peak 15 min	5:15-5:30	2.9%
Peak hour	5:00-6:00	8.8%
Peak 2 hours	4:15-6:15	16.5%
Peak 3 hours	3:15-6:15	24.2%

For the purposes of model estimation, it was necessary to define a “base” period for each trip purpose, for which the utility function is equal to zero. While the choice of the base period does not affect the estimation results, it does make interpretation of the model results easier. We decided to choose as the base alternative the time period with the highest percentage of daily trips for that purpose. Usually, this corresponds to the “logical” base period for each purpose (the time when one would expect most travelers to make trips of this purpose). The base purposes are shown in Table 2.

Table 2. Base Time Periods for Trip Purposes

Trip Purpose	Base Period
Home to work	a.m. peak
Work to home	p.m. peak
Home to shop	mid-day
Shop to home	mid-day
Home to education	a.m. peak
Education to home	mid-day
Home to other	mid-day
Other to home	off-peak

VARIABLE DEFINITIONS

We defined the following variables for use in this round of model estimation.

- Number of persons in household;
- Number of persons age 16 and older;

- Vehicle dummy—1 if there is at least one vehicle in the household, 0 otherwise;
- Drive alone dummy—1 of trip is made by auto drive with no passengers, 0 otherwise; and
- Income group dummy (for income groups 1 through 5)—1 if traveler's household income is in group, 0 otherwise.

The income groups were defined consistently with the household survey. The income groups in the survey were defined as:

1. Less than $ 15,000
2. $15,000 - $24,999
3. $25,000 - $34,999
4. $35,000 - $49,999
5. $50,000 - $64,999
6. $65,000 or over

As mentioned above, we did not have variables related to transportation level of service available for this round of model estimation. A third category of variables, related to geography, was also not used for this round although these variables should be considered in the next round.

MODEL ESTIMATION

Models were estimated for each of the eight trip purposes using household variables defined from the survey data set. All of the estimated parameters are specific to the departure time period (i.e., there are no generic variables), meaning that the utility of the base alternative is zero. Table 3 summarizes the estimation statistics for the eight models. This table shows that all eight models have low rho-squared values with respect to the constants. This implies that the household variables do not have a great deal of explanatory power in these models. This result is not surprising; one would not expect that household characteristics such as number of persons, income, or vehicle ownership are the main determinants of the times persons choose to travel.

Table 3. Summary of Model Estimation Statistics

Model from	Model To	Number of Alts.	Number of Obs.	Likelihood wrt Zero	Likelihood wrt Constants	Final Likelihood	Rho-Squared wrt Zero	Rho-Squared wrt Constants
Home	Work	4	3208	-4447.23	-3730.32	-3672.62	0.174	0.016
Work	Home	4	2577	-3572.48	-2681.07	-2658.65	0.256	0.008
Home	Shop	4	2507	-3475.44	-2831.75	-2744.22	0.210	0.031
Shop	Home	4	2316	-3210.66	-2590.30	-2489.75	0.225	0.039
Home	Educ.	4	1181	-1637.21	-1328.73	-1258.75	0.231	0.053
Educ.	Home	4	993	-1376.59	-1228.98	-1142.86	0.170	0.070
Home	Other	4	3819	-5294.26	-5036.34	-4880.39	0.078	0.031
Other	Home	4	3033	-4204.63	-3586.98	-3474.63	0.174	0.031

It should be noted that for all models, as expected, the constant terms for the non-base periods are negative, implying that, all other things being equal, persons tend to travel during the base period for each purpose. This is consistent with the way in which these base periods were defined.

Home based work

Table 4 shows the estimation results for home to work trips. The coefficients on the income level variables are significant. In general, the income coefficients for the non-base periods decrease as the income level increases, indicating that higher income workers are more likely to travel in the a.m. peak period. This makes sense since many of the jobs that would begin at times other than the morning may be part-time or lower income jobs. Other less significant variables include the household size-related variables; in general, persons from larger households were less likely to travel to work in the morning peak period. Coefficients for the vehicle and drive alone dummies are specific only to one time period each and were significant at less than the 90% confidence level. There was a slightly higher likelihood for solo drivers to travel in the off-peak and for persons from households without cars to travel in the mid-day.

Table 5 shows the estimation results for work to home trips. Few of the coefficients estimated are significant at the 95% level. The main conclusion is that lower income travelers are more likely to return home from work during the mid-day, perhaps reflecting that such trips are most likely made by part-time workers.

It would be expected that the time of day for work trips be related to the job type. Therefore, it would have been useful to include information on employment type. Unfortunately, the household survey data set does not include any data with respect to employment type.

Home based shop

Table 6 shows the estimation results for home to shop trips. There is a correlation between household income and the time of day choice for shopping trips, with lower income persons being more likely to shop during the mid-day period. This may reflect that most higher income people are at work during the mid-day and therefore must shop at other times. Persons from larger households and those who shop with others—these are probably related since many household members shop together—are more likely to shop during the p.m. and off-peak periods.

Table 7 shows the estimation results for shop to home trips. The estimated model is similar to the home to shop model, which reflects the fact that the entire shopping activity often takes place within a single time period as we have defined them. The main exception is that persons from lower income households are more likely to return home from shopping in the morning peak period. Since many stores are not open during the a.m. peak, this may reflect stops on the way home from work made by persons working night shifts, who tend to have lower incomes.

It is interesting that in both Tables 6 and 7, the drive alone dummy coefficient is positive for the a.m. peak period and negative for the other periods. Since the a.m. peak period is relatively short compared to other periods, this variable is perhaps correlated with the trip duration or the activity duration. Further information on average trip length/duration may provide additional explanatory power to this model.

Home based education

Table 8 shows the estimation results for home to education trips. We believe that the vast majority of trips made by students in elementary and secondary schools should occur in the morning peak period while most of the trips made by students during other time periods would be for the purpose of higher education. In this context, the results seem quite logical, especially considering that nearly all of the trips are made by auto. Persons driving alone would be much more likely to be college students while those traveling with others would include children driven to school by parents or others. Thus the coefficients for the drive alone dummy for the non-base periods are strongly positive. The negative coefficients for the number of household members over 16 years of age for non-base periods may reflect the presence of college age students. Recall that the household survey data set provides no information about the educational institution at the destination.

Table 9 shows the estimation results for education to home trips. These results mirror those for the home to education model estimation. The main exception is the negative coefficient for the p.m. peak, which may reflect that some elementary or secondary schools dismiss students late enough that the trip home becomes a p.m. peak trip.

Home based other

Table 10 shows the estimation results for home to other trips. As occurs with all purposes that aggregate individual purposes (such as home based other, non-home based), the nature of the trip is not well defined; it rather represents a “mix” of different trip types.

The most significant variable in this model is household size. It would seem that persons from larger households are more likely to travel in the afternoon peak and off-peak periods (and to a lesser extent, the morning peak) than are persons from smaller households. Some of these trips may be made by children (or parents serving children) since the effect seems to be the opposite of that reflected by the signs of the coefficients for the number of persons age 16 and over. Auto trips made with others are more likely to be made during the afternoon and evening while drive alone trips are more likely to be made in the morning peak. The latter undoubtedly include many stops in the way to work.

Table 11 shows the estimation results for other to home trips. Drive alone trips are more likely to be made earlier in the day, while trips made by larger households are most likely to be made at night and least likely to be made during the mid-day (when many people are at work or school).

Discussion

The general conclusion of this round of model estimation is that while household variables are significant in explaining time of day behavior, they are not the predominant indicators of the time period in which persons choose to travel. This conclusion was not unexpected. Income seems to be significant only in the work and shop trip models. The presence of auto passengers and household size are more important in the education and other trip models. Auto ownership does not appear to be a very significant indicator of time of day choice.

It is useful to compare the results we obtained with those documented by the Metropolitan Transportation Commission (MTC) in Oakland, California[1]. MTC estimated a binary logit time of day choice model for home to work trips in the San Francisco Bay Areas using household survey data collected in 1990. The alternatives were a.m. peak period (6:30 to 8:30) and other. Variables included demographic and mode variables:

- Shared ride dummy variable
- Household income
- Retail industry variable

[1] Purvis, Chuck. "Peak Spreading Models: Promises and Limitations." Proceedings of the Seventh TRB Conference on the Application of Transportation Planning Methods, Boston, MA, 1999.

Level of service variables:

- Difference between congested and free flow time
- Auto distance
- Auto distance squared

Geographic variables:

- Bridge crossing dummy variable
- Bay Bridge westbound dummy variable

We used two of the three demographic variables used by MTC in our home to work model, income and a drive alone dummy (equivalent to one minus the shared ride dummy). We could not use an industry variable for workers because that information was not available in the Tampa Bay data set. The MTC model showed similar behavior to that of our model concerning these two variables. Higher income workers were more likely to travel during the a.m. peak period, as were carpoolers. The effect of the shared ride dummy variable was more significant in the MTC model than in our model, which is likely due to the significant peak period time and toll savings for carpoolers in the Bay Area in some corridors. It should be noted that MTC reports that the inclusion of the income variable does significantly improve the model's explanatory capability.

The level of service variables were the most significant set of variables in the MTC model. We will be using level of service in the next round of model estimation with the Tampa Bay survey. As mentioned previously, we did not attempt to use any geographic variables in this round of model estimation, but the significance of these variables in the MTC model indicates that it is worth exploring this type of variable in our next round. While the geography of the Bay Area with its limited and congested bay crossings probably increases the significance of these variables in the MTC models, there could be significant variables defined for the Tampa Bay area. For example, dummy variables could include Tampa Bay crossing, CBD destination, county-specific variables, etc. In general, the models estimated so far are consistent with both expectations and experience in other studies. It will be valuable to continue estimating models once we have level of service data and geographic variables to consider.

Table 4. Home to Work Model

Time Period	Constant	Household Size	HH Size (Age 16+)	Vehicle Dummy	Drive Alone Dummy	Income Group 1	Income Group 2	Income Group 3	Income Group 4	Income Group 5
AM PEAK	0.00									
MIDDAY	-1.42 (-4.0)		0.22 (4.0)	-0.52 (-1.6)		0.65 (2.4)	0.82 (5.0)	0.57 (3.6)	0.48 (3.2)	0.15 (0.9)
PM PEAK	-4.33 (-13.2)		0.48 (5.8)			1.55 (3.6)	0.90 (2.7)	1.47 (5.2)	1.08 (3.8)	0.66 (2.0)
OFF PEAK	-1.46 (-7.6)	0.11 (3.3)			0.19 (1.4)	0.65 (2.8)	0.59 (4.0)	0.62 (4.6)	0.56 (4.4)	0.53 (4.0)

Table 5. Work to Home Model

Time Period	Constant	Household Size	HH Size (Age 16+)	Vehicle Dummy	Drive Alone Dummy	Income Group 1	Income Group 2	Income Group 3	Income Group 4	Income Group 5
AM PEAK	-3.77 (-5.8)	0.23 (1.8)	-0.32 (-1.6)		0.57 (1.1)	0.92 (1.6)		0.33 (1.0)		0.21 (0.6)
MIDDAY	-1.74 (-8.6)					1.04 (3.8)	0.60 (3.5)	0.53 (3.4)	0.32 (2.0)	
PM PEAK	0.00									
OFF PEAK	-1.13 (-2.9)		0.16 (3.1)			0.39 (1.6)				-0.26 (-2.0)

Table 6. Home to Shop Model

Time Period	Constant	Household Size	HH Size (Age 16+)	Vehicle Dummy	Drive Alone Dummy	Income Group 1	Income Group 2	Income Group 3	Income Group 4	Income Group 5
AM PEAK	-1.66 (-5.0)	-0.06 (-0.8)			0.35 (2.3)	-0.41 (-1.3)	-0.38 (-1.4)	-0.23 (-0.9)	-0.12 (-0.5)	-0.18 (-0.6)
MIDDAY	0.00									
PM PEAK	-1.08 (-4.8)	0.22 (4.1)			-0.10 (-0.9)	-0.63 (-2.8)	-0.74 (-3.9)	-0.65 (-3.6)	-0.44 (-2.4)	-0.39 (-1.8)
OFF PEAK	-1.37 (-5.8)	0.34 (6.2)			-0.40 (-3.2)	-1.45 (-4.7)	-1.16 (-5.3)	-0.86 (-4.3)	-0.36 (-1.9)	-0.33 (-1.5)

Table 7. Shop to Home Model

Time Period	Constant	Household Size	HH Size (Age 16+)	Vehicle Dummy	Drive Alone Dummy	Income Group 1	Income Group 2	Income Group 3	Income Group 4	Income Group 5
AM PEAK	-5.68 (-7.1)	0.39 (3.2)			1.10 (3.0)	1.15 (1.6)	0.76 (1.1)	0.90 (1.4)	1.14 (1.8)	0.57 (0.8)
MIDDAY	0.00									
PM PEAK	-0.24 (-1.1)	0.01 (0.2)			-0.43 (-4.2)	-0.34 (-1.5)	-0.24 (-1.3)	-0.25 (-1.3)	0.03 (0.2)	0.10 (0.5)
OFF PEAK	-0.48 (-2.1)	0.27 (5.2)			-0.63 (-5.5)	-1.43 (-5.2)	-1.37 (-6.7)	-0.83 (-4.6)	-0.45 (-2.5)	-0.36 (-1.8)

Table 8. Home to Education Model

Time Period	Constant	Household Size	HH Size (Age 16+)	Vehicle Dummy	Drive Alone Dummy	Income Group 1	Income Group 2	Income Group 3	Income Group 4	Income Group 5
AM PEAK	0.00									
MIDDAY	-2.68 (-2.5)		-0.27 (-2.6)	1.49 (1.4)	1.64 (9.6)					
PM PEAK	-1.91 (-2.2)		-0.28 (-2.2)	0.21 (0.3)	1.58 (7.6)					
OFF PEAK	-0.79 (-1.4)		0.11 (1.1)	-1.13 (-2.2)	0.55 (2.8)					

Table 9. Education to Home Model

Time Period	Constant	Household Size	HH Size (Age 16+)	Vehicle Dummy	Drive Alone Dummy	Income Group 1	Income Group 2	Income Group 3	Income Group 4	Income Group 5
AM PEAK	-1.35 (-3.2)		-0.62 (-4.0)		2.43 (7.9)					
MIDDAY	0.00									
PM PEAK	0.77 (3.5)		-0.18 (-2.0)		-0.74 (-4.4)					
OFF PEAK	-1.11 (-3.8)		-0.01 (-0.1)		0.44 (2.1)					

Table 10. Home to Other Model

Time Period	Constant	Household Size	HH Size (Age 16+)	Vehicle Dummy	Drive Alone Dummy	Income Group 1	Income Group 2	Income Group 3	Income Group 4	Income Group 5
AM PEAK	-1.50 (-9.0)	0.27 (3.3)	-0.13 (-1.2)		0.46 (4.6)					
MIDDAY	0.00									
PM PEAK	-1.10 (-7.0)	0.73 (11.8)	-0.60 (-6.4)		-0.30 (-3.2)					
OFF PEAK	-1.46 (-9.9)	0.61 (9.7)	-0.24 (-2.7)		-0.13 (-1.5)					

Table 11. Other to Home Model

Time Period	Constant	Household Size	HH Size (Age 16+)	Vehicle Dummy	Drive Alone Dummy	Income Group 1	Income Group 2	Income Group 3	Income Group 4	Income Group 5
AM PEAK	-2.58 (-6.9)	-0.11 (-0.9)	-0.14 (-0.7)		1.13 (4.9)					
MIDDAY	-0.06 (-0.4)	-0.57 (-8.5)	0.42 (4.4)		0.70 (7.7)					
PM PEAK	-0.22 (-1.4)	-0.24 (-4.2)	0.09 (0.9)		0.23 (2.3)					
OFF PEAK	0.00									