

**NASHVILLE AREA MPO  
2035 REGIONAL TRANSPORTATION PLAN**

**TRAVEL DEMAND MODEL DEVELOPMENT NOTES**



NASHVILLE AREA

**Metropolitan Planning Organization**

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## 1.0 Introduction

This travel demand model update was developed for Nashville Area Metropolitan Planning Organization's 2035 Regional Transportation Plan. In the update, a base year, 2008, and three Horizon years were selected: 2015, 2025, and 2035. This document describes the development and calibration/validation of the passenger component for the base year only.

The model was developed using TransCad 5.0, and the following main data sources:

- Census 2000
- 1997 Nashville MPO's Household Travel Survey
- INFO-USA database for the base year business locations and number employees,
- Woods and Poole database for base year and future year population/ employment control total.
- TDOT Transportation Roadway Inventory Management System (TRIMS) Database
- TDOT ADAM Database
- Aerial Photos and Parcel Files
- Nashville Area Travel Speed Survey

A few major changes were made in this model:

### Freight Model

A Freight and Truck Component was added to the model update. The model estimates three classes of trucks: Commercial vehicle, Single-Unit Truck, and Multi-Unit Truck trips. The model also outputs the region's commodity flow. For more details, refer to the Freight Component tech memo.

### Study Area and Traffic Analysis Zone (TAZ) structure

In order to perform a more detailed analysis, the TAZ structure and study area boundary were changed significantly. Now all of Robertson County is included in the model. Second, the number of TAZs was increased from 1440 to 2102 because of expanded study area and completed roadway projects. Some TAZs were also split in order to reflect the growth in the area.

### External Trips

New External stations were selected based on the new study area boundary. New External to External trips, Internal to External, and External to Internal trip percentages were estimated using The Tennessee State Wide Model (TDOT, 2002) using select link analysis in TransCAD 5.0.

### Network

Network updates include alignment updates, attributes updates, etc. More detailed information can be found in Section 2.

### Integrated Horizon Year Scenarios

Different attributes for different horizon years in the network include: Direction, FHWA Functional Class, Number of Lanes, Center Turn Lanes Flag, and Pavement width are now coded in the same network file instead of individual files for each horizon years. For more detail network fields, please refer to the appendix.

## 2.0 Highway Network Update

The network update includes

- Expanded study area
- Vehicle Classification Count data
- Continuous left turn lane and divided roadway designation
- New projects(As of 2030 Travel Demand Model)
- Functional Classification Updates
- 2008 ADT and vehicle class count
- Posted speed
- State route number
- U.S. route number
- External stations
- Truck model related fields (eg: SU, MU, CV)

### 2.1 Expanded Study Area

Robertson County: The study area was expanded to cover all of Robertson County. It means the network had to be expanded as well. First, all collectors and up roadways were added to the network. Secondly, local roads were added to create more accurate volume distribution during the assignment phase of the model.

Maury County: In order to compile information from the Census data correctly, some TAZ boundaries in Maury County were changed. The network was then updated to reflect the changes made in TAZ boundary.

### 2.2 Vehicle Classification Count Data

425 Classification count station data were incorporated to the network. It includes vehicle class composition and directional flow information. The count data is also used to develop TOD factor for trucks and EE trips.

### 2.3 Continuous Left Turn Lane (CLTL) and Divided Roadway

Continuous left-turn lanes are the common access management treatment. Typically, they are used in the center of a four-lane or two-lane roadway. It is being used to provide extra lane for left turning vehicles. The Continuous left turn lane field was reviewed in the update. New construction/widening projects that involved adding CLTL were updated in the network. The divided roadways were also updated.

### 2.4 New Projects

Projects completed from January 2002 to December 2008 were added to the base year network. The data sources include local inputs and Nashville Area MPO TIP documents.

## 2.5 Functional Classification

In the previous update, roadways were classified using part of TDOT’s classification study conducted in 1989 and some field study results. In this update, the network functional class was updated using the TDOT TRIMS database only.

### 2.5.1 Facility Type

An automatic process was developed to read the highway link attribute and the associated TRIMS data in order to determine a facility type for each link to be used as an input into the highway assignment process. The primary TRIMS data fields used in the facility type process are as follows:

- **Func\_CLASS** – This is the normal Highway Planning Network (NHPN) functional classification of the roadway in the network. There are generally classified into rural facilities and urban facilities. They are further classified by Interstates, arterials, collectors, and local access roads. Table below shows the NHPN function classification codes.
- **Lanes** - The number of lanes (bi-directional) coded in the NHPN
- **Pavement\_W** – The total width of the roadway for all travel lanes. The lane width can give important information about the operational characteristics of a facility as it can affect capacity and travel speeds. A lane width of 11 feet or greater is considered to be standard width and anything less than that as sub-standard.
- **DIR** – Directional code of the highway link. A code of “0” indicates a two-way road, and non-zero (1 or -1) indicates a one-way link.

Table 2.5.1.1: NHPN Functional Classifications

| Code | Classification                   | Code | Classification                 |
|------|----------------------------------|------|--------------------------------|
| 01   | Rural Interstate                 | 14   | Urban other principal Arterial |
| 02   | Rural Principal Arterial         | 16   | Urban Minor Arterial           |
| 03   | Rural Freeway                    | 17   | Urban Collector                |
| 06   | Rural Minor Arterial             | 19   | Urban local Access             |
| 07   | Rural Major Collector            | 20   | System-System Ramp             |
| 08   | Rural Minor Collector            | 21   | On Ramp                        |
| 09   | Rural local Access               | 22   | Off Ramp                       |
| 10   | National Park Service Road       | 23   | Collector-Distributor Road     |
| 11   | Urban Interstate                 | 99   | Centroid Connector             |
| 12   | Urban Other Freeways/Expressways |      |                                |

Based on these network fields, a facility type is calculated for use as input into the travel demand model assignment procedure. The facility type classifications are shown in Table. Table describes the relationships used in the model stream to relate the NHPN variables to facility type designations.

As can be seen in Table, the key characteristic in determining the facility type designation for each link in the network is the NHPN Functional Classification Code for the link. The detailed facility type designations for the arterial links are based upon the geometric characteristics of the roadway, i.e., number of travel lanes, two-way or one-way, and lane width. For example, if the two lane roadway (local lanes in both direction) has a NHPN Functional Classification Code of 02 (rural principal arterial) which lane widths of less than 11 feet, it would have facility type code of 12 (major arterial). This same roadway would have a facility type code of 11 (Principal arterial) if it was a one-way facility. These facility type codes along with the area type codes are the parameters used in assigning the capacities and free flow speeds for each link in the network.

Table 2.5.1.2: Federal Highway Functional Class

| Code | Facility Type         | Code | Facility Type      |
|------|-----------------------|------|--------------------|
| 01   | interstate            | 11   | Principal Arterial |
| 02   | Freeway               | 12   | Major Arterial     |
| 03   | Expressway            | 13   | Minor Arterial     |
| 04   | Collector-Distributor | 21   | Collector          |
| 06   | System-System Ramp    | 31   | Local              |
| 07   | On-Ramp               | 50   | Transit-Only       |
| 08   | Off-Ramp              | 99   | Centroid Connector |

## 2.6 Capacity and Speed

Normalized Capacity based on area type and facility type was not changed. See table below.

Table 2.6.1: Normalized Capacity Based on Area Type and Facility Type

| Facility Type |  | Area Type <sup>9</sup>  |      |      |      |                         |      |                         |
|---------------|--|-------------------------|------|------|------|-------------------------|------|-------------------------|
| Code          | Description                              | 1                       | 2    | 3    | 4    | 5                       | 6    | 7                       |
| <b>1</b>      | <b>Interstate</b>                        | <b>1790<sup>8</sup></b> | 1830 | 1870 | 1910 | <b>1930<sup>8</sup></b> | 1870 | <b>1810<sup>8</sup></b> |
| <b>2</b>      | <b>Freeway<sup>2</sup></b>               | 1590                    | 1620 | 1650 | 1680 | 1700                    | 1690 | 1680                    |
| <b>3</b>      | <b>Expressway<sup>1</sup></b>            | 1380                    | 1400 | 1420 | 1440 | 1470                    | 1510 | 1550                    |
| <b>4</b>      | <b>Collector-Distributor<sup>5</sup></b> | 1590                    | 1620 | 1650 | 1680 | 1700                    | 1690 | 1680                    |
| <b>6</b>      | <b>System-System Ramp<sup>4</sup></b>    | 1790                    | 1830 | 1870 | 1910 | 1930                    | 1870 | 1810                    |
| <b>7</b>      | <b>On-Ramp<sup>6</sup></b>               | 1600                    | 1650 | 1700 | 1750 | 1800                    | 1850 | 1900                    |
| <b>8</b>      | <b>Off-Ramp<sup>3</sup></b>              | 960                     | 970  | 980  | 990  | 1010 <sup>8</sup>       | 1145 | 1280                    |
| <b>11</b>     | <b>Principal Arterial</b>                | <b>960<sup>8</sup></b>  | 970  | 980  | 990  | <b>1010<sup>8</sup></b> | 1145 | <b>1280<sup>8</sup></b> |
| <b>12</b>     | <b>Minor Arterial</b>                    | <b>780<sup>8</sup></b>  | 790  | 800  | 810  | <b>820<sup>8</sup></b>  | 980  | <b>1140<sup>8</sup></b> |
| <b>13</b>     | <b>Minor Arterial</b>                    | <b>710<sup>8</sup></b>  | 730  | 750  | 770  | <b>770<sup>8</sup></b>  | 780  | <b>790<sup>8</sup></b>  |
| <b>21</b>     | <b>Collector-Distributor</b>             | <b>440<sup>8</sup></b>  | 470  | 500  | 530  | <b>560<sup>8</sup></b>  | 630  | <b>690<sup>8</sup></b>  |
| <b>31</b>     | <b>Local<sup>7</sup></b>                 | 350                     | 380  | 410  | 440  | 450                     | 500  | 550                     |

**Note:**

1. Expressway is interpolated between Interstate and Principal Arterial
  2. Freeway is interpolated between Interstate and Expressway
  3. Off-Ramp is equal to Principal Arterial
  4. System-System ramp is equal to Interstate
  5. Collector-Distributor is equal to Freeway
  6. On-Ramp - Values based on lowest and highest ramp capacities (HCM, Exhibit 25-3)
  7. Local capacities are assumed to be 20% lower than collectors
  8. Bold values are determined from HCM procedures and assumptions
  9. Value between Area Types are interpolated. Detailed definition can be found in 3.3(Page 20)
- Data Source: 2004 Nashville MPO Model Update Document

## 2.7 Posted Speed and AADT Update

Posted speed was updated using travel time study from year 2005 to 2007, Local government inputs, TDOT TRIMS database, and MPO staff field study. Year 2008 AADT data was updated using TDOT's latest volume count station data.

## 2.8 External Stations.

New External stations were selected based on the new study area boundary. New external to external trips (E-E), internal to external (I-E), and external to internal (E-I) trips were estimated using Select Link Analysis in the Tennessee State Wide Model (TDOT, 2002).

Table2.8.1: Passenger Car External to External Trip Percentage Table from TN Statewide Model

| NAMPO NODE ID | SWM Link ID | NAME      | PASS AB_FLOW | PASS BA_FLOW | TOTAL_FLOW | EE_AB | EE_BA | PASS_EE_% |
|---------------|-------------|-----------|--------------|--------------|------------|-------|-------|-----------|
| 198002        | 51632       | U.S. 31   | 13629        | 13629        | 27259      | 106   | 106   | 0.01      |
| 198005        | 52447       | I-65      | 13915        | 13919        | 27834      | 1775  | 1777  | 0.13      |
| 198006        | 53123       | U.S. 431  | 1464         | 1473         | 2937       | 0     | 0     | -         |
| 198010        | 52532       | U.S. 431  | 2753         | 2753         | 5506       | 30    | 30    | 0.01      |
| 198011        | 52332       | SR 10     | 4877         | 4876         | 9753       | 184   | 184   | 0.04      |
| 198017        | 53222       | U.S. 70N  | 1581         | 1582         | 3163       | 0     | 0     | -         |
| 198018        | 53199       |           | 1168         | 1168         | 2335       | 550   | 550   | -         |
| 198026        | 51680       | SR 12     | 8072         | 8073         | 16145      | 71    | 71    | 0.01      |
| 198032        | 52310       | U.S. 70 S | 6500         | 6497         | 12996      | 293   | 290   | 0.04      |
| 198033        | 53215       | I-40      | 16083        | 16079        | 32162      | 6141  | 6133  | 0.38      |
| 198039        | 53067       | U.S. 231  | 6043         | 6044         | 12087      | 133   | 133   | 0.02      |
| 198044        | 51625       | I-24      | 16844        | 16868        | 33713      | 5086  | 5079  | 0.3       |
| 198046        | 51944       | U.S. 31 A | 1427         | 1412         | 2839       | 29    | 29    | 0.02      |
| 198053        | 52802       | U.S. 41   | 283          | 283          | 565        | 1     | 1     | 0         |
| 198054        | 53074       | U.S. 41 A | 1927         | 1927         | 3854       | 10    | 10    | 0         |
| 198055        | 53613       | U.S. 70   | 7986         | 7982         | 15968      | 214   | 214   | 0.03      |
| 198056        | 53214       | U.S. 70   | 3241         | 3243         | 6484       | 706   | 705   | 0.22      |
| 198058        | 52254       | SR 52     | 3880         | 3880         | 7760       | 1122  | 1122  | 0.29      |
| 198059        | 57657       | U.S. 41   | 851          | 850          | 1701       | 0     | 0     | -         |
| 198060        | 57749       | I-24      | 15792        | 15801        | 31593      | 5612  | 5618  | 0.36      |
| 198066        | 49370       | U.S. 31W  | 4569         | 4569         | 9138       | 558   | 558   | 0.12      |
| 198069        | 52219       | I-65      | 15756        | 15748        | 31504      | 3306  | 3297  | 0.21      |
| 198070        | 52685       | SR 100    | 4194         | 4193         | 8388       | 377   | 377   | 0.09      |
| 198074        | 52717       | SR 96     | 3733         | 3733         | 7466       | 313   | 313   | 0.08      |
| 198075        | 52524       | U.S. 31 E | 2717         | 2718         | 5436       | 929   | 929   | 0.34      |
| 198076        | 53248       | SR 96     | 1691         | 1692         | 3383       | 626   | 627   | 0.37      |
| 198078        | 52442       | I-40      | 11070        | 11080        | 22150      | 7410  | 7422  | 0.67      |

Note: In SWM, passenger trips also include Single Unit and Commercial vehicles. It was assumed that passenger vehicles, commercial vehicles, and single Unit trucks all share the same external to external percentage at all the external stations.

## ***2.9 Miscellaneous Update***

- **Alignments:** Some roadway alignments were fixed based on Parcel and Aerial Maps
- **Names:** Name updates include adding SR, US route name, and updating the street names if necessary.
- **External Stations Number:** Traffic count station number field was added for external station traffic count.
- **Turn Penalty:** Turn Penalties were added to network for some interchanges and intersections.
- **Number of Lanes:** This is updated based on TRIMS, aerial photos, local inputs and TIP documents.

## 3.0 Socio-Economic (SE) Data and Traffic Analysis Zone (TAZ) Updates

The TAZ database update was a significant component of this model. The update includes changing the TAZ alignment, size and allocating the socio-economic (SE) data for each TAZ.

### 3.1 TAZ

The number of TAZs was increased from 1440 to 2102 for several reasons:

- Census: The TAZ boundaries were revised to fit census block group boundaries.
- Expanded Study Area: The study area now includes all of Robertson County
- Rapid Area Growth: Rutherford County and Williamson County are two of the fastest growing counties in the region. TAZ size was reviewed, and adjusted to reflect the growth.
- New Projects: Some TAZs were divided when new or future regionally significant projects cut through them.
- TAZ size is smaller around Transit routes and stations in order to simulate reasonable walking distance, as well as helping incorporate transit models in the near future.

#### 3.1.1 Alignments

TAZ alignments were also adjusted for:

- Roadway Alignment changes
- Future Major Projects, (e.g. SR-840 South)

#### 3.1.2 Attributes

All SE data is now stored in the TAZ file and the attributes from the previous model's SE data file have been moved to the TAZ file.

The TAZ file also stores information from Census Block Group, Tract, and Parcel data. The SE dictionary table is attached in the Appendix E.

TAZ database structure changes:

- County IDs now are 3-digit numbers, for example, 037 instead of 37
- TAZ numbers are now 3 digits instead of 6.
- TAZ numbers are created based on the CountyID. For example, in County ID 037, there are 100 TAZs. Those TAZs in the county will be numbered from 037001, 037002, 037003... 037100. This procedure is the same for all counties.
- The TAZ ID number is now based on the distance from the Central Business District (CBD) for each county. The smaller the TAZ ID number, the closer it is to the CBD. (E.g.; 037001 is the Nashville CBD TAZ)
- All the external stations' countyID are now 999 instead of a 6 digit number. (E.g.; 999001 is the first external station)

### 3.2 Socio-Economic Data

Base year population allocation was based on Census 2000 data and the parcel map for each county. Household and Population totals are tied to a control total. This total is based on 2008 ACS (American

Community Survey), and 2009 Woods and Poole data. For Employment, the allocation was based on InfoUSA for business locations and business types, and Woods and Poole Database for the employment control total.

### 3.2.1 Household and Population Allocation

➤ Household Size Rates

The household size rates are based on the 2000 Census and 2008 ACS. The rates were applied to all the TAZs to get the estimated population in each zone.

➤ Dwelling Units

The number of Households for each TAZ was estimated from improvement type and dwelling unit counts in the parcel maps. In Davidson County the availability of detailed building permit information allowed us to track new residential construction and include the resulting dwelling units in the model.

There are four different parcel systems in the 7-county study area. They are CASS 3 (Computer Aid System), CASS 4, Davidson County Parcel System, Rutherford County Parcel System. The following tables were used to determine if the parcel is used for residential purpose.

Table 3.2.1.1: CASS 3 and 4 Household Improvement Type

| <b>CAAS System</b>         | Building Type      |
|----------------------------|--------------------|
| IMP Code                   | Description        |
| 01                         | SINGLE FAMILY      |
| 03                         | SPECIAL RES        |
| 05                         | SINGLE FAMILY      |
| 09                         | EXCEPTIONAL        |
|                            |                    |
| 02                         | MULTI FAMILY       |
| 04                         | TOWNHOUSE          |
| 06                         | APARTMENT          |
| 07                         | RENTAL UNIT        |
| 08                         | RES CONDO          |
| 10                         | APARTMENT          |
| 12                         | Commercial Condo   |
|                            |                    |
| <b>CAAS 4 Extra Fields</b> | Dwelling unit Type |
| 51-56                      | Mobile Home        |

Table 3.2.1.2: Davidson Household Type

| <b>Davidson County</b> |                             |
|------------------------|-----------------------------|
| <b>Land_USE</b>        | <b>Description</b>          |
| 11                     | SINGLE FAMILY DWELLING      |
| 16                     | RESIDENTIAL ZERO LOT LINE U |
| 18                     | MOBILE HOME(S)              |
| 62                     | MOBILE HOME PARK            |
| 81                     | SFD(S) - RURAL              |
| 88                     | MOBILE HOMES(S) - RURAL     |
| 92                     | PARSONAGE                   |
|                        |                             |
| 13                     | TRIPLEX                     |
| 12                     | DUPLEX                      |
| 14                     | QUADRAPLEX                  |
| 15                     | RESIDENTIAL CONDOMINIUM     |
| 19                     | RESIDENTIAL COMBO. OR MISC. |
| 37                     | APARTMENT WALK UP           |
| 38                     | APARTMENT LOW-RISE          |
| 39                     | APARTMENT HIGH-RISE         |
| 82                     | DUPLEX(S) - RURAL           |
| 83                     | TRIPLEX(S) - RURAL          |
| 89                     | RURAL COMBINATION           |

Table 3.2.1.3: Rutherford County Household Type

| <b>Household Type</b> |                      |                             |
|-----------------------|----------------------|-----------------------------|
| <b>Account Type</b>   | <b>Property Type</b> | <b>Property Description</b> |
| Residential           | Residential          | Condo <= 3 Stories          |
| Residential           | Residential          | Condo > 3 Stories           |
| Agricultural          | Residential          | Condo <= 3 Stories          |
| City                  | Multiple Unit        | Apartment <= 3 Stories      |
| City                  | Residential          | Apartment <= 3 Stories      |
| Commercial            | Condo                | Condo <= 3 Stories          |
| Commercial            | Duplex               | Duplex One Story            |
| Commercial            | Duplex               | Duplex Two Story            |
| Commercial            | Multiple Unit        | Apartment <= 3 Stories      |
| Commercial            | Multiple Unit        | Apartment > 3 Stories       |
| Commercial            | Multiple Unit        | Condo <= 3 Stories          |
| Commercial            | Residential          | Apartment <= 3 Stories      |
| Commercial            | Residential          | Apartment > 3 Stories       |
| Commercial            | Residential          | Condo <= 3 Stories          |
| Farm                  | Mobile Home          | Permit Value                |
| Mobile Home           | Out Building         | Permit Value                |
| Multiple Unit         | Multiple Unit        | Apartment <= 3 Stories      |
| Multiple Unit         | Multiple Unit        | Apartment > 3 Stories       |
| Multiple Unit         | Residential          | Apartment                   |
| Residential           | Commercial           | Apartment                   |
| Residential           | Condo                | Condo <= 3 Stories          |

| Household Type |               |                        |
|----------------|---------------|------------------------|
| Residential    | Condo         | Condo > 3 Stories      |
| Residential    | Duplex        | Duplex One Story       |
| Residential    | Duplex        | Duplex Two Story       |
| Residential    | Mobile Home   | Permit Value           |
| Residential    | Multiple Unit | Apartment <= 3 Stories |
| Residential    | Residential   | Townhouse One Story    |
| Residential    | Residential   | Townhouse Two Story    |
| Residential    | Townhouse     | Townhouse 1 1/2 Story  |
| Residential    | Townhouse     | Townhouse One Story    |
| Residential    | Townhouse     | Townhouse Two Story    |
| State          | Residential   | Apartment <= 3 Stories |
| Agricultural   | Residential   | 1½ Story Fin           |
| Agricultural   | Residential   | 2 Story                |
| Agricultural   | Residential   | 3 Story                |
| Agricultural   | Residential   | Ranch One Story        |
| Farm           | Residential   | 1½ Story Fin           |
| Farm           | Residential   | 1½ Story Unfin         |
| Farm           | Residential   | 2 Story                |
| Farm           | Residential   | Ranch One Story        |
| Multiple Unit  | Residential   | Ranch One Story        |
| Residential    | Residential   | 1½ Story Fin           |
| Residential    | Residential   | 1½ Story Unfin         |
| Residential    | Residential   | 2½ Story               |
| Residential    | Residential   | 3 Story                |
| Residential    | Residential   | Bi Level 1 Story       |
| Residential    | Residential   | Bi Level 2 Story       |
| Residential    | Residential   | Ranch One Story        |
| Residential    | Residential   | Split Level            |

➤ Control Total

Refer to the following table for the control total used in the base year and future year TAZ files.

Table3.2.1.4 County Control Total

|                             | Year | Davidson | Maury   | Robertson | Rutherford | Sumner  | Williamson | Wilson  |
|-----------------------------|------|----------|---------|-----------|------------|---------|------------|---------|
| <b>Total Population</b>     | 2008 | 623,816  | 81,118  | 64,644    | 247,315    | 155,116 | 173,982    | 109,136 |
|                             | 2015 | 654,879  | 89,371  | 73,949    | 288,734    | 172,232 | 229,052    | 128,783 |
|                             | 2025 | 702,871  | 101,595 | 87,563    | 349,083    | 197,500 | 308,328    | 157,360 |
|                             | 2035 | 752,326  | 114,005 | 101,324   | 409,986    | 223,124 | 387,970    | 186,179 |
| <b>Number of Employment</b> | 2008 | 572,374  | 46,042  | 30,561    | 136,650    | 58,728  | 115,731    | 53,344  |
|                             | 2015 | 618,891  | 50,722  | 34,251    | 155,284    | 64,282  | 143,628    | 61,060  |
|                             | 2025 | 687,059  | 58,019  | 40,223    | 187,195    | 73,129  | 196,539    | 73,865  |
|                             | 2035 | 755,684  | 65,964  | 47,049    | 226,453    | 83,053  | 269,755    | 88,788  |
| <b>Number of Household</b>  | 2008 | 268,697  | 31,975  | 24,531    | 93,847     | 60,799  | 63,853     | 42,073  |
|                             | 2015 | 289,632  | 36,218  | 28,874    | 112,778    | 70,052  | 86,646     | 51,467  |
|                             | 2025 | 316,455  | 41,962  | 34,884    | 139,114    | 82,970  | 119,252    | 64,829  |
|                             | 2035 | 338,140  | 47,182  | 40,511    | 163,719    | 95,226  | 150,917    | 77,747  |
| <b>Household Size</b>       | 2008 | 2.23     | 2.5     | 2.61      | 2.57       | 2.53    | 2.71       | 2.56    |
|                             | 2015 | 2.17     | 2.43    | 2.54      | 2.5        | 2.44    | 2.63       | 2.48    |
|                             | 2025 | 2.13     | 2.39    | 2.49      | 2.46       | 2.36    | 2.57       | 2.4     |
|                             | 2035 | 2.12     | 2.38    | 2.48      | 2.46       | 2.32    | 2.56       | 2.37    |
| <b>Household Population</b> | 2008 | 599,194  | 79,938  | 64,026    | 241,187    | 153,821 | 173,042    | 107,707 |
|                             | 2015 | 628,501  | 88,010  | 73,340    | 281,945    | 170,927 | 227,879    | 127,638 |
|                             | 2025 | 674,049  | 100,289 | 86,861    | 342,220    | 195,809 | 306,478    | 155,590 |
|                             | 2035 | 716,857  | 112,293 | 100,467   | 402,749    | 220,924 | 386,348    | 184,260 |

Source: 2008 ACS and 2009 Woods and Poole Database.

### **3.2.2 Employment Allocation**

The main data sources for employment allocation include:

- Info USA database: The database provides business locations and number of on-site employees.
- Woods and Pool database. This database provides estimated control total for base year as well as predicted control total for future years up to year 2040.

All the businesses were categorized into 1 retail and 2 non-retail categories based on their North American Industry Classification System (NAICS) code. (See table below for detailed information.) The number of employees in different categories was summed in each TAZ, and then factored to arrive at the control total of employees.

Table 3.2.2.1 NAICS Code and Woods & Poole Conversion

| Categories        | Employment Categories                 | 2008 W&P Categories                                      | NAICS Code              |
|-------------------|---------------------------------------|--|-------------------------|
| <b>Industrial</b> | Farm and Agricultural Services, other | Farm Employment  | 11,99                   |
|                   |                                       | Forestry, Fishing, Related Actives and other Employment. |                         |
|                   | Mining                                | Mining Employment  | 21                      |
|                   | Construction Employment               | Construction Employment                                  | 23                      |
|                   | Manufacturing Employment              | Manufacturing Employment                                 | 31,32,33                |
|                   | Trans, Comm, & Public Utilities       | Utilities Employment                                     | 22,48,49                |
|                   |                                       | Transportation and Warehousing Employment                |                         |
| Wholesale Trade   | Wholesale Trade Employment            | 42   |                         |
| <b>Retail</b>     | Retail Trade                          | Retail Trade Employment                                  | 44,45,72                |
|                   |                                       | Accommodation and Food Services Employment               |                         |
| <b>Office</b>     | Finance, Insurance, & Real Estate     | Finance and Insurance Employment                         | 52,53                   |
|                   |                                       | Real Estate, Rental and Lease Employment                 |                         |
|                   | Services                              | Information Employment                                   | 51,54,55,56,61,62,71,81 |
|                   |                                       | Professional and Technical Service Employment            |                         |
|                   |                                       | Management of Companies and Enterprises Employment       |                         |
|                   |                                       | Administrative and Waste Services Employment             |                         |
|                   |                                       | Education Service Employment                             |                         |
|                   |                                       | Health Care and Social Assistance Employment             |                         |
|                   |                                       | Arts, Entertainment and Recreation Employment            |                         |
|                   |                                       | Other Services, Except Public Administration Employment  |                         |
| Government        | Government                            | 92   |                         |

Table 3.2.2.2: 2007 INFO USA Study area Number of employment (No part time or self-employed)

| INFO USA Numbers<br>(Study Area)      | Davidson | Maury  | Robertson | Rutherford | Sumner | Williamson | Wilson | Total   |
|---------------------------------------|----------|--------|-----------|------------|--------|------------|--------|---------|
| Farm and Agricultural Services, other | 769      | 63     | 81        | 294        | 43     | 161        | 58     | 1,469   |
| Mining                                | 767      | 54     | 65        | 107        | 35     | 75         | 56     | 1,159   |
| Construction Employment               | 27,228   | 1,845  | 1,532     | 6,369      | 3,563  | 5,733      | 2,056  | 48,326  |
| Manufacturing Employment              | 35,577   | 8,278  | 8,373     | 13,200     | 6,514  | 5,335      | 7,255  | 84,532  |
| Trans, Comm, & Public Utilities       | 14,728   | 762    | 457       | 4,984      | 1,173  | 984        | 1,407  | 24,495  |
| Wholesale Trade                       | 20,004   | 660    | 1,784     | 4,410      | 2,420  | 2,249      | 2,408  | 33,935  |
| Retail Trade                          | 94,647   | 8,556  | 4,436     | 25,881     | 8,050  | 23,121     | 8,316  | 173,007 |
| Finance, Insurance, & Real Estate     | 33,965   | 2,059  | 823       | 8,453      | 2,157  | 10,360     | 1,296  | 59,113  |
| Services                              | 188,162  | 11,204 | 5,478     | 39,401     | 13,286 | 29,732     | 9,004  | 296,267 |
| Government                            | 35,114   | 1,904  | 1,097     | 6,239      | 2,657  | 2,837      | 1,185  | 51,033  |
| Total                                 | 450,961  | 35,385 | 24,126    | 109,338    | 39,898 | 80,587     | 33,041 | 773,336 |

**Note:** There's a second source for the employment control total for Nashville MPO's study from US Department of Labor. However, this number doesn't include jobs not covered by unemployment insurance (Part time, agricultural employees, self-employed workers... etc). Those jobs were estimated in Woods and Poole database, they attract trips to the employment locations just like normal jobs.

Table 3.2.2.3: Aggregated Employment Control Total

|             | Category   | DAVIDSON | MAURY  | ROBERTSON | RUTHERFORD | SUMNER | WILLIAMSON | WILSON |
|-------------|------------|----------|--------|-----------|------------|--------|------------|--------|
| <b>2008</b> | Industrial | 109,867  | 15,048 | 13,564    | 49,329     | 20,178 | 19,650     | 18,803 |
|             | Retail     | 109,283  | 7,282  | 4,602     | 22,152     | 9,794  | 23,185     | 9,573  |
|             | Office     | 353,224  | 23,712 | 12,395    | 65,169     | 28,756 | 72,896     | 24,968 |
| <b>2015</b> | Industrial | 111,011  | 15,587 | 14,481    | 53,710     | 21,345 | 21,981     | 20,115 |
|             | Retail     | 115,466  | 7,966  | 5,061     | 26,573     | 10,765 | 29,460     | 11,500 |
|             | Office     | 392,414  | 27,169 | 14,709    | 75,001     | 32,172 | 92,187     | 29,445 |
| <b>2025</b> | Industrial | 111,981  | 16,446 | 15,853    | 60,927     | 23,358 | 25,870     | 22,306 |
|             | Retail     | 122,994  | 8,918  | 5,707     | 34,836     | 12,131 | 40,884     | 14,718 |
|             | Office     | 452,084  | 32,655 | 18,663    | 91,432     | 37,640 | 129,785    | 36,841 |
| <b>2035</b> | Industrial | 112,009  | 17,427 | 17,291    | 69,556     | 25,803 | 30,500     | 24,894 |
|             | Retail     | 128,471  | 9,797  | 6,313     | 46,155     | 13,407 | 55,713     | 18,475 |
|             | Office     | 515,204  | 38,740 | 23,445    | 110,742    | 43,843 | 183,542    | 45,419 |

### 3.3 Future year Socio-Economic data

Households and Employment were allocated by the Nashville MPO’s land use model, Refer to Nashville MPO’s Tri-County Study for more detailed information.

#### 3.3.1 Household Size and Vehicle Ownership Sub-model

Household size and vehicle ownership composition were estimated by the sub-model developed by using Census 2000 data.

Table 3.3.1.1 Household Size Sub-Model Lookup Table

| Average Household Size | 1P     | 2P    | 3P    | 4P    |
|------------------------|--------|-------|-------|-------|
| 1                      | 100.0% | 0.0%  | 0.0%  | 0.0%  |
| 1.1                    | 90.7%  | 9.3%  | 0.0%  | 0.0%  |
| 1.2                    | 82.7%  | 14.1% | 1.7%  | 1.5%  |
| 1.3                    | 76.4%  | 18.4% | 3.5%  | 1.7%  |
| 1.4                    | 70.5%  | 22.0% | 5.3%  | 2.2%  |
| 1.5                    | 64.9%  | 25.3% | 6.9%  | 2.9%  |
| 1.6                    | 59.6%  | 28.1% | 8.4%  | 3.9%  |
| 1.7                    | 54.5%  | 30.5% | 9.9%  | 5.1%  |
| 1.8                    | 49.8%  | 32.4% | 11.3% | 6.5%  |
| 1.9                    | 45.4%  | 34.0% | 12.5% | 8.1%  |
| 2.0                    | 41.2%  | 35.2% | 13.7% | 9.9%  |
| 2.1                    | 37.3%  | 36.0% | 14.8% | 11.9% |
| 2.2                    | 33.6%  | 36.5% | 15.8% | 14.1% |
| 2.3                    | 30.2%  | 36.5% | 16.8% | 16.5% |
| 2.4                    | 27.1%  | 36.4% | 17.6% | 18.9% |
| 2.5                    | 24.1%  | 35.9% | 18.4% | 21.6% |
| 2.6                    | 21.4%  | 35.2% | 19.1% | 24.3% |
| 2.7                    | 18.9%  | 34.3% | 19.7% | 27.1% |
| 2.8                    | 16.7%  | 33.0% | 20.2% | 30.1% |
| 2.9                    | 14.6%  | 31.6% | 20.7% | 33.1% |
| 3.0                    | 12.7%  | 30.0% | 21.1% | 36.2% |
| 3.1                    | 10.9%  | 28.3% | 21.4% | 39.4% |
| 3.2                    | 9.4%   | 26.4% | 21.6% | 42.6% |
| 3.3                    | 8.0%   | 24.3% | 21.8% | 45.9% |
| 3.4                    | 6.8%   | 22.1% | 21.9% | 49.2% |
| 3.5                    | 5.7%   | 19.9% | 21.9% | 52.5% |
| 3.6                    | 4.8%   | 17.6% | 21.8% | 55.8% |
| 3.7                    | 3.9%   | 15.3% | 21.7% | 59.1% |
| 3.8                    | 3.2%   | 12.9% | 21.6% | 62.3% |
| 3.9                    | 2.7%   | 10.4% | 21.3% | 65.6% |
| 4.0                    | 2.2%   | 8.0%  | 21.0% | 68.8% |
| 4.1                    | 1.8%   | 5.6%  | 20.7% | 71.9% |
| 4.2                    | 1.3%   | 4.8%  | 19.0% | 74.9% |
| 4.3                    | 0.8%   | 2.3%  | 19.0% | 77.9% |
| 4.4                    | 0.5%   | 0.6%  | 18.1% | 80.8% |
| 4.5                    | 0.4%   | 0.6%  | 17.0% | 82.0% |

Figure 3.3.1.1: Household Size Sub-model

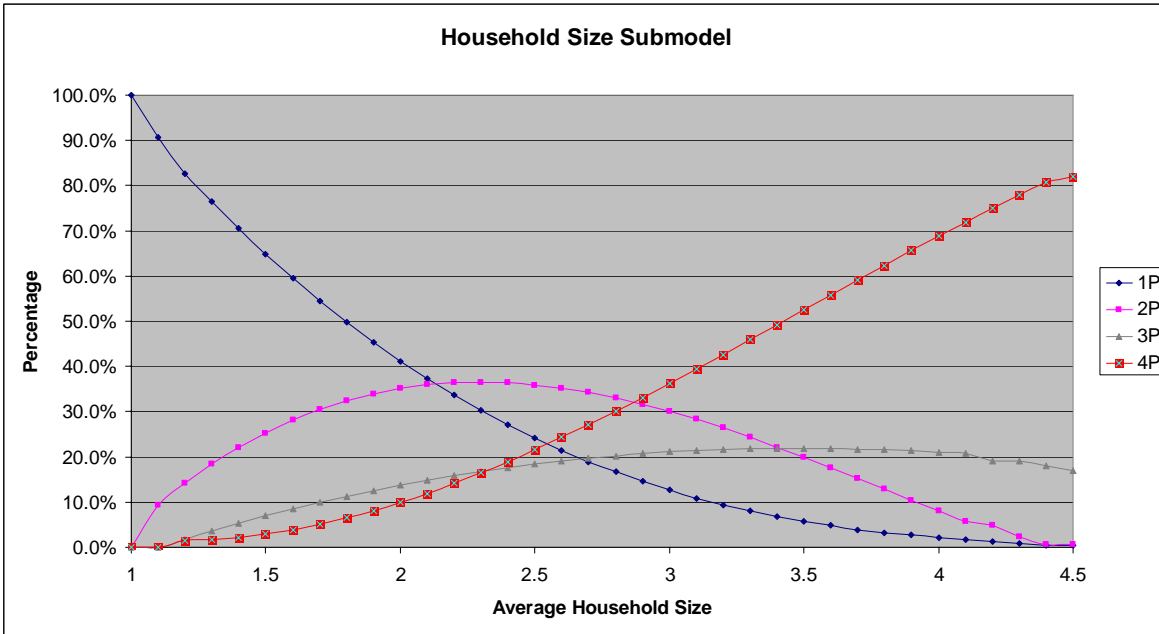


Table 3.3.1.2: Vehicle Ownership Lookup Table

| Average Vehicle Ownership | 0A    | 1A    | 2A    | 3A    | 4A    |
|---------------------------|-------|-------|-------|-------|-------|
| 0.5                       | 62.4% | 31.2% | 6.4%  | 0.0%  | 0.0%  |
| 0.6                       | 56.4% | 38.5% | 4.6%  | 0.5%  | 0.0%  |
| 0.7                       | 50.8% | 45.0% | 3.7%  | 0.5%  | 0.0%  |
| 0.8                       | 45.5% | 50.6% | 3.4%  | 0.5%  | 0.0%  |
| 0.9                       | 40.6% | 55.4% | 3.4%  | 0.5%  | 0.1%  |
| 1                         | 36.1% | 59.5% | 3.9%  | 0.5%  | 0.1%  |
| 1.1                       | 31.9% | 62.8% | 4.7%  | 0.5%  | 0.1%  |
| 1.2                       | 28.0% | 65.5% | 5.8%  | 0.5%  | 0.1%  |
| 1.3                       | 24.4% | 67.6% | 7.0%  | 0.6%  | 0.3%  |
| 1.4                       | 21.2% | 69.1% | 8.3%  | 0.8%  | 0.5%  |
| 1.5                       | 18.3% | 70.2% | 9.6%  | 1.3%  | 0.7%  |
| 1.6                       | 15.6% | 70.7% | 10.9% | 1.9%  | 0.9%  |
| 1.7                       | 13.2% | 70.8% | 12.4% | 2.5%  | 1.1%  |
| 1.8                       | 11.1% | 70.6% | 14.0% | 3.0%  | 1.3%  |
| 1.9                       | 9.2%  | 70.0% | 15.6% | 3.6%  | 1.6%  |
| 2                         | 7.6%  | 69.2% | 17.4% | 4.1%  | 1.8%  |
| 2.1                       | 6.2%  | 68.1% | 19.3% | 4.5%  | 2.0%  |
| 2.2                       | 5.0%  | 66.8% | 21.2% | 4.8%  | 2.1%  |
| 2.3                       | 4.0%  | 65.5% | 23.3% | 5.1%  | 2.2%  |
| 2.4                       | 3.2%  | 64.0% | 25.4% | 5.1%  | 2.3%  |
| 2.5                       | 2.6%  | 62.5% | 26.5% | 6.1%  | 2.3%  |
| 2.6                       | 2.2%  | 61.0% | 27.5% | 7.1%  | 2.3%  |
| 2.7                       | 1.9%  | 59.5% | 27.2% | 8.1%  | 3.3%  |
| 2.8                       | 1.7%  | 58.2% | 26.8% | 9.1%  | 4.3%  |
| 2.9                       | 1.5%  | 57.0% | 26.2% | 10.1% | 5.3%  |
| 3                         | 1.3%  | 56.0% | 25.4% | 11.1% | 6.3%  |
| 3.1                       | 1.1%  | 55.2% | 24.3% | 12.1% | 7.3%  |
| 3.2                       | 0.9%  | 54.8% | 22.9% | 13.1% | 8.3%  |
| 3.3                       | 0.7%  | 54.7% | 21.2% | 14.1% | 9.3%  |
| 3.4                       | 0.5%  | 55.0% | 19.2% | 15.1% | 10.3% |
| 3.5                       | 0.3%  | 55.7% | 16.6% | 16.1% | 11.3% |

Figure 3.3.1.2: One-Person Household Vehicle Ownership Sub-model

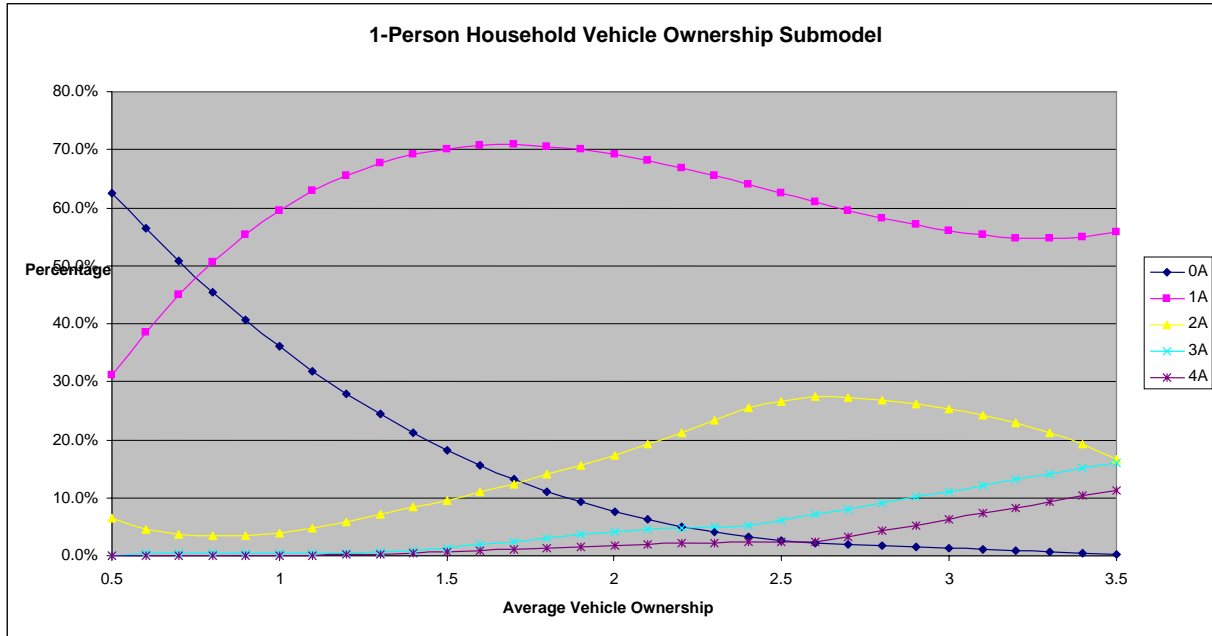


Figure 3.3.1.3: Two-Person Household Vehicle Ownership Sub-model

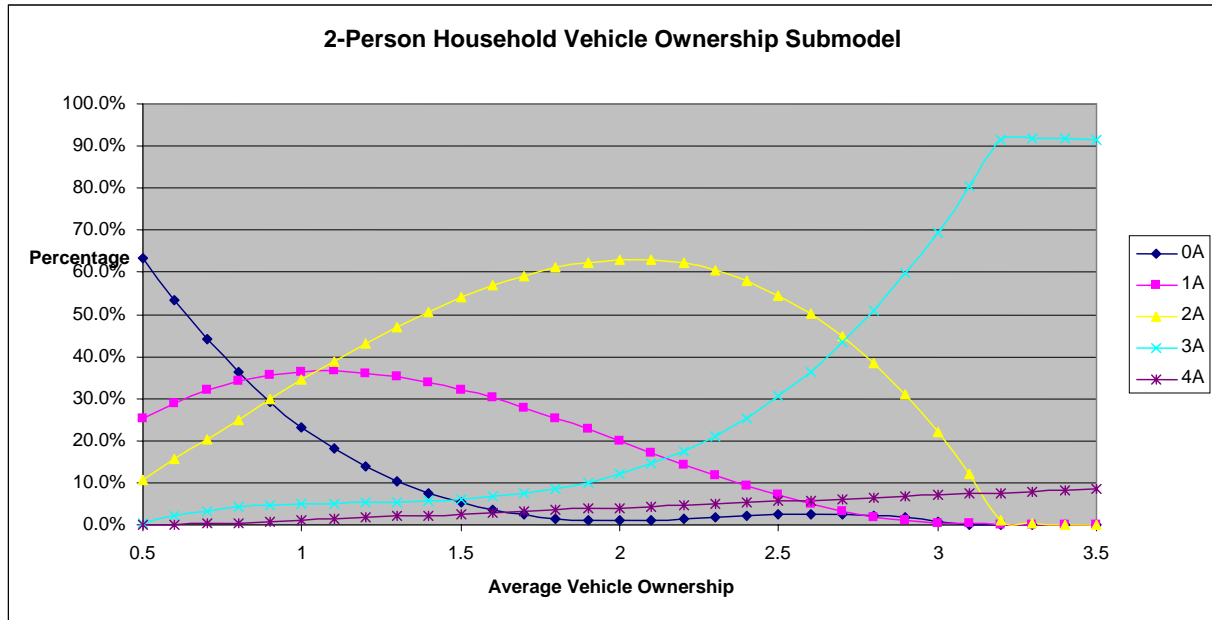


Figure 3.3.1.4: Three-Person Household Vehicle Ownership Sub-model

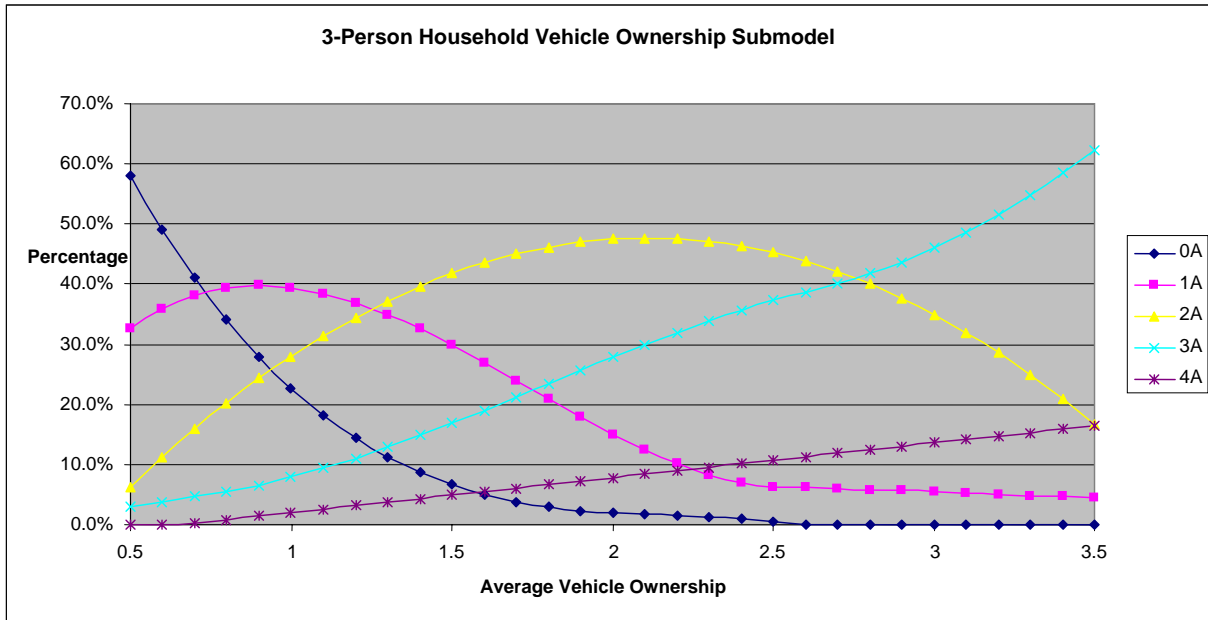
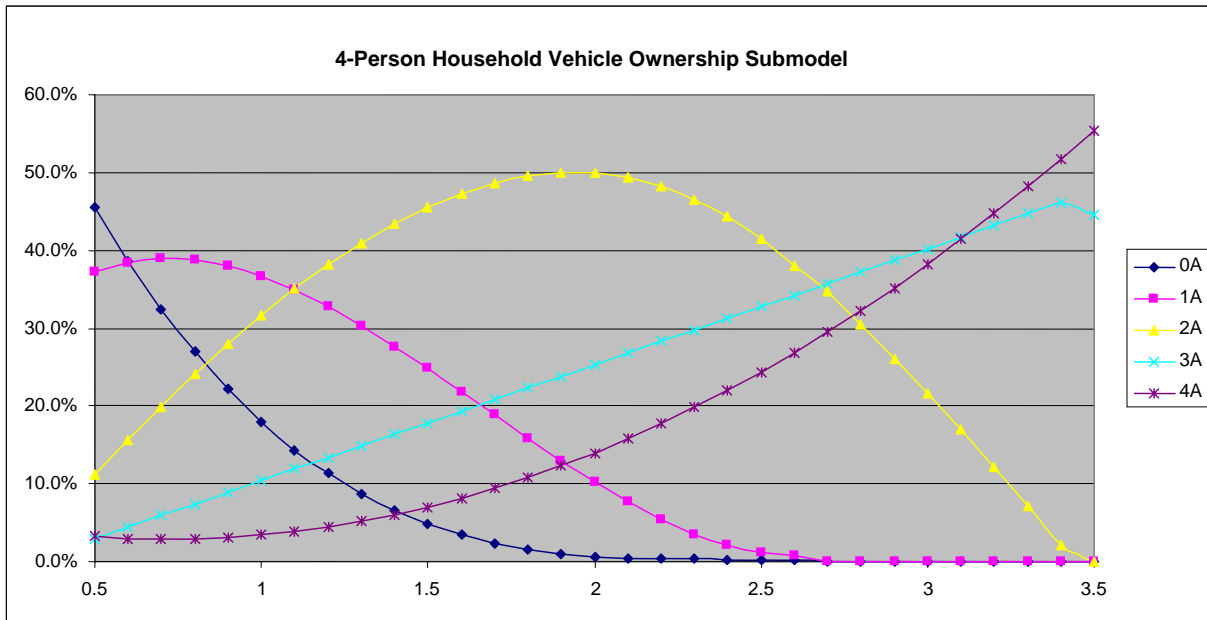


Figure 3.3.1.5: Four-Person Household Vehicle Ownership Sub-model



### 3.4 Area Type

Area types are used to represent how various development characteristics affect the transportation network, including highway network speed and capacity. Highway links are assigned an area type based on the TAZ where the link is located. This process facilitates the modification of link speed and capacities in future networks as development conditions change over time.

Population and employment densities are calculated using a “floating zone” process. Each TAZ’s “floating zone” density are estimated by adding the population and total employment for all zones whose Centroid are located within a one-half mile buffer or the TAZ boundary, and then dividing by the cumulative area for all the zones. Demographic data for 2006 served as the source for developing area type definitions.

Seven area types are used, with the area types approximating the following development patterns:

1. High Density Urban(Central Business District- CBD)
2. Dense Urban
3. Urban
4. Suburban Business
5. Suburban Residential
6. Exurban
7. Rural

Table 3.4.1: Nashville Area Type Definition

| Population density<br>(Per Acre) |      | Employment Density ( Per Acre) |      |      |      |      |      |       |       |
|----------------------------------|------|--------------------------------|------|------|------|------|------|-------|-------|
| Low                              | High | Low                            | 0.00 | 0.01 | 0.31 | 2.00 | 6.76 | 9.43  | 25.17 |
|                                  |      | High                           | 0.01 | 0.31 | 2.00 | 6.76 | 9.43 | 25.17 | -     |
| 0.00                             | 0.05 |                                | 7    | 7    | 6    | 4    | 3    | 3     | 1     |
| 0.05                             | 0.22 |                                | 7    | 6    | 6    | 4    | 3    | 3     | 1     |
| 0.22                             | 0.59 |                                | 6    | 6    | 5    | 4    | 3    | 2     | 1     |
| 0.59                             | 0.83 |                                | 6    | 6    | 5    | 4    | 3    | 2     | 1     |
| 0.83                             | 3.73 |                                | 5    | 5    | 5    | 4    | 3    | 2     | 1     |
| 3.73                             | 5.57 |                                | 5    | 5    | 4    | 3    | 3    | 2     | 1     |
| 5.57                             |      |                                | 5    | 5    | 4    | 3    | 2    | 2     | 1     |

## 4.0 Trip Generation and Trip Distribution

### 4.1 Trip Generation

Few minor changes were made to the trip generation rates in this model. They are

- Adding trip generation for dormitory
- Minor adjustments for trip generation rates.

There are 3 different trip purposes: Home-Based Work (HBW), Home-Based Other (HBO), and Non-Home Based (NHB). The trip rates are listed in the following tables, some minor adjustments were made during the calibration process.

Trip attraction for I-E and Truck trips were removed, because trucks are modeled separately and there is no satellite station or special generator in the network anymore.

Table 4.1.1: Trip Rates by Household Size and Vehicles Available - Production

| <b>HBW Trip Production Rate</b> |                |      |      |      |
|---------------------------------|----------------|------|------|------|
| Vehicle Available               | Household Size |      |      |      |
|                                 | 1              | 2    | 3    | 4+   |
| 0                               | 0.29           | 0.75 | 0.75 | 1.00 |
| 1                               | 1.00           | 1.18 | 1.50 | 1.75 |
| 2                               | 1.40           | 1.93 | 2.05 | 2.20 |
| 3+                              | 1.40           | 1.93 | 3.00 | 3.00 |
| <b>HBO Trip Production Rate</b> |                |      |      |      |
| Vehicle Available               | Household Size |      |      |      |
|                                 | 1              | 2    | 3    | 4+   |
| 0                               | 1.00           | 1.50 | 4.50 | 5.90 |
| 1                               | 1.95           | 2.50 | 4.65 | 7.00 |
| 2                               | 2.10           | 2.85 | 4.75 | 8.30 |
| 3+                              | 2.10           | 3.00 | 5.00 | 8.50 |
| <b>NHB Trip Production Rate</b> |                |      |      |      |
| Vehicle Available               | Household Size |      |      |      |
|                                 | 1              | 2    | 3    | 4+   |
| 0                               | 0.40           | 0.60 | 0.90 | 1.50 |
| 1                               | 1.50           | 2.20 | 3.00 | 3.40 |
| 2                               | 1.60           | 2.35 | 3.40 | 5.00 |
| 3+                              | 1.60           | 2.50 | 3.40 | 5.10 |

Table 4.1.2: Trip Attraction Rate

| Trip Purpose | HH    | Retail Emp. | Non-Retail Emp. | Total Emp. |
|--------------|-------|-------------|-----------------|------------|
| <b>HBW</b>   |       | 1.616       | 0.738           |            |
| <b>HBO</b>   | 3.368 |             |                 | 0.677      |
| <b>NHB</b>   | 1.101 |             |                 | 0.800      |

### 4.2.1 Dormitory trip generation

There was no dormitory trip generation in the previous update, it was assumed that the trips generated from the dormitory was somewhat captured in HBO and NHB trip purpose. In this update, the production and attraction rates were borrowed from Knoxville Transportation Planning Organization (TPO).

Dormitory HBO Production = 1.29 \* Dormitory Population  
 Dormitory HBO Attraction = 0.68 \* Dormitory Population  
 Dormitory NHB Production = 0.93 \* Dormitory Population  
 Dormitory NHB Attraction = 0.18 \* Dormitory Population

### 4.2 Trip distribution

Trip Distribution was re-calibrated using 1998 Nashville Household Travel Survey (HHTS). The following data were used during the process:

- Geo-Coded location map for all the origins and destinations in the HHTS
- Number of trips and trip purposes from the HHTS

The gravity model was calibrated using:

- AM peak skim matrix for the HBW Trips
- Off-peak skim matrix for the HBO and the NHB trips.

For all trip purposes, the modeled average travel time, percentage intra-zonal trips, trip length curve were compared to the household travel survey during the calibration process.

### 4.2.1 Travel Impedance

A Travel Impedance matrix was created with:

- Terminal time, it is the time added to each trips to simulate the time spent walking to and from a traveler’s vehicle within a TAZ.
- Inter-zonal travel time, the time that simulates the time people travel within the same TAZ. It is estimated using the sixty percent of the average travel time from the TAZ to four closest zones.
- Congested travel time was calculated using AM peak period assignment results.

Table 4.2.1.1: Terminal Time in Minutes

| Area Type      | Urban Very High Density | Urban High Density/ Commercial | Urban High Density/ Residential | Suburban Commercial | Suburban Residential | Exurban | Rural |
|----------------|-------------------------|--------------------------------|---------------------------------|---------------------|----------------------|---------|-------|
| Production End | 2                       | 2                              | 2                               | 1                   | 1                    | 1       | 1     |
| Attraction End | 2                       | 2                              | 2                               | 1                   | 1                    | 1       | 1     |

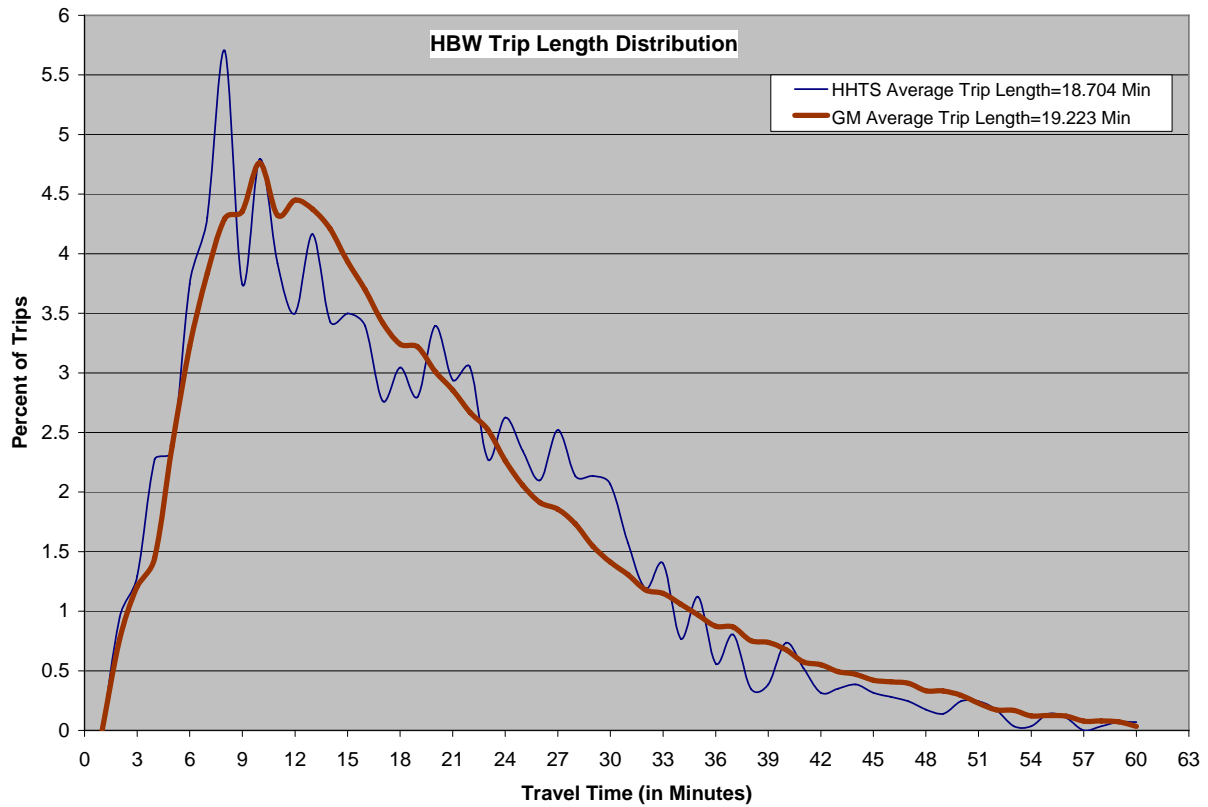
## 4.2.2 HBW Gravity Model

Data Source: AM period impedance matrix.

Calibration Criteria:

- Average travel time of observations and estimations should be within 3% .

Figure 4.2.2.1: HBW Trip Length Frequency Plot, +2.7% error



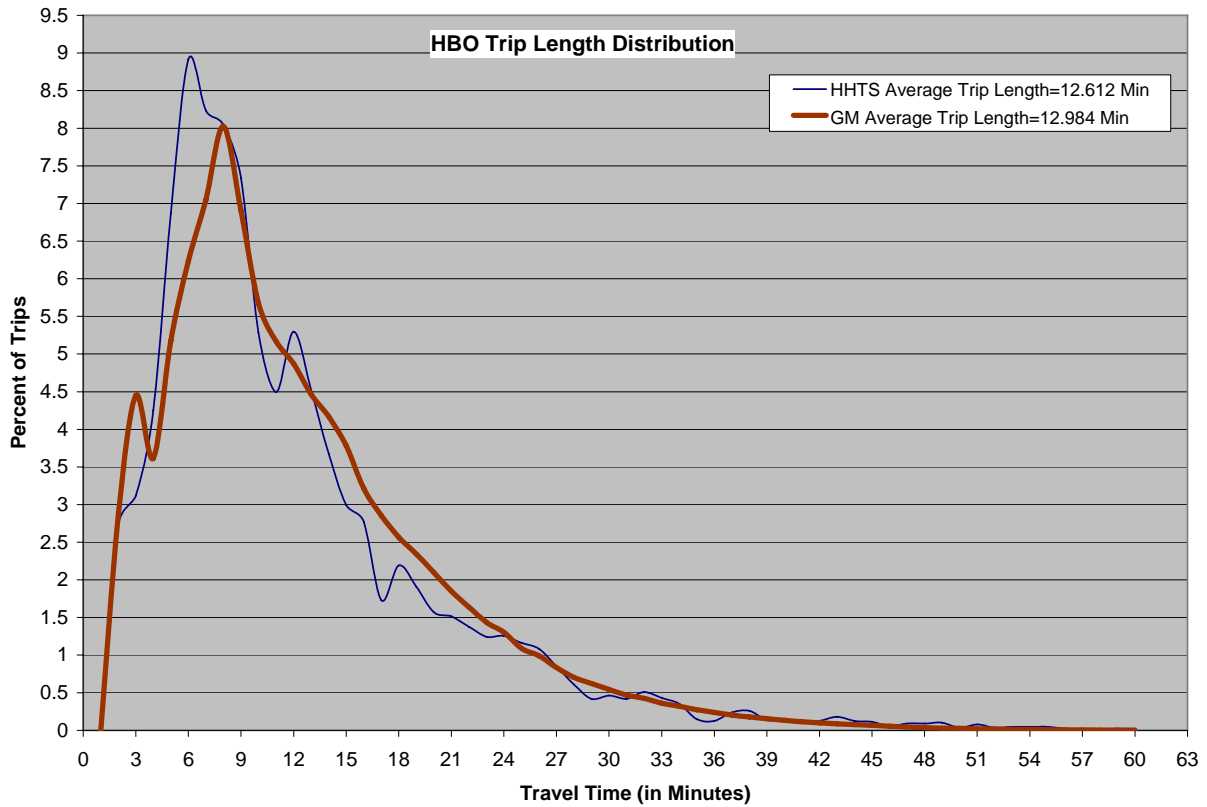
### 4.2.3 HBO Gravity Model

Data Source: Off-peak period impedance matrix.

Calibration Criteria:

- Average travel time of observations and estimations should be within 3% .

Figure 4.2.3.1: HBO Trip Length Frequency Plot, +2.9%



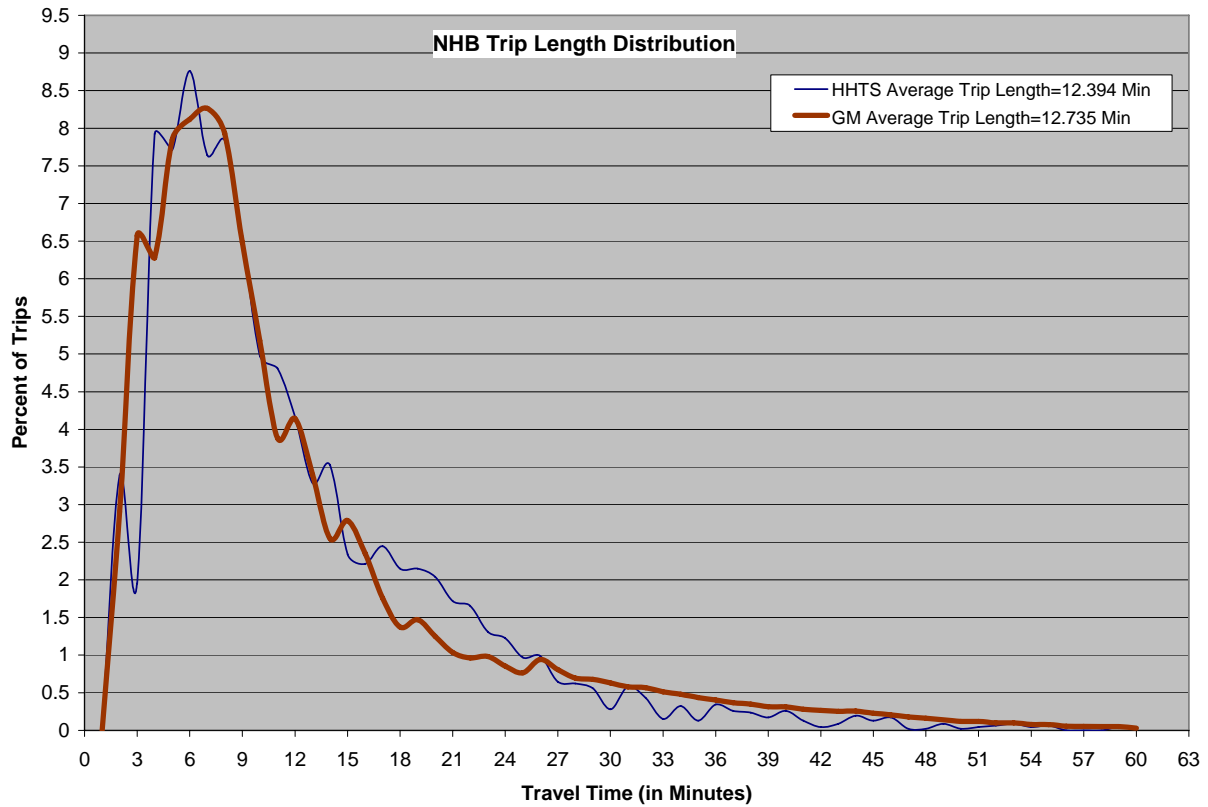
#### 4.2.4 NHB Gravity Model

Data Source: Off-peak period impedance matrix.

Calibration Criteria:

- Average travel time of observations and estimations should be within 3% .

Figure 4.2.4.1: NHB Trip Length Frequency Plot, +2.7%



## **5.0 Mode Split and Time-of-Day Factors**

### **5.1 Mode Split**

Mode Choice methodology was not changed. Assumptions from the previously updated model will still be used. However, integrating a mode choice model is planned for the next model update (LRTP 2040).

Auto Occupancy Rates are

- HBW – 1.16
- HBO – 1.62
- NHB – 1.41

### **5.2 Time of day**

Daily Vehicle trip tables from the trip distribution process were split into three time periods, before trips were assigned to the transportation network. The three time periods are:

1. AM Peak Period [5AM – 9AM]
2. PM Peak Period [3PM – 7PM]
3. Off-Peak Period(s) [All other Hours]

Figure 5.2.1: HBW TOD Trips (1997 Nashville Area MPO HHTS)

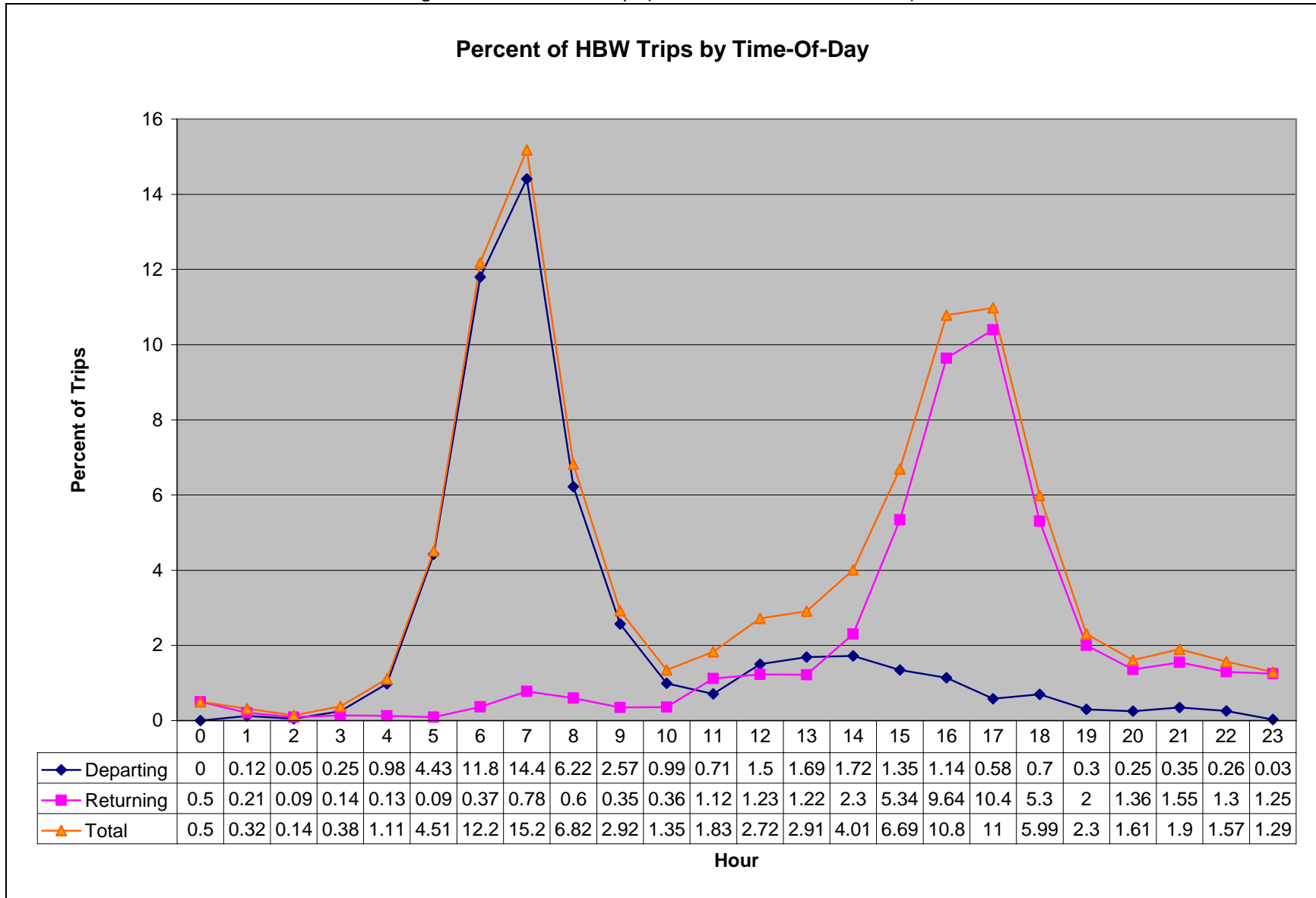


Figure 5.2.2: HBO TOD Trips (1997 Nashville Area MPO HHTS)

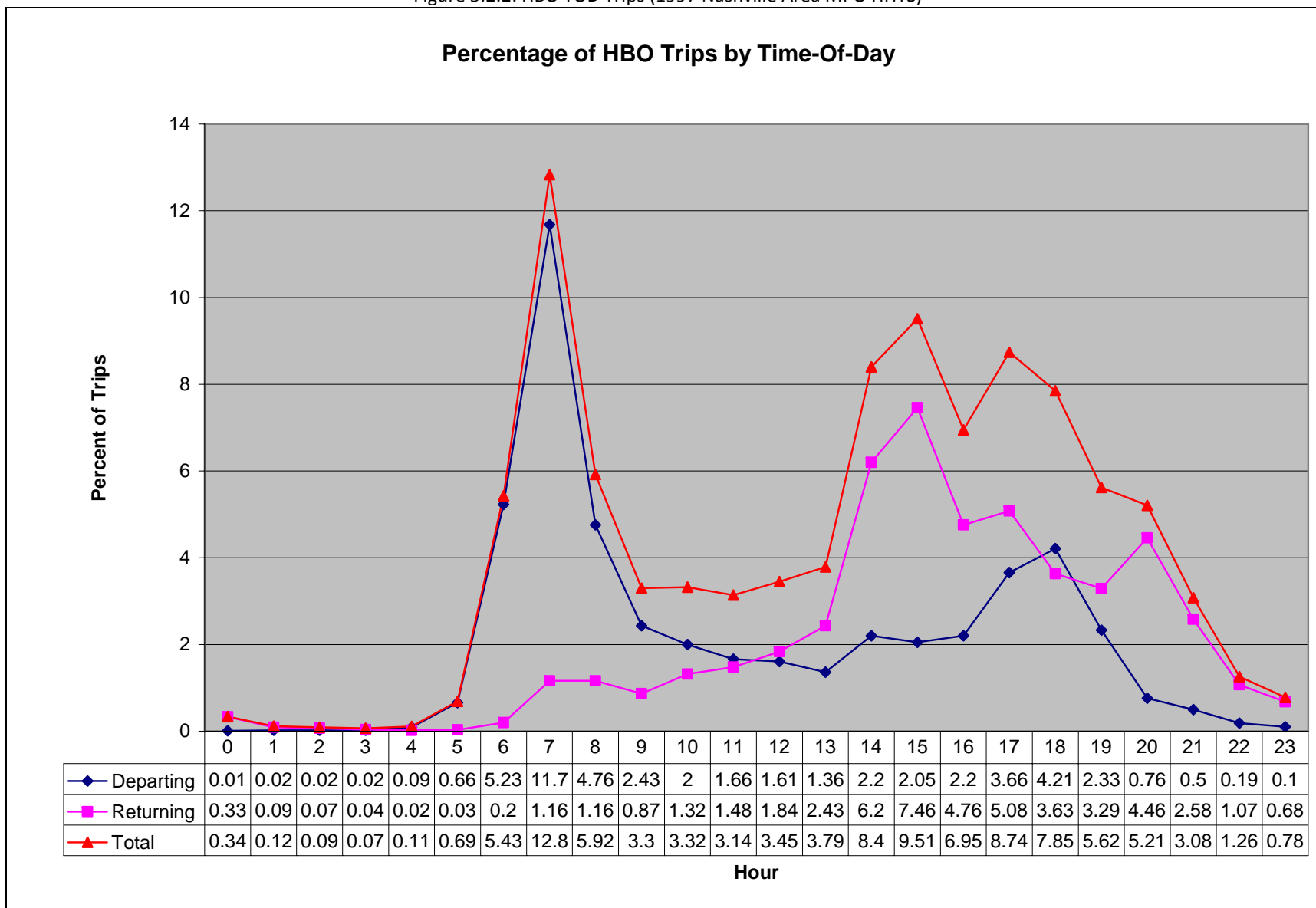


Figure 5.2.3: NHB TOD Trips (1997 Nashville Area MPO HHTS)

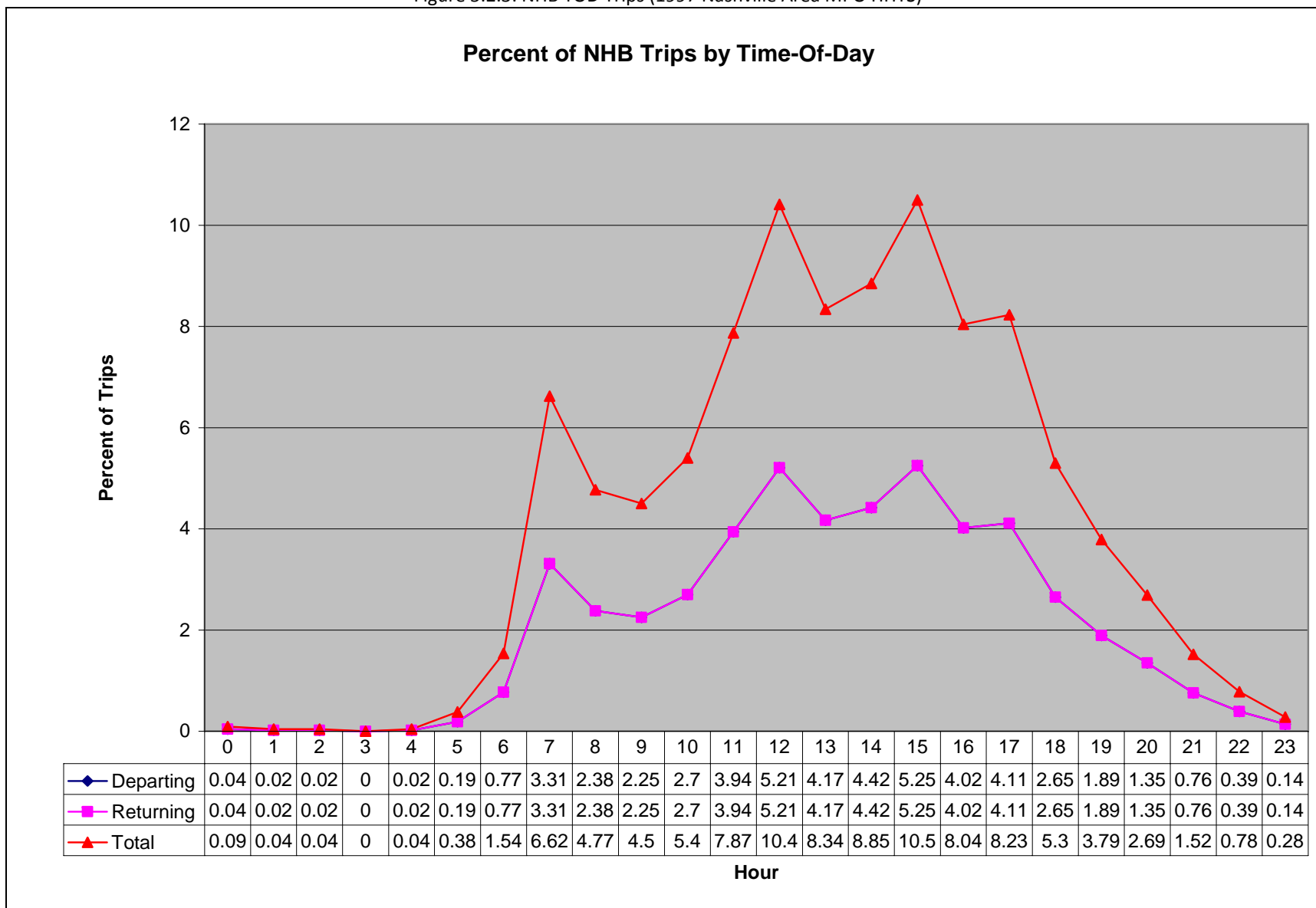
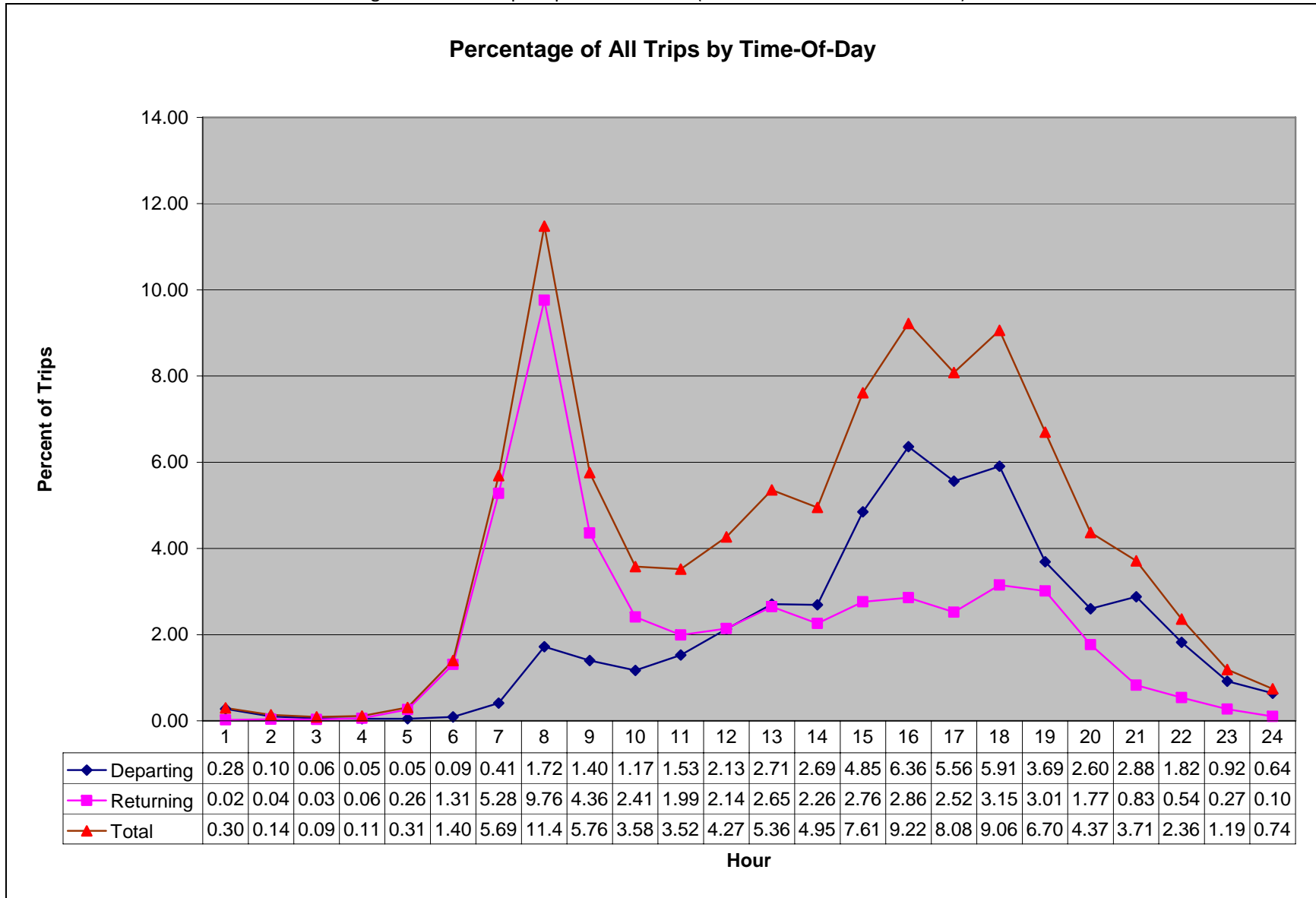


Figure 5.2.4: All Trip Purposes TOD Table (1997 Nashville Area MPO HHTS)



## 6.0 Traffic Assignment

### 6.1 Assumptions

- HOV lanes were treated as normal travel lanes due to insufficient data and high violation rate in the region.
- External to External Passenger Trips were pre-assigned and pre-loaded to the network.
- Free flow speed was updated. The result was compared to the posted speed and travel time study in order to ensure its accuracy. Refer to the table below for detail.

Table 6.1.1: Free Flow Speed for Different Area Types and Facility Types.

| Facility Type |                       | Area Type               |                                |                                 |                     |                      |         |       |
|---------------|-----------------------|-------------------------|--------------------------------|---------------------------------|---------------------|----------------------|---------|-------|
|               |                       | 1                       | 2                              | 3                               | 4                   | 5                    | 6       | 7     |
| Code          | Description           | Urban Very High Density | Urban High Density/ Commercial | Urban High Density/ Residential | Suburban Commercial | Suburban Residential | Exurban | Rural |
| 1             | Interstate            | 50                      | 55                             | 55                              | 60                  | 57                   | 65      | 70    |
| 2             | Freeway               | 50                      | 50                             | 50                              | 58                  | 55                   | 55      | 55    |
| 3             | Expressway            | 50                      | 50                             | 50                              | 50                  | 55                   | 60      | 60    |
| 4             | Collector-Distributor | 50                      | 50                             | 55                              | 55                  | 57                   | 60      | 60    |
| 6             | System-System Ramp    | 55                      | 55                             | 55                              | 55                  | 55                   | 55      | 55    |
| 7             | On-Ramp               | 45                      | 50                             | 50                              | 50                  | 50                   | 55      | 55    |
| 8             | Off-Ramp              | 22                      | 23                             | 30                              | 31                  | 34                   | 40      | 48    |
| 11            | Principal Arterial    | 29                      | 38                             | 42                              | 43                  | 47                   | 54      | 59    |
| 12            | Major Arterial        | 28                      | 35                             | 40                              | 42                  | 44                   | 45      | 40    |
| 13            | Minor Arterial        | 27                      | 33                             | 38                              | 41                  | 42                   | 44      | 39    |
| 21            | Collector-Distributor | 26                      | 32                             | 37                              | 36                  | 39                   | 32      | 32    |
| 31            | Local                 | 14                      | 14                             | 17                              | 18                  | 22                   | 28      | 28    |
| 99            | Centroid Connectors   | 14                      | 14                             | 17                              | 18                  | 22                   | 28      | 27    |

- Volume delay function parameters were based on the previous model. Refer to the table below for detail.

Table 6.1.2: Volume-Delay Function Parameters

| <b>Name</b>                      | <b>Area Type</b> | <b>Facility Type</b> | <b>Alpha</b> | <b>Beta</b> |
|----------------------------------|------------------|----------------------|--------------|-------------|
| <b>High Density Unsignalized</b> | 1-8              | 1-4                  | 0.84         | 4.0         |
| <b>High Density Signalized</b>   | 11-31            | 1-4                  | 0.84         | 5.5         |
| <b>Low Density Unsignalized</b>  | 1-8              | 5-7                  | 0.84         | 4.0         |
| <b>Low Density Signalized</b>    | 11-31            | 5-7                  | 0.84         | 5.5         |

## 6.2 Validation

The Validation guidelines are from

- Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee (F. Wegmann and J. Everett, University of Tennessee, 2003)
- Model Validation and Reasonableness Checking Manual (US Department of Transportation, 2001),
- NCHRP 365 Travel Estimation Techniques for Urban Planning (Transportation Research Board National Research Council, 1998).

The following tests were performed to ensure the model's performance is acceptable.

- **Volume**
  - Percent Volume Difference by Functional Classification

Table 6.2.1 Percent Volume Difference by Functional Classification

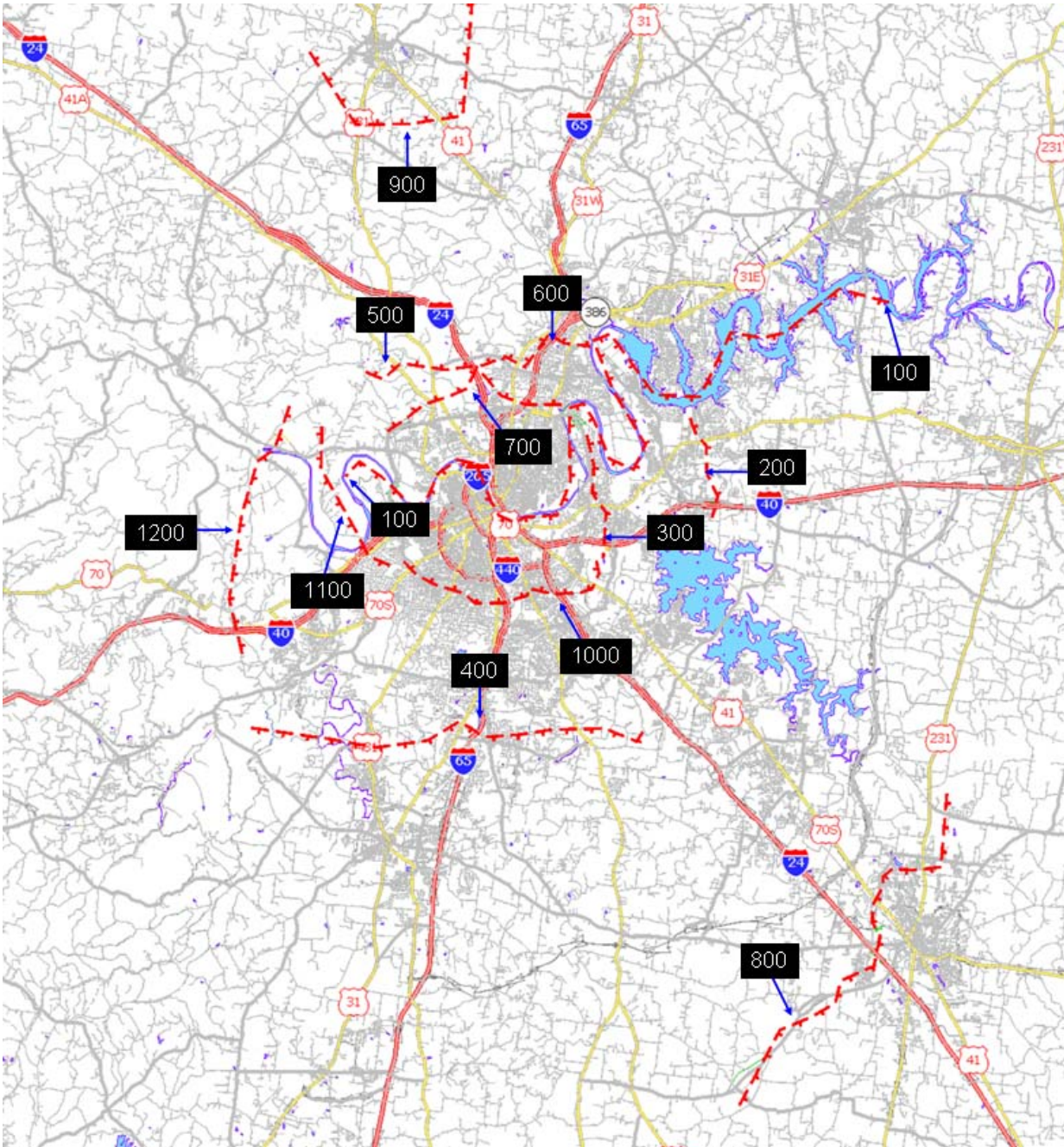
| % Difference Between Count & Volume |                       |                 |                |
|-------------------------------------|-----------------------|-----------------|----------------|
| Facility Type                       | Number of Observation | Nashville Model | Target Error % |
| Interstate/Freeway                  | 239                   | 2.39%           | ± 7%           |
| Principle Arterial                  | 305                   | 1.44%           | ± 10%          |
| Minor Arterial                      | 437                   | -2.52%          | ± 15%          |
| Collector                           | 692                   | -2.64%          | ± 25%          |

- o Screen Line analysis, all the screen lines have 10% target volume vs. count error, refer to the map in next page for the screen line locations

Table 6.2.2: Screen Line volume vs. count %

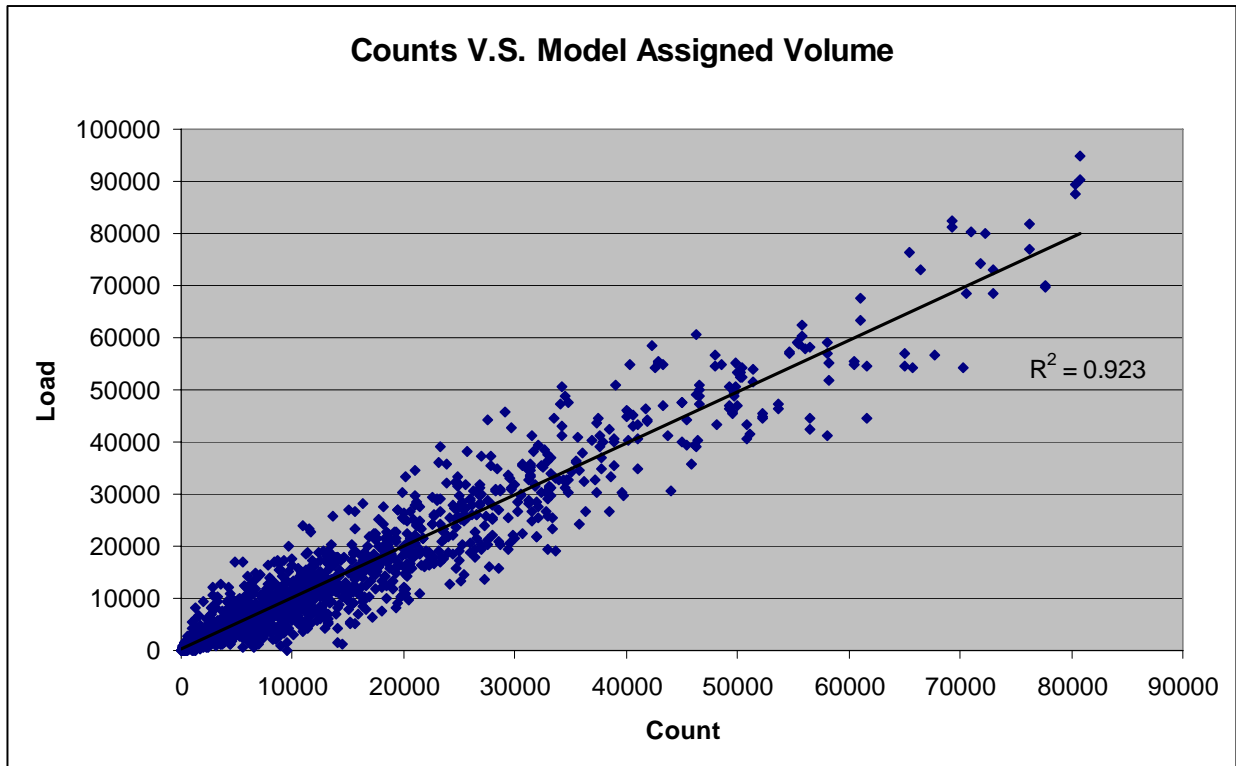
| <b>NO.</b> | <b>Screen Line Name</b>        | <b>% Volume/ Count difference</b> |
|------------|--------------------------------|-----------------------------------|
| 100        | Cumberland River               | 6.0%                              |
| 200        | E of Nashville (I-40 Corridor) | 7.1%                              |
| 300        | E of Nashville Outside SR155   | 3.1%                              |
| 400        | N of Franklin(I-65 Corridor)   | -8.2%                             |
| 500        | N of Nashville (I-24 Corridor) | 7.1%                              |
| 600        | N of Nashville (I-65 Corridor) | -8.2%                             |
| 700        | N of Nashville Outside SR155   | 8.3%                              |
| 800        | Northwest of Murfreesboro      | 1.6%                              |
| 900        | Roberson to Davison            | -0.7%                             |
| 1000       | S of Nashville Outside SR155   | 0.4%                              |
| 1100       | W of Nashville (I-40 Corridor) | 7.1%                              |
| 1200       | W of Nashville Outside SR155   | -2.5%                             |

Figure 6.2.1: Screen Line Locations



- Coefficient of Determination  $R^2$  has to be more than 0.88

Figure 6.2.2: Counts V.S. Model Assigned Volume



- **Root Mean Square Error Percentage (RMSE %)**

Table 6.2.3: RMSE for different volume groups

| Volume Range  | Model % RMSE | Maximum Desirable % RMSE |
|---------------|--------------|--------------------------|
| 0-4,999       | 78.57%       | 115.80%                  |
| 5000-9,999    | 41.88%       | 43.10%                   |
| 10,000-19,999 | 29.23%       | 28.30%                   |
| 20,000-39,999 | 20.88%       | 25.40%                   |
| 40,000-59,999 | 16.60%       | 30.30%                   |
| >60,000       | 11.79%       | 19.20%                   |
| Total         | 30.17%       | 30%                      |

- **Vehicle Mile Traveled (VMT)**

Table 6.2.4: Model VMT V.S. HPMS Target error Percent

**Table: VMT V.S. HPMS Target error %**

| Functional Class | Source | Davidson   | Roberson  | Rutherford | Sumner    | Williamson | Wilson    | Sum        | Error % | Target % |
|------------------|--------|------------|-----------|------------|-----------|------------|-----------|------------|---------|----------|
| Interstate       | Model  | 8,622,969  | 1,457,871 | 2,324,932  | 399,012   | 1,753,656  | 1,445,338 | 16,003,779 | 0.78%   | ±12%     |
|                  | HPMS   | 8,636,823  | 1,389,686 | 2,340,700  | 355,320   | 1,753,891  | 1,403,700 | 15,880,120 |         |          |
| Freeway          | Model  | 1,368,575  |           | 166,023    | 345,816   | 10,934     | 22,642    | 1,913,990  | 9.31%   | ±22%     |
|                  | HPMS   | 1,216,511  | 0         | 181,977    | 296,555   | 20,977     | 34,997    | 1,751,017  |         |          |
| Arterial         | Model  | 6,995,299  | 781,379   | 2,620,053  | 1,612,846 | 1,805,638  | 1,312,500 | 15,127,715 | -7.42%  | ±27%     |
|                  | HPMS   | 7,304,833  | 657,506   | 2,953,051  | 1,780,147 | 2,104,422  | 1,540,999 | 16,340,958 |         |          |
| Collector        | Model  | 976,306    | 286,074   | 759,723    | 632,329   | 675,050    | 471,843   | 3,801,324  | -8.53%  | ±33%     |
|                  | HPMS   | 1,073,693  | 329,788   | 814,078    | 656,290   | 739,029    | 542,751   | 4,155,629  |         |          |
| Sum              | Model  | 17,963,149 | 2,525,324 | 5,870,731  | 2,990,003 | 4,245,278  | 3,252,323 | 36,846,808 |         |          |
|                  | HPMS   | 18,231,860 | 2,376,980 | 6,289,806  | 3,088,312 | 4,618,319  | 3,522,447 | 38,127,724 | -3.36%  |          |

## 7.0 Model Application

### 7.1 What's New

- New Functions
  - Trip Generation is now built in the model interface
  - Trip Balancing is now built in the model interface
  - Added "Performance Measure" for calibration purpose
  - Added "Select Link Analysis" Option
  - Added "Air Pollution" section to calculate the inputs needed for Mobile 62
- Data input
  - SE data input field is removed, all the data in SE file is stored in the TAZ file instead.
  - New input field added for truck volume.
- Trucks
  - All the truck components were removed.
  - Reads Truck O/D Matrix and assign the trips in "Trip Generation" section
  - Assignment result is now coded in the network.
- User Interface
  - Changed the progress bar information. The progress bar now shows more accurate percentage, as well as the current procedure.
  - Added new error handler message, when any error occurs, the error message will pop up and show which part of the process went wrong.
- Others
  - Added Loop function to the repeated functions. This reduced a great number of script lines.
  - External to External Trips are passenger only trips. Truck trips were estimated in the truck model.
  - All the output and temporally files are stored in \output folder instead of the main model folder.
  - Default matrix Column and Row names were changed in TransCAD 5.0. The names were fixed in the script.

## Appendix A: Network Dictionary

| Name       | Type              | Description   |
|------------|-------------------|---|
| ID         | Integer (4 bytes) | ID number   |
| Length     | Real (8 bytes)    | Link Length (Mile)                                    |
| Dir        | Integer (2 bytes) | Direction, 0=Two-Way Roadway, 1 or -1, One Way        |
| DIR2006    | Integer (2 bytes) | Same As Above, 2006 Scenario                          |
| DIR2015E   | Integer (2 bytes) | Same As Above, 2015 E+C Scenario                      |
| DIR2015L   | Integer (2 bytes) | Same As Above, 2015 LRTP Scenario                     |
| DIR2025E   | Integer (2 bytes) | Same As Above, 2025 E+C Scenario                      |
| DIR2025L   | Integer (2 bytes) | Same As Above, 2025 LRTP Scenario                     |
| DIR2035E   | Integer (2 bytes) | Same As Above, 2035 E+C Scenario                      |
| DIR2035L   | Integer (2 bytes) | Same As Above, 2035 LRTP Scenario                     |
| NAME       | Character         | Link Name   |
| County     | Character         | County Number where the link is located               |
| HOV_FLAG   | Integer (2 bytes) | HOV Lane Flag, 1=Hov Lane                             |
| AreaType   | Integer (2 bytes) | Generalized Area Type from the Model                  |
| FTYPE      | Integer (2 bytes) | Facility Type   |
| FUNC_CLASS | Integer (2 bytes) | FHWA Functional Class                                 |
| FCL2006    | Integer (2 bytes) | Same As Above, 2006 Scenario                          |
| FCL2015E   | Integer (2 bytes) | Same As Above, 2015 E+C Scenario                      |
| FCL2015L   | Integer (2 bytes) | Same As Above, 2015 LRTP Scenario                     |
| FCL2025E   | Integer (2 bytes) | Same As Above, 2025 E+C Scenario                      |
| FCL2025L   | Integer (2 bytes) | Same As Above, 2025 LRTP Scenario                     |
| FCL2035E   | Integer (2 bytes) | Same As Above, 2035 E+C Scenario                      |
| FCL2035L   | Integer (2 bytes) | Same As Above, 2035 LRTP Scenario                     |
| LANES      | Integer (2 bytes) | Number of Lanes                                       |
| LAN2006    | Integer (2 bytes) | Same As Above, 2006 Scenario                          |
| LAN2015E   | Integer (2 bytes) | Same As Above, 2015 E+C Scenario                      |
| LAN2015L   | Integer (2 bytes) | Same As Above, 2015 LRTP Scenario                     |
| LAN2025E   | Integer (2 bytes) | Same As Above, 2025 E+C Scenario                      |
| LAN2025L   | Integer (2 bytes) | Same As Above, 2025 LRTP Scenario                     |
| LAN2035E   | Integer (2 bytes) | Same As Above, 2035 E+C Scenario                      |
| LAN2035L   | Integer (2 bytes) | Same As Above, 2035 LRTP Scenario                     |
| PAVEMENT W | Integer (2 bytes) | Pavement Width for all lanes                          |
| PAV2006    | Integer (2 bytes) | Same As Above, 2006 Scenario                          |
| PAV2015E   | Integer (2 bytes) | Same As Above, 2015 E+C Scenario                      |
| PAV2015L   | Integer (2 bytes) | Same As Above, 2015 LRTP Scenario                     |
| PAV2025E   | Integer (2 bytes) | Same As Above, 2025 E+C Scenario                      |
| PAV2025L   | Integer (2 bytes) | Same As Above, 2025 LRTP Scenario                     |
| PAV2035E   | Integer (2 bytes) | Same As Above, 2035 E+C Scenario                      |
| PAV2035L   | Integer (2 bytes) | Same As Above, 2035 LRTP Scenario                     |
| CTL_FLAG   | Integer (2 bytes) | Continuous Left Turn Lane Flag, 1=With Left turn Lane |
| CTL2006    | Integer (2 bytes) | Same As Above, 2006 Scenario                          |
| CTL2015E   | Integer (2 bytes) | Same As Above, 2015 E+C Scenario                      |
| CTL2015L   | Integer (2 bytes) | Same As Above, 2015 LRTP Scenario                     |
| CTL2025E   | Integer (2 bytes) | Same As Above, 2025 E+C Scenario                      |

| Name          | Type              | Description   |
|---------------|-------------------|---|
| CTL2025L      | Integer (2 bytes) | Same As Above, 2025 LRTP Scenario                   |
| CTL2035E      | Integer (2 bytes) | Same As Above, 2035 E+C Scenario                    |
| CTL2035L      | Integer (2 bytes) | Same As Above, 2035 LRTP Scenario                   |
| LinkID        | Integer (4 bytes) | Link ID, for internal use                           |
| CBD           | Real (8 bytes)    | Distance to CBD, for internal Use                   |
| DIVIDED       | Integer (2 bytes) | Dividing Factor, for Internal use                   |
| CONTFAC       | Real (4 bytes)    | Count Factor, for Internal use                      |
| TDOT STA      | Character         | TDOT Station Number                                 |
| DAILY_FLOW    | Integer (4 bytes) | Daily Flow for the Link                             |
| 2006_ADT      | Integer (4 bytes) | 2006 AADT form the Count Station                    |
| 2006_PASS_ADT | Real (8 bytes)    | 2006 Passenger Count                                |
| 2006_COM_ADT  | Real (8 bytes)    | 2006 Commercial Vehicle Count                       |
| 2006_SU_ADT   | Real (8 bytes)    | 2006 Single Unit Truck Count                        |
| 2006_MU_ADT   | Real (8 bytes)    | 2006 Multi-unit Truck Count                         |
| TIP_N         | Character         | TIP Project Number                                  |
| E_C           | Character         | Existing or Committed Project                       |
| S.R.          | Integer (4 bytes) | State Route Number 1                                |
| S.R.2         | Integer (4 bytes) | State Route Number 2                                |
| U.S._1        | Character         | U.S. Route Number 1                                 |
| U.S._2        | Character         | U.S. Route Number 2                                 |
| U.S._3        | Character         | U.S. Route Number 3                                 |
| U.S._4        | Character         | U.S. Route Number 4                                 |
| SPEED_LMT     | Integer (4 bytes) | Speed Limit   |
| CLSS_C_ID     | Integer (4 bytes) | Class Count Station ID                              |
| CLSS_C_YR     | Integer (4 bytes) | Class Count Station year                            |
| VHCL_P_COM    | Real (4 bytes)    | 2006 Passenger Percent                              |
| VHCL_P_PAS    | Real (4 bytes)    | 2006 Commercial Vehicle Percent                     |
| VHCL_PASS     | Real (4 bytes)    | 2006 4-Wheel Vehicle Percent(VHCL_P_PAS+VHCL_P_COM) |
| VHCL_SU_TR    | Real (4 bytes)    | 2006 Single Unit Truck Percent                      |
| VHCL_MU_TR    | Real (4 bytes)    | 2006 Multi-unit Truck Percent                       |
| CCSTYLE       | Integer (4 bytes) | CCSTYLE, Internal Use                               |
| Add / Remove  | Integer (4 bytes) | Add/Remove Flag, Internal Use                       |
| PROHIBITION   | Integer (2 bytes) | PROHIBITION Flag                                    |
| SPEED         | Real (8 bytes)    | Free Flow Speed                                     |
| Capacity      | Real (8 bytes)    | Hourly Capacity                                     |
| Alpha         | Real (8 bytes)    | Alpha for Volume/Delay Function                     |
| Beta          | Real (8 bytes)    | Beta For Volume/Delay Function                      |
| Time          | Real (8 bytes)    | Free Flow Travel Time                               |
| TimeOP        | Real (8 bytes)    | Off Peak Travel Time                                |
| CapAM_AB      | Real (8 bytes)    | Time of Day Directional Capacity                    |
| CapAM_BA      | Real (8 bytes)    | Time of Day Directional Capacity                    |
| CapMD_AB      | Real (8 bytes)    | Time of Day Directional Capacity                    |
| CapMD_BA      | Real (8 bytes)    | Time of Day Directional Capacity                    |
| CapPM_AB      | Real (8 bytes)    | Time of Day Directional Capacity                    |
| CapPM_BA      | Real (8 bytes)    | Time of Day Directional Capacity                    |
| CapOP_AB      | Real (8 bytes)    | Time of Day Directional Capacity                    |
| CapOP_BA      | Real (8 bytes)    | Time of Day Directional Capacity                    |

| Name        | Type              | Description   |
|-------------|-------------------|---|
| AMFlow_AB   | Integer (4 bytes) | Time of Day Directional Traffic Flow                  |
| AMFlow_BA   | Integer (4 bytes) | Time of Day Directional Traffic Flow                  |
| MDFlow_AB   | Integer (4 bytes) | Time of Day Directional Traffic Flow                  |
| MDFlow_BA   | Integer (4 bytes) | Time of Day Directional Traffic Flow                  |
| PMFlow_AB   | Integer (4 bytes) | Time of Day Directional Traffic Flow                  |
| PMFlow_BA   | Integer (4 bytes) | Time of Day Directional Traffic Flow                  |
| OPFlow_AB   | Integer (4 bytes) | Time of Day Directional Traffic Flow                  |
| OPFlow_BA   | Integer (4 bytes) | Time of Day Directional Traffic Flow                  |
| AMFlow_Tot  | Integer (4 bytes) | Time of Day Total Traffic Flow                        |
| MDFlow_Tot  | Integer (4 bytes) | Time of Day Total Traffic Flow                        |
| PMFlow_Tot  | Integer (4 bytes) | Time of Day Total Traffic Flow                        |
| OPFlow_Tot  | Integer (4 bytes) | Time of Day Total Traffic Flow                        |
| AMSpeed_AB  | Real (8 bytes)    | Time of Day Directional Travel Speed                  |
| AMSpeed_BA  | Real (8 bytes)    | Time of Day Directional Travel Speed                  |
| MDSpeed_AB  | Real (8 bytes)    | Time of Day Directional Travel Speed                  |
| MDSpeed_BA  | Real (8 bytes)    | Time of Day Directional Travel Speed                  |
| PMSpeed_AB  | Real (8 bytes)    | Time of Day Directional Travel Speed                  |
| PMSpeed_BA  | Real (8 bytes)    | Time of Day Directional Travel Speed                  |
| OPSpeed_AB  | Real (8 bytes)    | Time of Day Directional Travel Speed                  |
| OPSpeed_BA  | Real (8 bytes)    | Time of Day Directional Travel Speed                  |
| AM_VMT      | Integer (4 bytes) | Time of Day Vehicle Mile Traveled                     |
| MD_VMT      | Integer (4 bytes) | Time of Day Vehicle Mile Traveled                     |
| PM_VMT      | Integer (4 bytes) | Time of Day Vehicle Mile Traveled                     |
| OP_VMT      | Integer (4 bytes) | Time of Day Vehicle Mile Traveled                     |
| DAILY_VMT   | Integer (4 bytes) | Daily Vehicle Mile Traveled                           |
| TRKAM_AB    | Real (4 bytes)    | Truck Time of Day Total Traffic Flow                  |
| TRKAM_BA    | Real (4 bytes)    | Truck Time of Day Total Traffic Flow                  |
| TRKMD_AB    | Real (4 bytes)    | Truck Time of Day Total Traffic Flow                  |
| TRKMD_BA    | Real (4 bytes)    | Truck Time of Day Total Traffic Flow                  |
| TRKPM_AB    | Real (4 bytes)    | Truck Time of Day Total Traffic Flow                  |
| TRKPM_BA    | Real (4 bytes)    | Truck Time of Day Total Traffic Flow                  |
| TRKOP_AB    | Real (4 bytes)    | Truck Time of Day Total Traffic Flow                  |
| TRKOP_BA    | Real (4 bytes)    | Truck Time of Day Total Traffic Flow                  |
| TOTFLOW     | Real (4 bytes)    | TOTAL Truck Flow                                      |
| Pass_PER    | Real (4 bytes)    | Passenger Vehicle Percentage, Internal Use            |
| PASS_Count  | Real (4 bytes)    | Passenger Vehicle Count, Internal Use                 |
| PASS_Load   | Real (4 bytes)    | Passenger Vehicle Load, Internal Use                  |
| PRELOADAMAB | Real (4 bytes)    | Truck and External Trips Preload Volume, Internal Use |
| PRELOADAMBA | Real (4 bytes)    | Truck and External Trips Preload Volume, Internal Use |
| PRELOADMDAB | Real (4 bytes)    | Truck and External Trips Preload Volume, Internal Use |
| PRELOADMDBA | Real (4 bytes)    | Truck and External Trips Preload Volume, Internal Use |
| PRELOADOPAB | Real (4 bytes)    | Truck and External Trips Preload Volume, Internal Use |
| PRELOADOPBA | Real (4 bytes)    | Truck and External Trips Preload Volume, Internal Use |
| PRELOADPMAB | Real (4 bytes)    | Truck and External Trips Preload Volume, Internal Use |
| PRELOADPMBA | Real (4 bytes)    | Truck and External Trips Preload Volume, Internal Use |
| PRELOADTOT  | Real (4 bytes)    | Truck and External Trips Preload Volume, Internal Use |
| TRK_DIS     | Integer (4 bytes) | Truck Prohibited Link Flag, 1= Prohibited             |

## Appendix B: Network Node Dictionary

| <b>NAME</b>             | <b>Attribute</b>  | <b>Description</b>                         |
|-------------------------|-------------------|--|
| <b>STANUM</b>           | Character         | TDOT Count Station Number                  |
| <b>CCSTYLE</b>          | Integer (4 bytes) | 99= Centroid 98=External Stations          |
| <b>ExtCount</b>         | Integer (4 bytes) | Traffic Count                              |
| <b>EEPct</b>            | Real (8 bytes)    | <b>Passenger Vehicle</b> EE percentage     |
| <b>County</b>           | Character         | County Name                                |
| <b>EEProds</b>          | Integer (4 bytes) | EE Production                              |
| <b>EEAttr</b>           | Integer (4 bytes) | EE Attraction                              |
| <b>IEProds</b>          | Integer (4 bytes) | IE or EI Production                        |
| <b>IEAttrUnbalanced</b> | Integer (4 bytes) | Special Generator(Not used in this update) |
| <b>PASS_PER</b>         | Real (8 bytes)    | Passenger Vehicle Percentage               |
| <b>Name</b>             | Character         | Route Name (if any)                        |

## Appendix C: TAZ Dictionary

| Name                        | Attribute         | Description                                    |
|-----------------------------|-------------------|--|
| <b>ID</b>                   | Integer (4 bytes) | TAZ ID   |
| <b>Area</b>                 | Real (8 bytes)    | TAZ Area                                       |
| <b>CountyID</b>             | Character         | County ID                                      |
| <b>BlkGrp</b>               | Character         | Census Block Group Number                      |
| <b>Tract</b>                | Character         | Census Tract Number                            |
| <b>HH</b>                   | Real (8 bytes)    | Number of Household                            |
| <b>AUTO</b>                 | Real (8 bytes)    | Number of Auto                                 |
| <b>TotPop</b>               | Real (8 bytes)    | Number of Population                           |
| <b>TotEmp</b>               | Real (8 bytes)    | Number of Employee                             |
| <b>Retail_Employment</b>    | Real (8 bytes)    | Number of Retail Employee                      |
| <b>NonRetail_Employment</b> | Real (8 bytes)    | Number of Non-Retail Employee                  |
| <b>1P-0A</b>                | Real (8 bytes)    | Number of Household With x persons and y autos |
| <b>1P-1A</b>                | Real (8 bytes)    | Number of Household With x persons and y autos |
| <b>1P-2A</b>                | Real (8 bytes)    | Number of Household With x persons and y autos |
| <b>1P-3A</b>                | Real (8 bytes)    | Number of Household With x persons and y autos |
| <b>1P-4A</b>                | Real (8 bytes)    | Number of Household With x persons and y autos |
| <b>2P-0A</b>                | Real (8 bytes)    | Number of Household With x persons and y autos |
| <b>2P-1A</b>                | Real (8 bytes)    | Number of Household With x persons and y autos |
| <b>2P-2A</b>                | Real (8 bytes)    | Number of Household With x persons and y autos |
| <b>2P-3A</b>                | Real (8 bytes)    | Number of Household With x persons and y autos |
| <b>2P-4A</b>                | Real (8 bytes)    | Number of Household With x persons and y autos |
| <b>3P-0A</b>                | Real (8 bytes)    | Number of Household With x persons and y autos |
| <b>3P-1A</b>                | Real (8 bytes)    | Number of Household With x persons and y autos |
| <b>3P-2A</b>                | Real (8 bytes)    | Number of Household With x persons and y autos |
| <b>3P-3A</b>                | Real (8 bytes)    | Number of Household With x persons and y autos |
| <b>3P-4A</b>                | Real (8 bytes)    | Number of Household With x persons and y autos |
| <b>4P-0A</b>                | Real (8 bytes)    | Number of Household With x persons and y autos |
| <b>4P-1A</b>                | Real (8 bytes)    | Number of Household With x persons and y autos |
| <b>4P-2A</b>                | Real (8 bytes)    | Number of Household With x persons and y autos |
| <b>4P-3A</b>                | Real (8 bytes)    | Number of Household With x persons and y autos |
| <b>4P-4A</b>                | Real (8 bytes)    | Number of Household With x persons and y autos |
| <b>HBWP</b>                 | Real (8 bytes)    | Number of HBW trips produced by the TAZ        |
| <b>HBWA</b>                 | Real (8 bytes)    | Number of HBW trips attracted by the TAZ       |
| <b>HBOP</b>                 | Real (8 bytes)    | Number of HBO trips produced by the TAZ        |
| <b>HBOA</b>                 | Real (8 bytes)    | Number of HBO trips attracted by the TAZ       |
| <b>NHBP</b>                 | Real (8 bytes)    | Number of NHB trips produced by the TAZ        |
| <b>NHBA</b>                 | Real (8 bytes)    | Number of NHB trips attracted by the TAZ       |
| <b>IEA</b>                  | Real (8 bytes)    | EI Attraction Trips                            |
| <b>ccstyle</b>              | Integer (4 bytes) | TAZ map Style                                  |
| <b>BlkGrp_n</b>             | Character         | Block Group                                    |
| <b>tag</b>                  | Real (8 bytes)    | Distance to CBD                                |
| <b>POPoHH_S</b>             | Real (4 bytes)    | Single Family persons/HH from Census           |
| <b>POPoHH_M</b>             | Real (4 bytes)    | Multi Family persons/HH from Census            |
| <b>Vacant_S</b>             | Real (4 bytes)    | Single Family Household Vacant Percent         |

|                    |                   |  |
|--------------------|-------------------|--|
| <b>Vacant_M</b>    | Real (4 bytes)    | Multi Family Household Vacant Percent                      |
| <b>ALLpop</b>      | Real (4 bytes)    | All Household Persons/HH from Census                       |
| <b>ALLvac</b>      | Real (4 bytes)    | All Household Vacant Rate from Census                      |
| <b>HH_S</b>        | Real (4 bytes)    | Number of Single Family Household                          |
| <b>HH_M</b>        | Real (4 bytes)    | Number of Multi Family Household                           |
| <b>UnweightPop</b> | Real (4 bytes)    | Estimated Population before applying the control total     |
| <b>Acres</b>       | Real (4 bytes)    | Area in Acre   |
| <b>PopDensity</b>  | Real (4 bytes)    | TAZ population Density                                     |
| <b>EmpDensity</b>  | Real (4 bytes)    | TAZ employment Density                                     |
| <b>AreaType</b>    | Integer (2 bytes) | Area type based on Float Population and Employment Density |
| <b>FloatAcres</b>  | Real (4 bytes)    | Sum of population of this TAZ and 4 adjacent zones         |
| <b>FloatPop</b>    | Real (4 bytes)    | Sum of area of this TAZ and 4 adjacent zones               |
| <b>FloatEmp</b>    | Real (4 bytes)    | Sum of employment of this TAZ and 4 adjacent zones         |
| <b>02pop</b>       | Integer (4 bytes) | 2002 Population  |
| <b>02emp</b>       | Integer (4 bytes) | 2002 total employment                                      |
| <b>EMP_FARM</b>    | Real (4 bytes)    | Number of Employee in Farming                              |
| <b>EMP_MINE</b>    | Real (4 bytes)    | Number of Employee in Mining                               |
| <b>EMP_CONT</b>    | Real (4 bytes)    | Number of Employee in Construction                         |
| <b>EMP_MANU</b>    | Real (4 bytes)    | Number of Employee in Manufacture                          |
| <b>EMP_TRAN</b>    | Real (4 bytes)    | Number of Employee in Transportation                       |
| <b>EMP_WHOL</b>    | Real (4 bytes)    | Number of Employee in Whole Sale                           |
| <b>EMP_RETL</b>    | Real (4 bytes)    | Number of Employee in Retail                               |
| <b>EMP_FIRE</b>    | Real (4 bytes)    | Number of Employee in Financial Services                   |
| <b>EMP_SRVC</b>    | Real (4 bytes)    | Number of Employee in Service                              |
| <b>EMP_GOV</b>     | Real (4 bytes)    | Number of Employee in Government                           |

## Appendix D: Model Structure

### Initialization

#### Update Facility Type

Update the network facility type using link's function class and pavement width.  
TYPE filed is used to calculate the roadway capacity.

#### Update Area Type

Update the network area type using TAZ's float business and population density.

#### Update Speed and Capacity

Generalized Speed and Capacity

#### Update TOD Capacity

Add Fields for External Station Calculation

Trip Generation and Balance

### Create Network

Create Network

### Feedback Loop

Skimming

IE-TT

HBW Trip Distribution

HBO Trip Distribution

NHB Trip Distribution

TOD Trip Distribution

OP Assignment

New Network

AM Assignment

PM Assignment

### Model Result

Model Result

Performance Result

Trip Length Distribution