# Technical Memorandum 3
# Travel Demand Model Process

INTERSTATE 24 TDOT CORRIDOR STUDY

March 2013

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# Travel Demand Model Process

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# 1.0 Introduction

## 1.1 Corridor Location and Overview

The purpose of the I-24 Multimodal Corridor Study is to examine potential multimodal transportation improvements that would address existing and emerging transportation system issues associated with this strategic corridor through central Tennessee connecting the Clarksville, Nashville and Chattanooga urban areas. The corridor extends from the Kentucky border to where it meets I-75 in Hamilton County, a distance of approximately 185 miles (refer to Figure 1.1).

The analysis of corridor needs will go through a structured process of characterizing existing and projected corridor conditions, describing the purpose and need for corridor improvements, defining a set of performance measures against which to evaluate improvement options, and evaluating potential corridor improvements against these performance measures to develop a set of recommended improvements.

## 1.2 Purpose of This Document in the Study Process

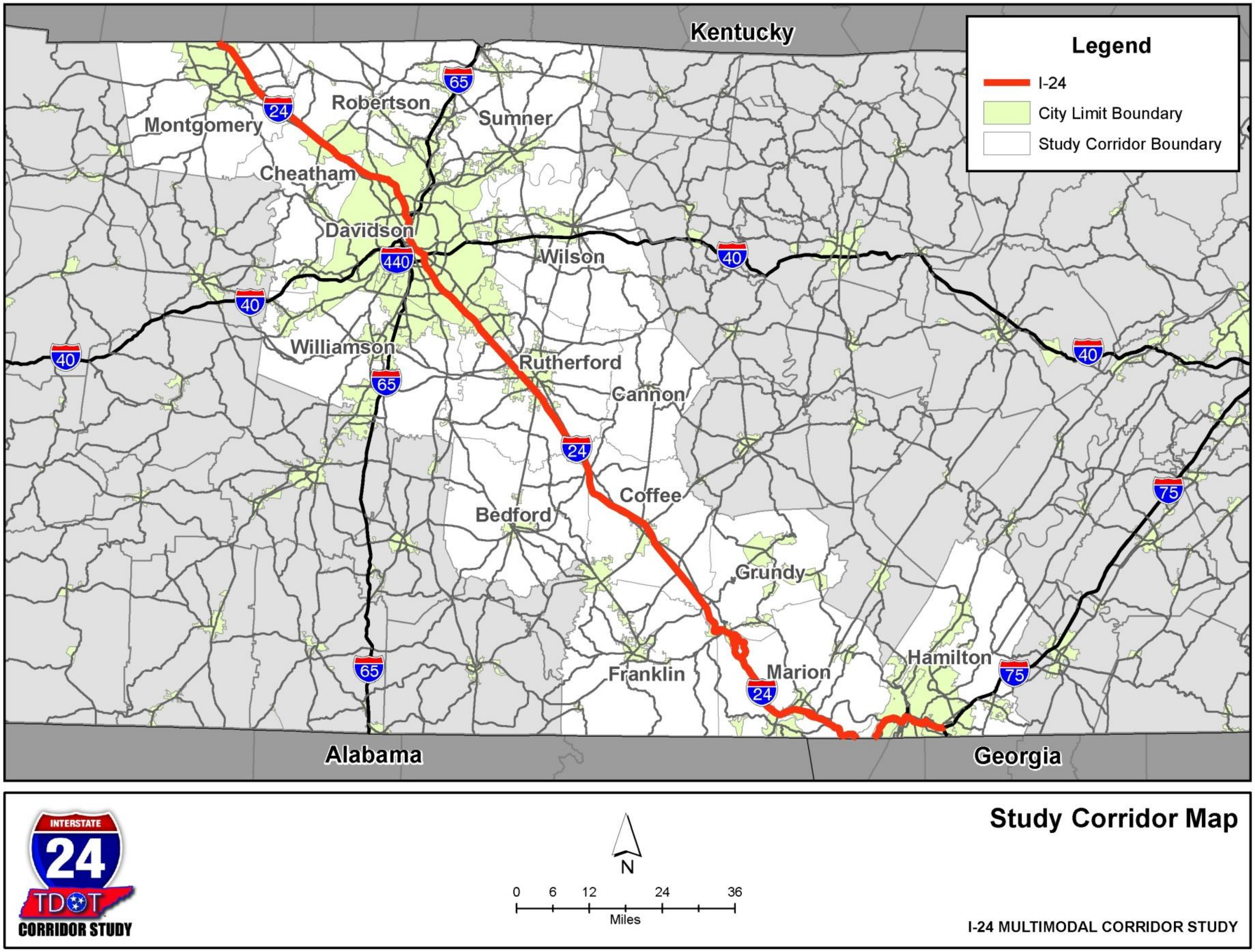
This technical memorandum is a reference document describing the travel demand modeling procedure that was used for the I-24 Multimodal Corridor Study. The travel demand model forecasts future year auto and truck trips, travel patterns, congestion and delay on I-24 and roadways interchanging with it. Its primary contribution to the corridor study is forecasting congestion and delay statistics for alternative transportation improvement strategies. These statistics are referred to as 'performance measures.' These measures will aid in identifying which proposed strategies are most effective in reducing future year congestion and delay on I-24 and nearby roadways in the I-24 Corridor from Clarksville to Chattanooga.

The modeling process is challenging from the standpoint of the corridor being approximately 185 miles in length and passing through three separate metropolitan planning regions (MPOs): Clarksville, Nashville and Chattanooga. To model such a long corridor with different area type characteristics, the modeling process makes use of four separate travel demand models that are already used for transportation planning in the corridor. These four travel demand models and their respective planning organizations are listed below.

- Tennessee Statewide Model (*Tennessee Department of Transportation*)
- Clarksville MPO Model (*Clarksville-Montgomery County Regional Planning Commission*)
- Nashville MPO Model (*Metropolitan Nashville Planning Commission*)
- Chattanooga MPO Model (*Chattanooga-Hamilton County Regional Planning Agency*)

These are referred to as the Tier I – Macro Scale Models. Many of the forecasted performance measures output for the I-24 Multimodal Corridor Study will come directly from these models.

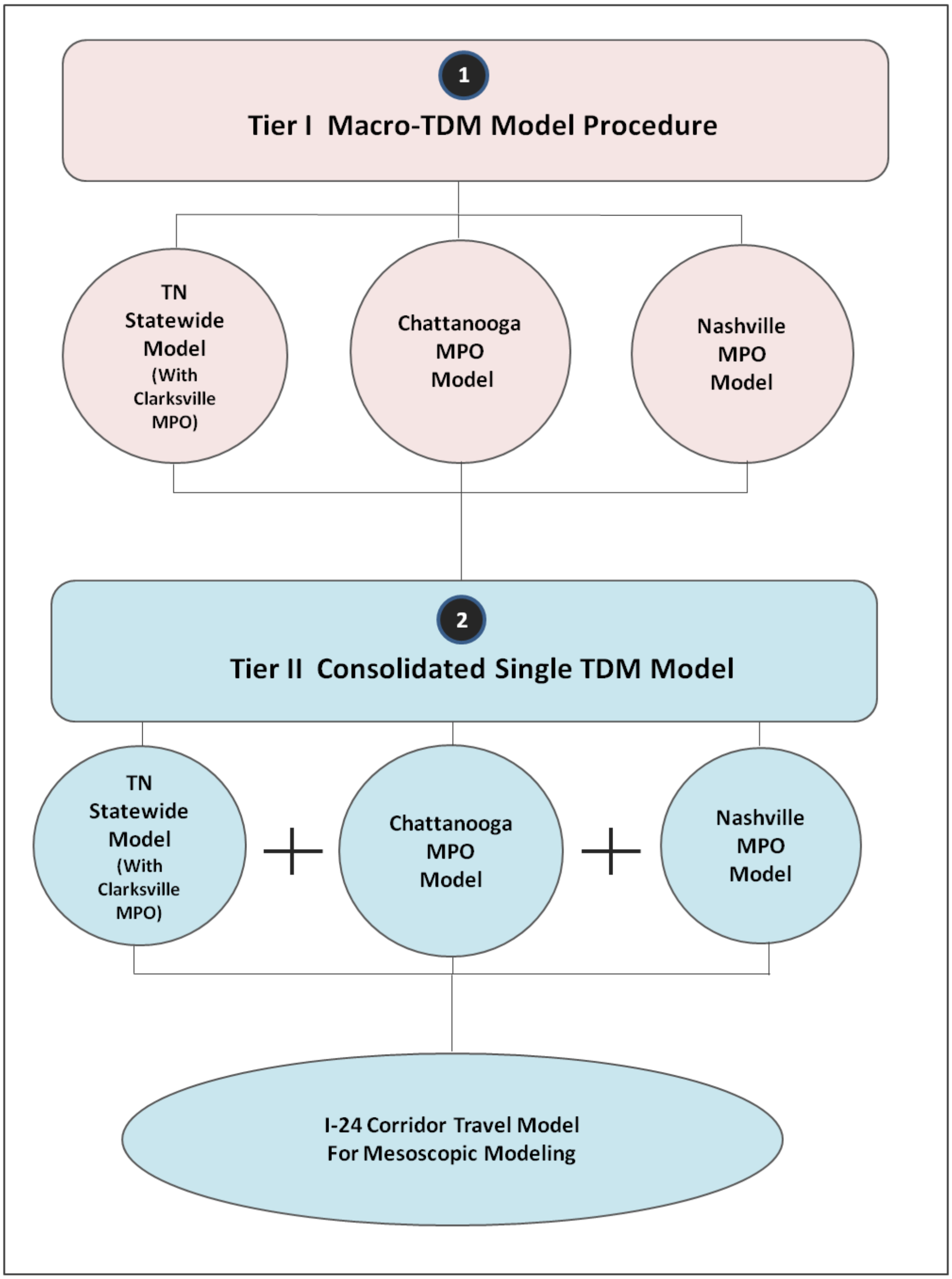
**Figure 1.1: Study Corridor Map**



Others, however, will come from what is referred to as the Tier II - 'Consolidated' I-24 Corridor Model. This analytical tool has the capability to perform mesoscopic modeling which provides the study team with a more dynamic tool to measure congestion and delay on sections of I-24.

An overview of the I-24 modeling process is depicted in Figure 1.2 using a flow diagram. More complete descriptions of each Tier I macro model, as well as the Tier II 'Consolidated' model, are included in later sections of this document.

**Figure 1.2: Model Process Overview**



### 1.3 Model Area

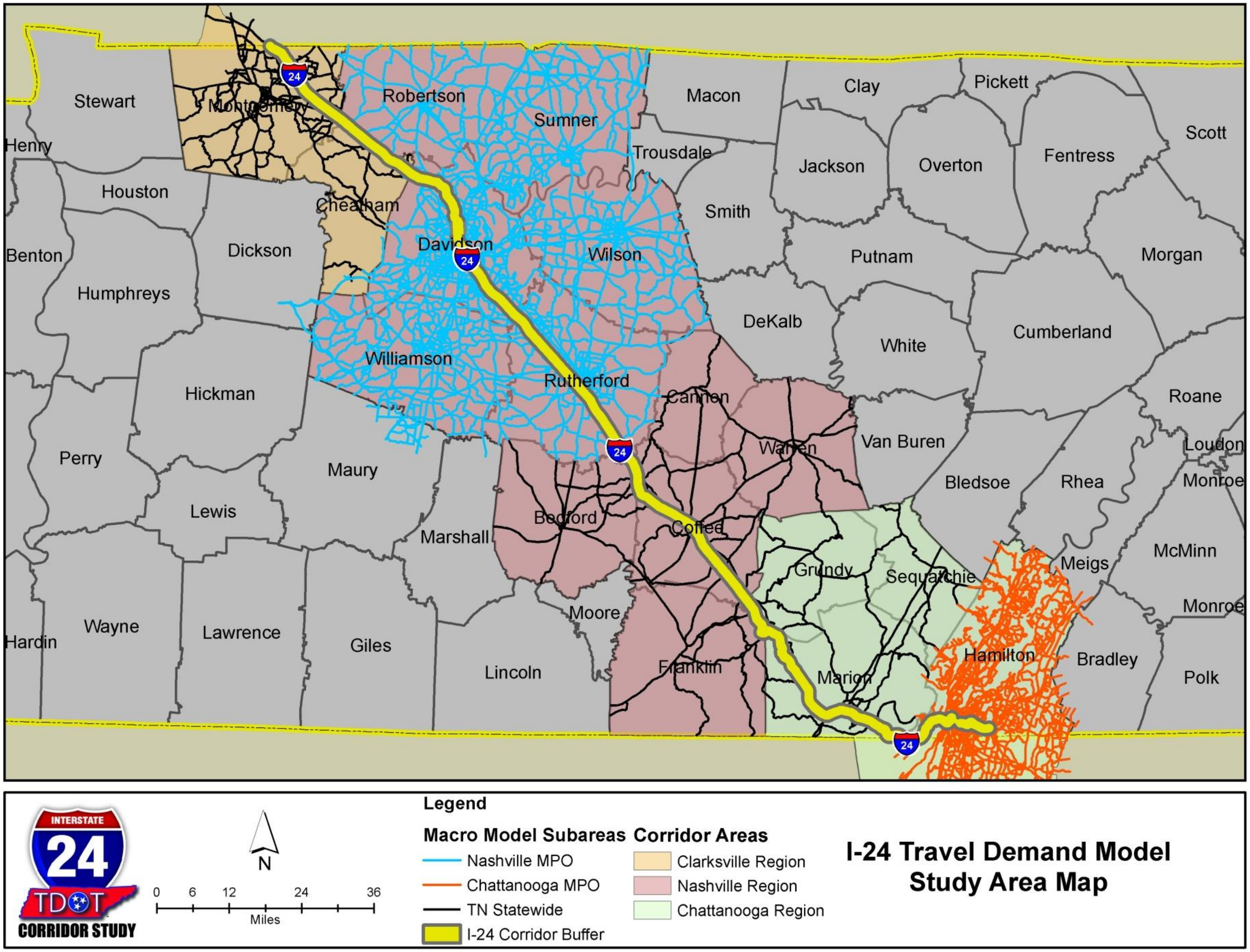
The length of the corridor under study is approximately 185 miles, including three metropolitan regions plus more rural subareas of the I-24 corridor located northwest and southeast of the Nashville MPO region. As indicated above, four different macro-models were employed to facilitate Tier I macro-modeling. The Tennessee (TN) Statewide Model was used to forecast performance measures on sections of I-24 and on other roadways in the traffic analysis area. These subareas of the corridor included primary roadways in Cheatham County northwest of Nashville and in Bedford, Coffee, Cannon, Warren, Franklin, Grundy, Sequatchie and Marion counties in between the Nashville and Chattanooga metropolitan areas.

The model analysis area was split into three Corridor Areas to display and report travel patterns and statistics from the Tier I Macro Models. Reporting results for MPO models and rural subareas models separately does not provide a meaningful summary of the modeling output because of the split geography in the Statewide Model network area. To compensate for the split geography, output from the Statewide Model is split three ways and associated with one of the MPO models so that modeled information is presented and reported in a logical fashion:

- Corridor Area 1 – Clarksville Reporting Region;
- Corridor Area 2 – Nashville Reporting Region; and,
- Corridor Area 3 – Chattanooga Reporting Region.

The model geography associated with the four macro-models that were used in the Tier I modeling process, along with the three Corridor Areas that were used for reporting, is displayed in Figure 1.3.

**Figure 1.3: Model Area Map**



## 2.0 Travel Surveys

With the exception of transit service and ridership reported in the final part of this section, the survey tabulations reported in this section were used to compare against existing auto and truck travel patterns embedded in the Tennessee Statewide Model. Travel pattern data from several available survey data sets that were conducted as close to the study's base year of 2010 as possible were used in the comparison. Adjustments to the Statewide Model's trip data base as a result of this comparison were critical to the entire modeling process as they focused on long distance travel.

The Statewide Model was a key element in the process of transitioning from Tier I to Tier II model development. To allow the consolidation of travel demand into one single model during the Tier II model development, daily auto and truck travel patterns from the 'Modified' Statewide Model were used to 'join' travel demand from the Nashville and Chattanooga macro-models.

The existing base and future horizon year of the Statewide Model going into this study was 2002 and 2030, respectively. For purposes of conducting the I-24 Multimodal Corridor Study, modeled travel patterns and vehicle flows were adjusted to represent a new base year of 2010 and a future year of 2040 for all macro models including the Statewide Model.

The four survey data sets that were used to adjust travel patterns in the Statewide Model are listed below. Each is summarized later in this section along with I-24 Corridor transit data reported for calendar year 2010.

- American Community Survey (2006-2008 Sample)
- National Household Travel Survey (2009 Sample)
- Transearch 2007 (Multiple samples of freight shipments in years prior to 2007)
- Freight Analysis Framework[3]

### 2.1 American Community Survey (2006-2008)

The United States Census Bureau's American Community Survey (ACS) is a continuous data collection effort that provides new household samples every year. In this particular application of ACS data, the tabulated data is in response to the survey question that asks "What are the locations where persons aged 16+ residing in the household work". Survey respondents provide the place of residence location as a part of the introductory screening process.

The ACS sample size of households, at the time these tabulations were performed, was insufficient to provide home-to-work flow figures for some counties in the I-24 Model Analysis area, like Cannon, Grundy and Sequatchie counties.

Home-Work flows were tabulated for three levels of geography, as follows:

- MPO-to-MPO;
- County-to-MPO; and,
- MPO-to-Outside Study Area (i.e., External).

It is notable that 'Home-Work' flow statistics are not equal units to daily auto trips in the Statewide Model. It does provide insight, however, with regards to the relative volume of work trips between two or more distinct origin-destination pairs.

**Table 2.1: MPO-to-MPO 'Home-Work' Flows from ACS**

| | DESTINATION MPO | | | |
|---|---|---|---|---|
| **ORIGIN MPO** | Chattanooga | Clarksville | Nashville | Grand Total |
| Chattanooga | 142,475 | 0 | 495 | 142,970 |
| Clarksville | 20 | 43,745 | 5,520 | 49,285 |
| Nashville | 295 | 1,170 | 609,995 | 611,460 |
| Grand Total | 142,790 | 44,915 | 616,010 | 803,715 |

Source: US Census Bureau's ACS Work Flow Tabulations
Note: Robertson County was not included inside the Nashville MPO in computing this table.

**Table 2.2: County-to-MPO 'Home-Work' Flows from ACS**

| **ORIGIN COUNTY** | | **MPO DESTINATION** | **1-way Flow** |
|---|---|---|---|
| Cheatham | - | Clarksville | 485 |
| Robertson | - | Clarksville | 610 |
| Cheatham | - | Nashville | 11,765 |
| Robertson | - | Nashville | 10,905 |
| Bedford | - | Nashville | 4,455 |
| Coffee | - | Nashville | 3,145 |
| Warren | - | Nashville | 945 |
| Franklin | - | Nashville | 295 |
| Franklin | - | Chattanooga | 55 |
| Marion | - | Chattanooga | 4,035 |

Source: US Census Bureau's ACS Work Flow Tabulations
Note: Robertson County was not included inside the Nashville MPO in computing this table.

**Table 2.3: MPO-to-External 'Home-Work' Flows from ACS**

| ORIGIN MPO | DESTINATION REGION(1) | 1-way Flows |
|---|---|---|
| Nashville | NE | 941 |
| | NO | 3,577 |
| | NW | 80 |
| | SO | 1,679 |
| | SW | 2,574 |
| | | 8,851 |
| Chattanooga | NE | 559 |
| | NO | 383 |
| | NW | 39 |
| | SO | 26,493 |
| | SW | 2,714 |
| | | 30,188 |
| Clarksville | NE | 15 |
| | NO | 1,969 |
| | NW | 0 |
| | SO | 15 |
| | SW | 65 |
| | | 2,064 |

**(1) Destination Region Geography**

'NO' - states located north of I-24 Corridor and Tennessee (KY, IN, OH, MI, IL, WI, WV, etc.)

'SO' - states located south of I-24 Corridor and Tennessee (GA, AL, FL)

'SW' - states located southwest of I-24 Corridor and Tennessee (AK, MS, LA, TX, OK, etc.)

'NE' - states located northeast of I-24 Corridor and Tennessee (VA, MD, PA, NY, NJ, etc.)

'NW' - states located northwest of I-24 Corridor and Tennessee (MO, KS, CO, IA, MN, OR, WA, etc.)

Source: US Census Bureau's ACS Work Flow Tabulations
Note: Robertson County was not included inside the Nashville MPO in computing this table.

## 2.2 National Household Travel Survey (2009)

The United States Federal Highway Administration (FHWA) sponsors the National Household Travel Survey (NHTS). Its basic sampling plan and questionnaire forms are sufficient to inform policymakers of nationwide travel behavior. Travel behavior includes household and person trip rates, trip purposes, trip mode, trip distance, plus household characteristics, such as: number of persons in the household, automobile availability and the number of workers in the household.

The FHWA has an optional program for State Departments of Transportation (DOTs) to augment the number of households sampled in their State as a supplementary add-on to their ordinary NHTS. The add-on samples are also enhanced in terms of the amount of survey data made available to a DOT. The Tennessee DOT opted to participate in the Add-On program during the 2009 NHTS. With the add-ons, a total of 2,552 households in Tennessee were surveyed. Of these, 928 or 36% were located in the I-24 Corridor model area. Approximately 33% of the households were classified as being in a rural area of the corridor.

The tabulations presented herein were made from a subset of NHTS 2009 survey trips. The target trips were identified by filtering to identify auto vehicle trips that were made during a weekday. The domain of NHTS trip samples was not limited to work travel, like the ACS. The

NHTS gives a glimpse at origins and destinations in the corridor made for all types of model trip purposes. Nevertheless, survey trips from the NHTS sample are limited by household-based travel only. This means commercial, most business, government and institutional trip making is not included. Origin-Destination trip volumes reported below reflect the full population of these trips, since trip expansion factors were applied to the sample. In interpreting or using the data, one always should be cognizant that the data comes from a sampling of households.

**Table 2.4: MPO-to-MPO Daily Auto Flows from NHTS**

| | DESTINATION MPO | | | |
|---|---|---|---|---|
| **ORIGIN MPO** | Chattanooga | Clarksville | Nashville | Grand Total |
| Chattanooga | 515,042 | 0 | 331 | 515,373 |
| Clarksville | 0 | 312,642 | 5,072 | 317,714 |
| Nashville | 0 | 1,975 | 2,212,212 | 2,214,187 |
| Grand Total | 515,042 | 314,617 | 2,217,615 | 3,047,274 |

Source: NHTS 2009 sample of auto driver trips in I-24 Corridor model area
Note 1: Daily flows computed using survey trip expansion factors
Note 2: Robertson County was not included inside the Nashville MPO in computing this table.

**Table 2.5: County-to-MPO Daily Auto Flows from NHTS**

| ORIGIN COUNTY | | MPO DESTINATION | Daily Flow |
|---|---|---|---|
| Cheatham | - | Clarksville | 2,155 |
| Robertson | - | Clarksville | 23,070 |
| Cheatham | - | Nashville | 30,798 |
| Robertson | - | Nashville | 39,403 |
| Cannon | - | Nashville | 5,953 |
| Bedford | - | Nashville | 1,125 |
| Grundy | - | Nashville | 0 |
| Coffee | - | Nashville | 0 |
| Warren | - | Nashville | 0 |
| Franklin | - | Nashville | 2,659 |
| Grundy | - | Chattanooga | 0 |
| Franklin | - | Chattanooga | 0 |
| Marion | - | Chattanooga | 17,068 |
| Sequatchie | - | Chattanooga | 9,859 |

Source: NHTS 2009 sample of auto driver trips in I-24 Corridor model area
Note 1: Daily flows computed using survey trip expansion factors
Note 2: Robertson County was not included inside the Nashville MPO in computing this table.

**Table 2.6: MPO-to-External Daily Auto Flows from NHTS**

| ORIGIN MPO | DESTINATION REGION(1) | Daily Trips |
|---|---|---|
| Nashville | NE | 2,275 |
| | NO | 4,009 |
| | NW | 0 |
| | SO | 693 |
| | SW | 41,635 |
| | | 48,612 |
| Chattanooga | NE | 0 |
| | NO | 5,748 |
| | NW | 1,115 |
| | SO | 11,167 |
| | SW | 934 |
| | | 18,964 |
| Clarksville | NE | 0 |
| | NO | 14,111 |
| | NW | 0 |
| | SO | 0 |
| | SW | 0 |
| | | 14,111 |

**(1) Destination Region Geography**

'NO' - states located north of I-24 Corridor and Tennessee (KY, IN, OH, MI, IL, WI, WV, etc.)

'SO' - states located south of I-24 Corridor and Tennessee (GA, AL, FL)

'SW' - states located southwest of I-24 Corridor and Tennessee (AK, MS, LA, TX, OK, etc.)

'NE' - states located northeast of I-24 Corridor and Tennessee (VA, MD, PA, NY, NJ, etc.)

'NW' - states located northwest of I-24 Corridor and Tennessee (MO, KS, CO, IA, MN, OR, WA, etc.)

Source: NHTS 2009 sample of auto driver trips in I-24 Corridor model area
Note 1: Daily flows computed using survey trip expansion factors
Note 2: Robertson County was not included inside the Nashville MPO in computing this table.

## 2.3 Transearch (2007)

TDOT purchased a database of national commodity flow movements that corresponded to a base year of 2007 as well as commodity forecasts for future year 2035. The data is customized, spatially, for TDOT's applications by a company named IHS Global Insight, specializing in Information Services. Transearch datasets, customized by IHS, are used by many State DOT's to enhance their understanding of how freight movements affect economic development and service levels on their transportation system, including safety.

The Transearch database used in the I-24 Multimodal Corridor Study was not exactly the same as the original one purchased by TDOT. This set of 2007 and 2035 commodity flow data was further refined for TDOT beyond what was done by IHS Global Insight, as part of a previous Interstate System corridor study.

Transearch data contains more valuable information than commodity flow movements. It provides commodity movements by type of freight mode. Moreover, it provides annualized truck and railcar flows in association with the commodity flows by freight mode data. That unit is a little different from what is used in the travel demand modeling process for trucks. To convert annualized truck flows to average weekday truck flows a factor of 300 was used to divide the annualized truck volumes.

## Table 2.7: MPO-to-MPO Daily Truck Flows from Transearch

| Transearch Base Year 2007 | | | | |
|---|---|---|---|---|
| | DESTINATION MPO | | | |
| **ORIGIN MPO** | Chattanooga | Clarksville | Nashville | Grand Total |
| Chattanooga | 167 | 10 | 139 | 316 |
| Clarksville | 6 | 26 | 101 | 133 |
| Nashville | 42 | 41 | 1,662 | 1,745 |
| Grand Total | 215 | 77 | 1,902 | 2,194 |
| **Transearch Forecast Year 2035** | | | | |
| | DESTINATION MPO | | | |
| **ORIGIN MPO** | Chattanooga | Clarksville | Nashville | Grand Total |
| Chattanooga | 242 | 13 | 167 | 422 |
| Clarksville | 14 | 30 | 84 | 128 |
| Nashville | 65 | 49 | 2,003 | 2,117 |
| Grand Total | 321 | 92 | 2,254 | 2,667 |

Source: IHS Global Insights and TDOT
Note 1: Average weekday flows computed using factors to expand the sample to full population of trucks
Note 2: Robertson County was not included inside the Nashville MPO in computing this table.

## Table 2.8: County-to-MPO Daily Truck Flows from Transearch

| Transearch Base Year 2007 | | | | Transearch Future Year 2035 | | | |
|---|---|---|---|---|---|---|---|
| **ORIGIN COUNTY** | | **MPO DESTINATION** | **Daily Flow** | **ORIGIN COUNTY** | | **MPO DESTINATION** | **Daily Flow** |
| Cheatham | - | Clarksville | 11 | Cheatham | - | Clarksville | 13 |
| Robertson | - | Clarksville | 2 | Robertson | - | Clarksville | 3 |
| Cheatham | - | Nashville | 124 | Cheatham | - | Nashville | 116 |
| Robertson | - | Nashville | 63 | Robertson | - | Nashville | 52 |
| Bedford | - | Nashville | 42 | Bedford | - | Nashville | 46 |
| Coffee | - | Nashville | 44 | Coffee | - | Nashville | 67 |
| Cannon | - | Nashville | 38 | Cannon | - | Nashville | 40 |
| Warren | - | Nashville | 65 | Warren | - | Nashville | 54 |
| Grundy | - | Nashville | 7 | Grundy | - | Nashville | 21 |
| Franklin | - | Nashville | 53 | Franklin | - | Nashville | 60 |
| Grundy | - | Chattanooga | 2 | Grundy | - | Chattanooga | 4 |
| Franklin | - | Chattanooga | 28 | Franklin | - | Chattanooga | 35 |
| Marion | - | Chattanooga | 22 | Marion | - | Chattanooga | 14 |
| Sequatchie | - | Chattanooga | 0 | Sequatchie | - | Chattanooga | 1 |

Source: IHS Global Insights and TDOT
Note 1: Average weekday flows computed using factors to expand the sample to full population of trucks
Note 2: Robertson County was not included inside the Nashville MPO in computing this table

## Table 2.9: MPO-to-External Daily Truck Flows from Transearch

| Transearch Base Year 2007 | | | Transearch Future Year 2035 | | |
|---|---|---|---|---|---|
| ORIGIN MPO | DESTINATION REGION(1) | Daily Trips | ORIGIN MPO | DESTINATION REGION(1) | Daily Trips |
| Nashville | NE | 1,085 | Nashville | NE | 1,831 |
| | NO | 1,105 | | NO | 1,622 |
| | NW | 108 | | NW | 190 |
| | SO | 525 | | SO | 927 |
| | SW | 951 | | SW | 1,784 |
| | Memphis, TN | 560 | | Memphis, TN | 874 |
| | | 4,334 | | | 7,228 |
| Chattanooga | NE | 352 | Chattanooga | NE | 618 |
| | NO | 231 | | NO | 359 |
| | NW | 31 | | NW | 200 |
| | SO | 312 | | SO | 144 |
| | SW | 251 | | SW | 258 |
| | Memphis, TN | 429 | | Memphis, TN | 499 |
| | | 1,606 | | | 2,078 |
| Clarksville | NE | 89 | Clarksville | NE | 40 |
| | NO | 136 | | NO | 1,156 |
| | NW | 7 | | NW | 396 |
| | SO | 51 | | SO | 314 |
| | SW | 108 | | SW | 319 |
| | Memphis, TN | 51 | | Memphis, TN | 175 |
| | | 442 | | | 2,400 |
| Non-MPO | NE | 117 | Non-MPO | NE | 308 |
| Areas | NO | 225 | Areas | NO | 424 |
| | NW | 9 | | NW | 30 |
| | SO | 115 | | SO | 476 |
| | SW | 166 | | SW | 472 |
| | Memphis, TN | 99 | | Memphis, TN | 187 |
| | | 731 | | | 1,710 |

Source: IHS Global Insights and TDOT
Note 1: Average weekday flows computed using factors to expand the sample to full population of trucks
Note 2: Robertson County was not included inside the Nashville MPO in computing this table
in computing this table.

**(1) Destination Region Geography**

'**NO**' - states located north of I-24 Corridor and Tennessee
(KY, IN, OH, MI, IL, WI, WV, etc.)
'**SO**' - states located south of I-24 Corridor and Tennessee
(GA, AL, FL)
'**SW**' - states located southwest of I-24 Corridor and Tennessee
(AK, MS, LA, TX, OK, etc.)
'**NE**' - states located northeast of I-24 Corridor and Tennessee
(VA, MD, PA, NY, NJ, etc.)
'**NW**' - states located northwest of I-24 Corridor and Tennessee
(MO, KS, CO, IA, MN, OR, WA, etc.)
'**Memphis, TN**' - Shelby, Memphis and Tipton counties

**Table 2.10: External-to-External Daily Truck Flows from Transearch**

| EXTERNAL REGIONS | | | Transearch | Transearch |
|---|---|---|---|---|
| Origin | | Destination | 2007 | 2035 |
| North(1) | - | South | 2,206 | 3,260 |
| South(2) | - | North | 2,209 | 3,465 |
| Grand Total | | | 4,415 | 6,725 |

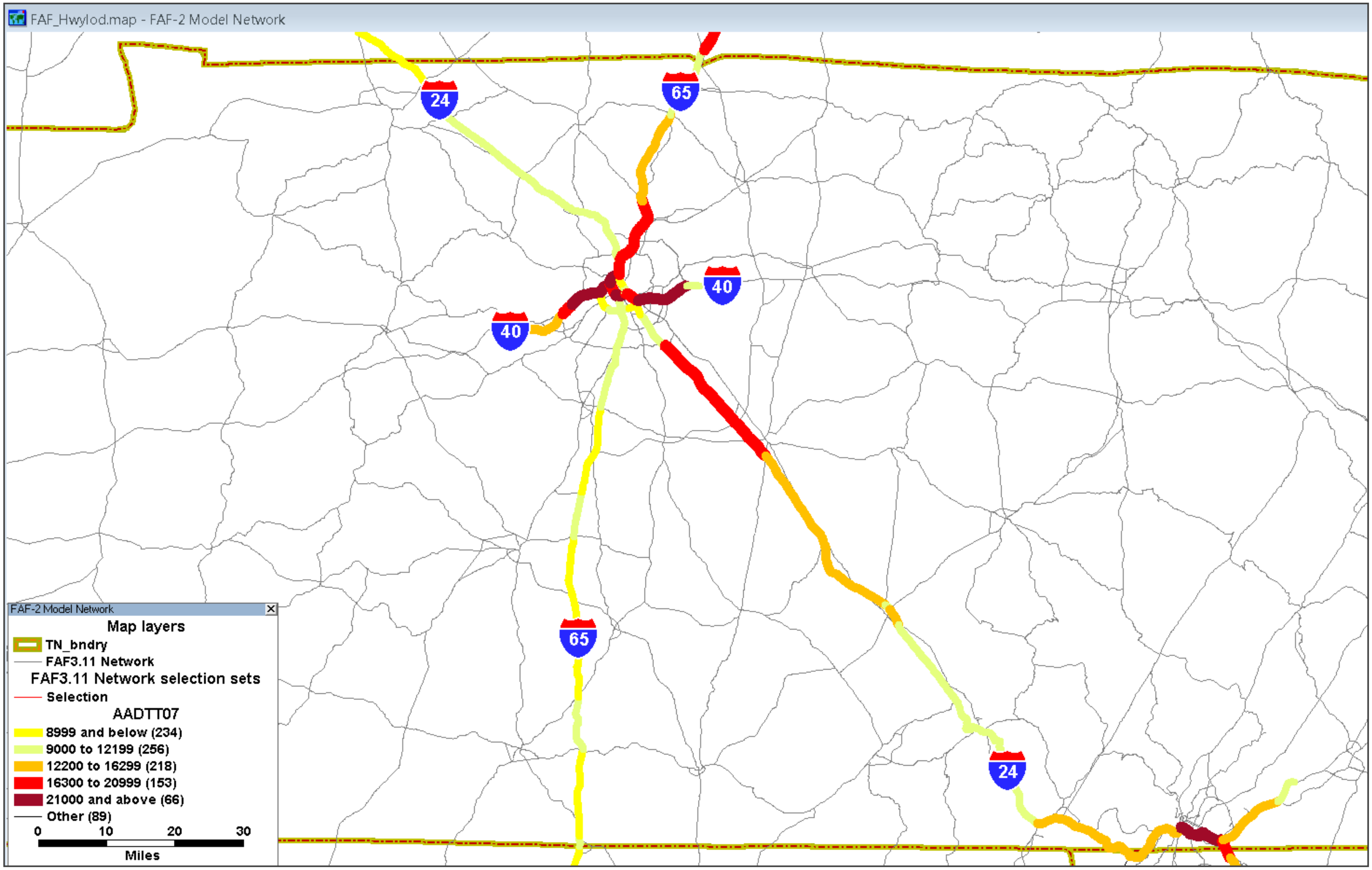
Source: IHS Global Insights and TDOT
Note 1: Average weekday flows computed using factors to expand the sample to full population of trucks
Note 2: Robertson County was not included inside the Nashville MPO in computing this table
in computing this table.

**External Region Geography**
(1) '**North**' - states located northwest of I-24 Corridor
(KY, IN, OH, MI, IL, WI, WV, etc.)
(2) '**South**' - states located south of I-24 Corridor and Tennessee
(GA, AL, FL)

## 2.4 Freight Analysis Framework – Version 3 (FAF$^3$)

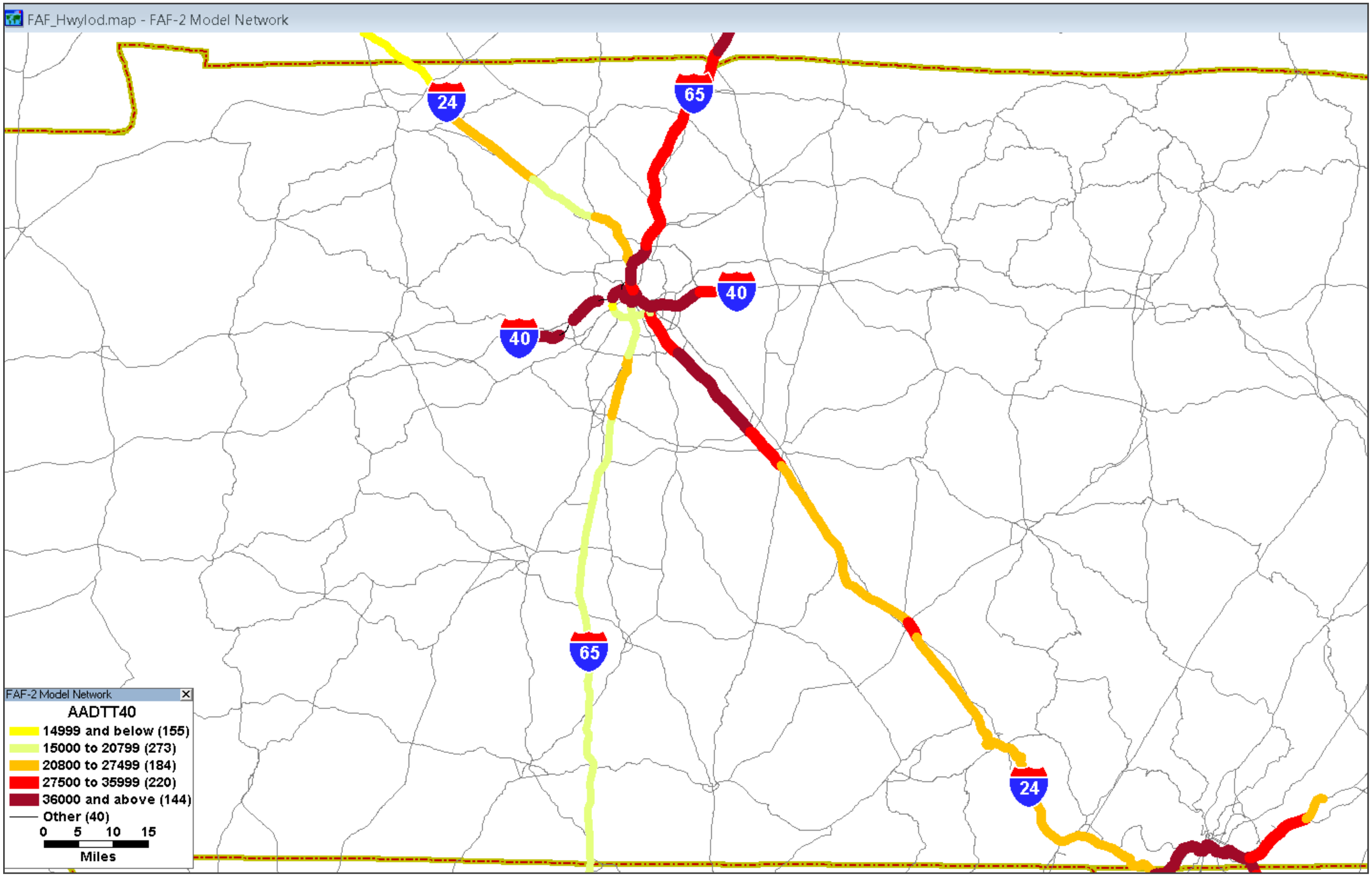
The Freight Analysis Framework, like the NHTS, is an ongoing Federal Highway Administration (FHWA) data collection and value-added project. It is a nationwide commodity flow database with origin-destination cargo flows by mode that is identical to Transearch in many respects. The current base and future years for the FAF are 2007 and 2040. The most striking difference is the spatial geography, defining origin and destination areas, for FAF follows Bureau of Economic Analysis (BEA) geography which consists of approximately 150 economic analysis zones for the entire United States. The FAF is used to produce nationwide traffic assignments of truck traffic. Inside Tennessee, Transearch customizes commodity flow data into county-level units of geography for analysis. There are other benefits that Transearch offers. IHS Global Insights is able to provide more information about trans-shipments of intermodal cargo as well as local drayage movements near large freight terminals in its customized Transearch products. It should be noted that only the Transearch truck database was used in the process of reconciling truck patterns in the Tennessee Statewide Model with the most recent patterns available from the commodity flow survey.

**Figure 2.1: Estimated 2007 Truck AADT (FAF3)**




Source: FHWA Freight Analysis Framework (FAF[3])

**Figure 2.2: Forecasted 2040 Truck AADT (FAF3)**




Source: FHWA Freight Analysis Framework (FAF[3])

## 2.5 National Transit Database

Existing conditions for transit service in the I-24 Corridor is reported using off-model data. Of the three MPO travel demand models, only modeled transit trips from the Chattanooga MPO model were available. To be consistent across all analysis areas, base year 2010 transit system statistics from the National Transit Database are reported herein.

There are more than 13.1 million (unlinked) transit trips per year in the I-24 Corridor. Using a factor of 300 to estimate average weekday unlinked trips and a factor of 1.5 to convert unlinked trips into linked trips that are equivalent to other model-based person trips, the average weekday transit ridership in the corridor would be 29,250 daily trips.

**Table 2.11: Annual Transit Service and Ridership Statistics - 2010**

| Area Served | Transit System | Service Area (mi^2) | Service Area Population | Mode | Annual Unlinked Passenger Trips | Annual Passenger Miles | Annual Vehicle Revenue Miles | Annual Vehicle Revenue Hours |
|---|---|---|---|---|---|---|---|---|
| Chattanooga | CARTA | 289 | 155,554 | Bus | 2,631,013 | 9,328,005 | 2,125,131 | 163,451 |
| | | | | Demand Response | 73,068 | 437,190 | 450,866 | 35,315 |
| | | | | Inclined Plane | 357,459 | 357,459 | 19,095 | 6,220 |
| | | | | **Subtotal** | **3,061,540** | **10,122,654** | **2,595,092** | **204,986** |
| Clarksville | CTS | 118 | 128,741 | Bus | 703,464 | 3,904,204 | 1,040,126 | 62,492 |
| | | | | Demand Response | 30,254 | 200,273 | 308,202 | 21,328 |
| | | | | **Subtotal** | 733,718 | 4,104,477 | 1,348,328 | 83,820 |
| Nashville | MTA | 484 | 613,856 | Bus | 8,623,771 | 43,852,632 | 4,265,592 | 313,114 |
| | | | | Demand Response | 247,173 | 2,999,243 | 1,915,999 | 115,867 |
| | | | | Demand Response - Taxi | 71,555 | 781,631 | 541,259 | 12,648 |
| | | | | **Subtotal** | **8,942,499** | **47,633,506** | **6,722,850** | **441,629** |
| Nashville | RTA | 4,750 | 1,447,856 | Bus | 43,407 | 1,210,501 | 69,047 | 2,308 |
| | | | | Commuter Rail | 204,679 | 3,292,050 | 177,653 | 6,069 |
| | | | | Vanpool | 164,592 | 6,237,951 | 759,267 | 15,151 |
| | | | | **Subtotal** | **412,678** | **10,740,502** | **1,005,967** | **23,528** |
| **TOTALS** | | 5,641 | 2,346,007 | **TOTALS** | **13,150,435** | **72,601,139** | **11,672,237** | **753,963** |

**Data Source: FTA 2010 National Transit Database**
Does not include human services transit, rural transit, intercity bus, intercity rail, taxi, shuttles or van (other than as explicity listed)

Transit services are currently operated over sections of I-24, mostly in the northern half of the study corridor. There is express bus service in the Nashville region operated by the Nashville Area RTA plus several local routes operated by the MTA. These routes serve people who live in or have a destination near to I-24. It should be noted that Clarksville Transit also operates a bus service to and from Nashville.

## 3.0 Tier I Macro Models

The intention of the Tier I modeling process was to assemble the four macro-scale travel demand models side-by-side and use their individual traffic assignment statistics. By integrating sections of the 'modified' Tennessee Statewide Model in between the MPO models, the entire I-24 analysis area would be modeled. Some of the advantages of using this procedure are: system-level travel demand, congestion and delay statistics could be computed without a lengthy model-development start-up period; and, it is good practice to try and use the appropriate MPO model for sections of a long Interstate corridor inside urbanized area boundaries. The macro-scale models in the I-24 model area are:

- Tennessee Statewide;
- Clarksville MPO;
- Nashville MPO; and,
- Chattanooga MPO.

The I-24 Multimodal Corridor Study modeling team was able to get the Tennessee Statewide, Nashville MPO and Chattanooga MPO models running properly for application. Clarksville, however, was not able to run successfully. It would only run for one particular model scenario, the old base year 2008 scenario. The modeling team, however, could not run the application with a new set of files comprising a base year 2010 scenario. To compensate for not being able to apply the Clarksville MPO model application, the Clarksville highway network and zones were embedded into the Tennessee Statewide Model.

Each of the macro-scale models was updated to the 2010-level for application in the I-24 Multimodal Corridor Study. A future horizon year of 2040 was chosen for the I-24 Multimodal Corridor Study. Each of the macro-scale models will also be updated to include future year 2040 baseline condition scenarios. The model development team was fortunate to have received an updated version of the Chattanooga MPO travel demand model. This version already included updated model scenarios that included a base year of 2010 and future year of 2040. The update process for each of these models is described in more detail below.

### 3.1 Tennessee Statewide

The Statewide Model was modified to address three separate modeling issues. The first issue pertained to the original Statewide Model with an existing base year of 2002 and future year of 2030. The second was the level of detail existing in the road network and zone delineation to conduct an Interstate System corridor study. The third issue occurred when it became evident that the I-24 Multimodal Corridor Study modeling team could not get the Clarksville MPO model to execute for a new 2010 model scenario. In response to this, the Clarksville highway network and its zone system were embedded into the Tennessee Model.

The Statewide Model was reviewed for its highway network and zone coverage inside the I-24 Corridor analysis area. An extra layer of 'adjustments' were performed on the Statewide Model that were not applied to the other macro-scale models. The travel patterns embedded in the original auto and truck trip tables were reviewed in light of the ACS Work Flows, NHTS Total Trip Flows and Transearch Truck Flows that are summarized in the previous section. These adjustments are explained in this section as well.

#### *3.1.1 Clarksville MPO Model Network*

I-24 is modeled in the Clarksville network as a set of one-way link pairs from the entry point in the southeast to the exit point in Kentucky northwest of the US-41A interchange in Christian County, Kentucky. Inside the Clarksville MPO model region, I-24 has 6 interchanges and all are included in the modeled network, from the SR-76 junction in the south to US-41A/Fort Campbell Boulevard interchange in Kentucky. All six are modeled with one way links representing entry, exit and loop ramps. All major surface roads connecting to/from I-24 are represented in the model. All major surface roads running parallel to I-24 and/or interconnecting to roads connected directly to I-24 are represented in the model. The level of network detail in the Clarksville MPO model is sufficient to support the modeling needs of the I-24 Multimodal Corridor Study.

#### *3.1.2 Clarksville MPO Model Zones*

A review of the zonal boundary structure in the Clarksville model shows that there are two or more zones on each side of I-24 located between all pairs of consecutive interchanges except in one location. Zones 305 and 306 located on the north and south sides of I-24 between the interchanges at US-41A/Fort Campbell Boulevard and Pembroke Oak Grove Road are locations that do not meet the recommended level of disaggregation. These two zones are at the far northwest corner of the modeling area and are mostly rural-agricultural in nature with very little additional roadway infrastructure beyond what is already in the model network. Both zones are directly connected to US-41A/Fort Campbell Boulevard and Pembroke Oak Grove Road which interchange with I-24. These two existing zones could be disaggregated into 4 zones but this would likely have little effect on the I-24 Corridor modeling results.

There is one small subarea of the Clarksville zone system that merited splitting due to a proposed new interchange that could be studied as part of the corridor study. This new interchange would be located between SR-76 and SR-256 which is the next interchange south in Robertson County.

#### *3.1.3 Merged Statewide and Clarksville MPO*

*Original Statewide Model Network*

I-24 is modeled using a single, two-way link to represent travel in both directions, which is different from the coding method used in the MPO models. All of I-24's interchanges, outside the MPO model areas, are represented in the original Statewide Model highway network but with a single node. Moreover, some interchanging cross streets are modeled using a stub link and access link - without connectivity to the (non-Interstate) primary road system. From the

Chattanooga MPO area to the Clarksville MPO area, there are 17 interchanges on I-24 (outside of the MPO model study areas).

*Original Statewide Model Zones*

A review of the zonal boundary structure used in the Statewide model shows that there is generally insufficient delineation of traffic analysis areas between I-24 interchanges. With the current zone density the model will not be able to distinguish which I-24 interchange would be most desirable for motorists to use to reach their destination. Further delineation of the Statewide Model's zone system is recommended.

*External Stations*

A map review of MPO model external station links in the I-24 model analysis area in comparison with roadways represented in the Statewide Model highway network revealed that some additional road facilities should be coded into the Statewide Model network to facilitate the movement of autos and trucks between different Macro Model subareas. This will be necessary to facilitate development of the Tier II modeling process.

*2010 Update Process*

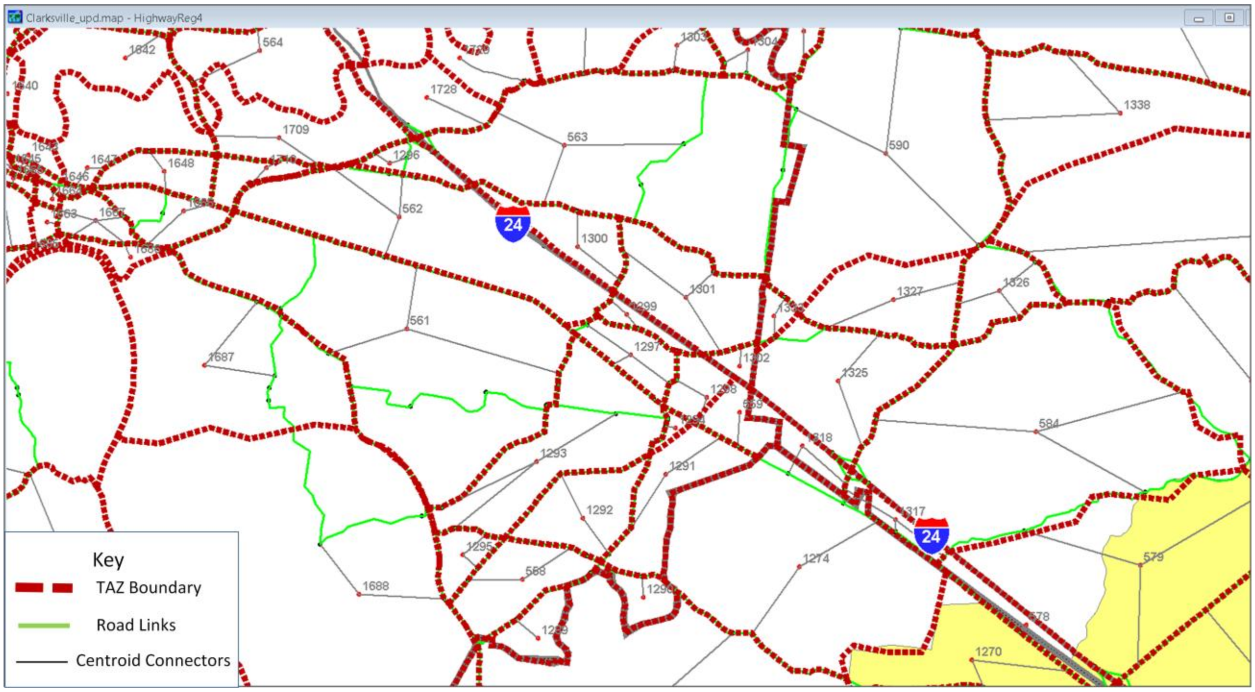
The model update was much more extensive for the Statewide Model in comparison with the other macro-scale models. A list of these modifications is presented in Table 3.1. Zone refinements resulted in raising the number of TAZs from 1,397 in the original statewide model to 1,768 in the I-24 Multimodal Corridor Study version of the Statewide Model. Part of that increase is a result of finer zone delineation in Non-MPO areas, but a lot was also due to embedding the Clarksville MPO zone system into the Statewide Model.

Many of the Statewide Model adjustments listed in the table are illustrated in three map figures. The first display is presented in Figure 3.1 which contains a map of the eastern Clarksville MPO area alongside I-24. This map shows the level of network and zone detail that was built into the base year 2010 Statewide Model. In this particular subarea of Montgomery County, several roads and zones were added to facilitate the modeling of future year transportation improvements.

**Table 3.1: List of Updates to Tennessee Statewide Model**

| | |
|---|---|
| NETWORK | |
| 1 | Dualized I-24 Interstate links inside of the corridor study's model area but not inside MPO areas |
| 2 | Added I-24 ramp links for better interchange definition links inside of the corridor study's model area but not inside MPO areas |
| 3 | Added new zone centroid access links to be consistent with additional zones |
| 4 | Added new roadway links for connectivity between I-24 interchanges and the Non-Interstate primary road system inside of the corridor study's model area but not inside MPO areas |
| 5 | Embedded Clarksville MPO highway network into the Statewide Model highway network |
| 6 | Added new roadway links for connectivity with MPO model external station facilities where the Statewide Model interfaces with MPO models |
| ZONES | |
| 6 | Added new zones where necessary to enable modeled I-24 trips to use the most logical network path during traffic assignment |
| 7 | Embedded Clarksville MPO zone system into the Statewide Model zone system |
| 8 | Renumbered new zones |
| 9 | Created zone equivalency list and percent trip allocations between old and new zone systems |
| AUTO/TRUCK TRIP TABLES | |
| 10 | Interpolated and extrapolated the original auto and truck trip table matrices from base and future years of 2002/2030 to base and future years of 2010/2040 |
| 11 | Disaggregated the original 1397 zone auto and truck trip matrices into a 1768 zone matrix |
| 12 | Modified selected O-D trip interchanges in the 2010 and 2040 auto and truck trip tables to better reflect patterns displayed by ACS, NHTS and Transearch vehicle flow summaries |
| 13 | Modified several O-D trip interchanges in the auto trip tables during model calibration to facilitate short distance movements between rural zones in the statewide model and rural zones in the MPO model areas |
| 14 | Created 'delta' trip table matrices for autos and trucks using the TransCAD matrix estimation procedure with TDOT's 2011 passenger car and truck AADT counts |

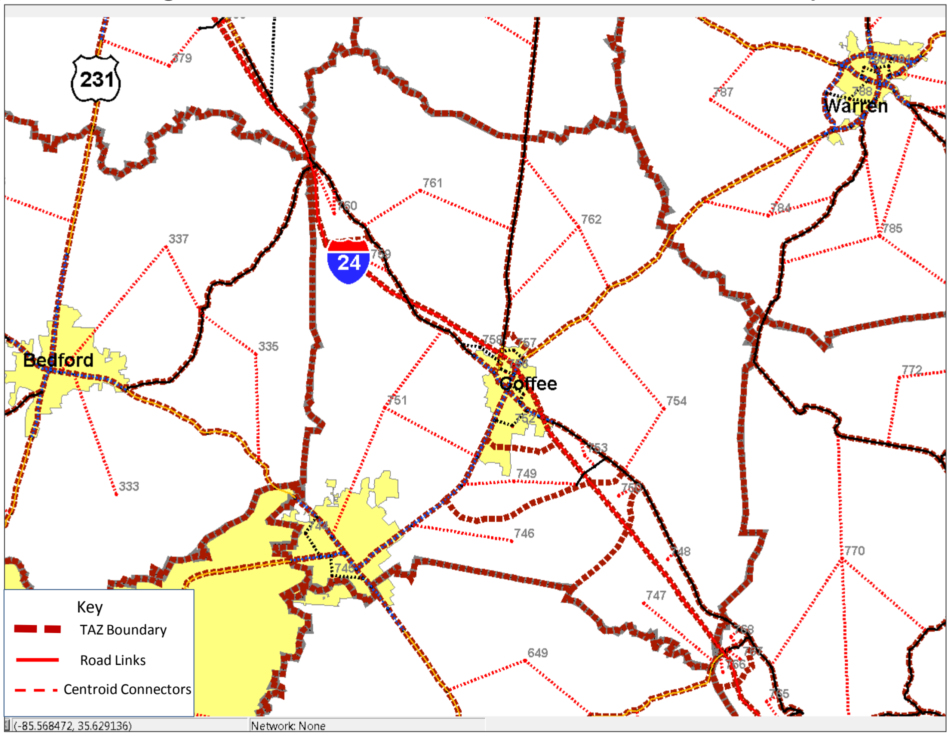
**Figure 3.1: Updated Statewide Model Network and Zone Detail (Clarksville Subarea)**




Data source: Updated Tennessee Statewide Model for I-24 Multimodal Corridor Study
Map source: Caliper Corporation TransCAD Version 5.0 map display

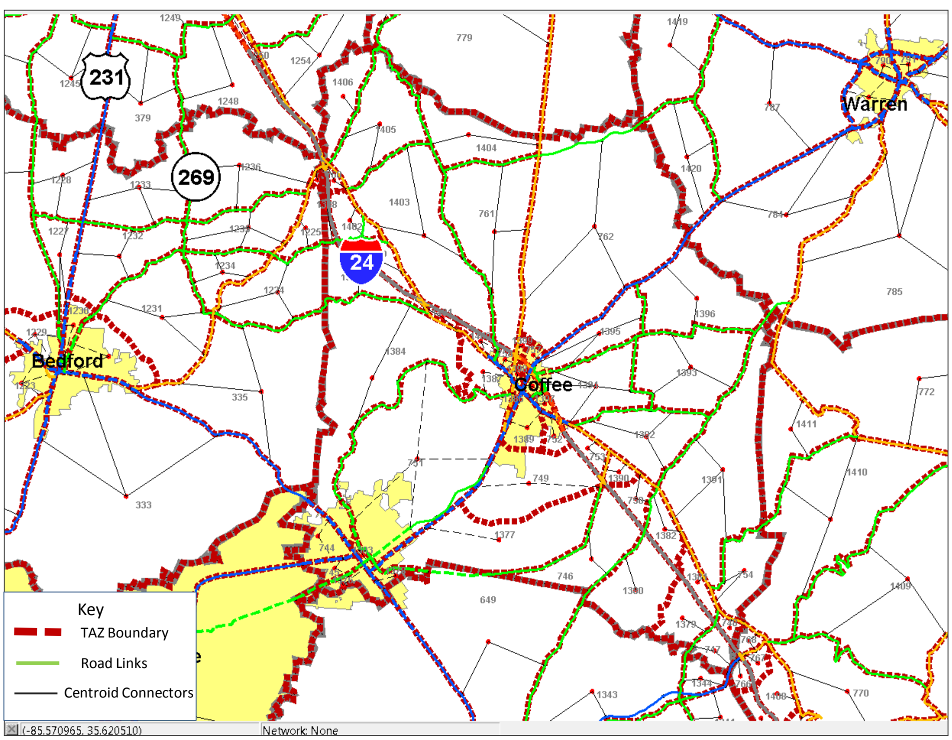
Maps displaying the original Statewide Model's road network and zones in Coffee County and the same subarea of the updated Statewide Model to be used in the I-24 Multimodal Corridor Study are presented in Figures 3.2 and 3.3, respectively. The before and after network and zone structure changes in Coffee County are typical of how these change were made in Non-MPO area counties in the I-24 model analysis area.

**Figure 3.2: Original Statewide Model Network and Zone Detail (Coffee County)**




Data source: Original Tennessee Statewide Model
Map source: Caliper Corporation TransCAD Version 5.0 map display

**Figure 3.3: Refined Statewide Model Network and Zone Detail (Coffee County)**




Data source: Updated Tennessee Statewide Model for I-24 Multimodal Corridor Study
Map source: Caliper Corporation TransCAD Version 5.0 map display

Selected auto and truck trip table adjustments that were made in accordance with a comparative review of survey and model data are listed in Table 3.2.

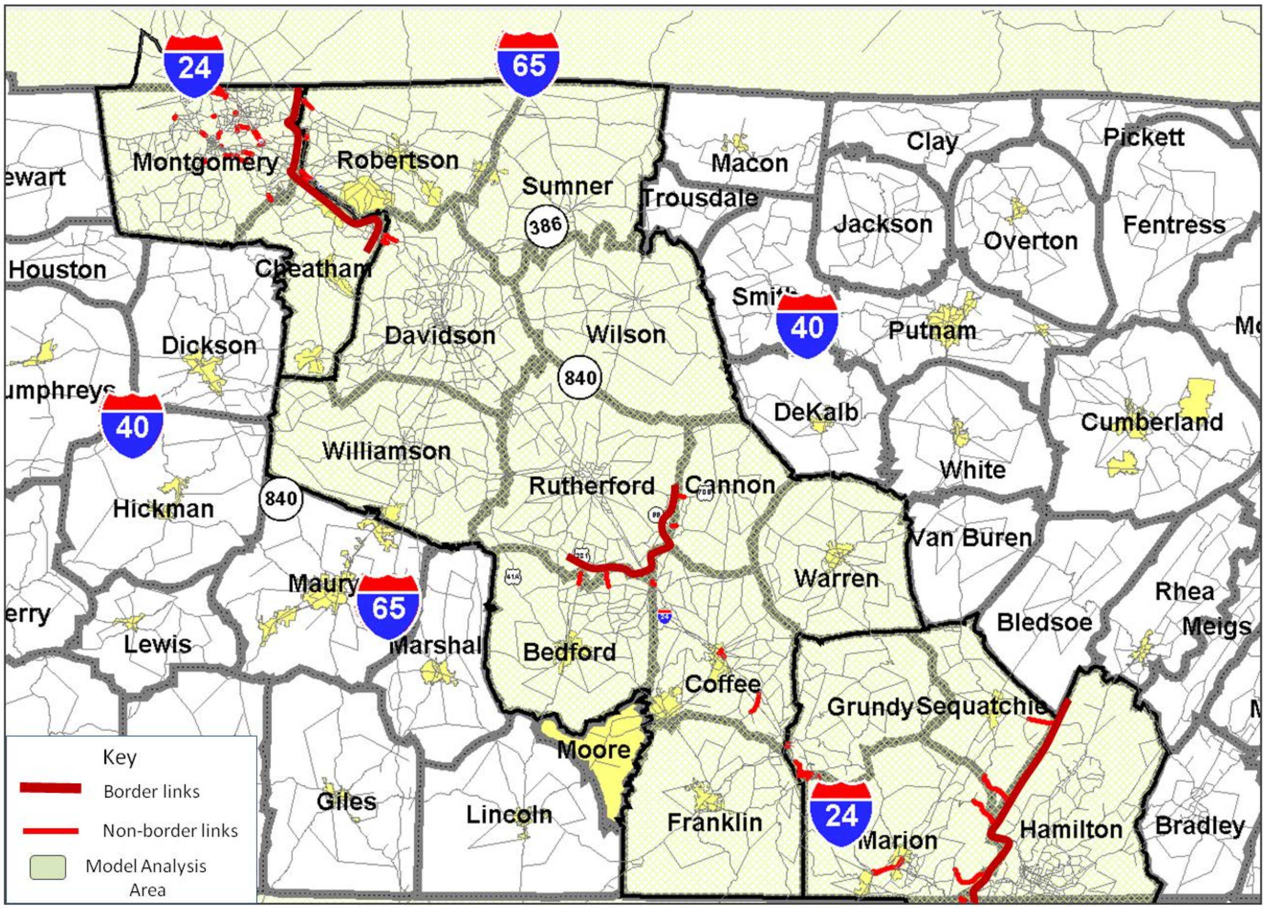
**Table 3.2: Summary of Trip Table Adjustments (From Trip Survey)**

| | |
|---|---|
| AUTO TRIP TABLES | |
| 1 | MPO-to-MPO origin-destination flows appeared to be appropriately represented in the original trip tables |
| 2 | County-to-MPO origin-destination flows were adjusted between Franklin County and the Nashville MPO area. '350' total daily auto trips were added in each direction of travel. |
| 3 | MPO-to-External origin-destination flows appeared to be appropriately represented in the original trip tables |
| TRUCK TRIP TABLES | |
| 4 | MPO-to-MPO origin-destination flows were adjusted (a) within Montgomery County - 200 trips in each direction of travel; and (b) between Montgomery County and the Nashville MPO - 250 daily truck trips in each direction of travel |
| 5 | County-to-MPO origin-destination flows were adjusted (a) Coffee County and Nashville MPO - 50 trips in each direction of travel; (b) between Franklin County and the Nashville MPO – 60 daily truck trips in each direction of travel; (c) between Franklin County and the Chattanooga MPO – 40 daily truck trips in each direction of travel; and, (d) between Marion County and the Nashville MPO – 50 daily truck trips in each direction of travel |
| 6 | MPO-to-External origin-destination flows were adjusted to increase truck flow between Memphis, TN and the Chattanooga MPO - 100 trips in each direction of travel |
| 7 | External-to-External truck travel from north of the I-24 model area to south of the study area appeared to be appropriately represented in the original truck trip tables |

After the modifications described above were made to the Statewide Model, a limited calibration and validation process was performed, focusing on assigned auto and truck volumes where the Statewide Model and the MPO models join. A set of 2011 (count year) auto and truck AADTs from TDOT's 'Traffic' data and GIS street centerline layer were used for validation.

A total of 61 highway network link locations were chosen for the validation. Approximately 30 were located inside the Clarksville MPO area, in light of how the Clarksville MPO area was modeled. Many of the others were located on the macro-scale model borders, where the Statewide Model meets MPO model external stations. Link validation sites are highlighted in Figure 3.4. The total population of network validation links is shown in bright red while the Statewide Model and MPO model borders are shown in a dark red-brown color.

**Figure 3.4: Validation Count Link Locations**




Data source: Tennessee Statewide Model for I-24 Multimodal Corridor Study
Map source: Caliper Corporation TransCAD Version 5.0 map display

Validation link locations were grouped into logical units to evaluate performance of the traffic updated Statewide Model's traffic assignment. The validation groups and final "Counted Volume" versus "Modeled Volume" tabulation is presented in Table 3.3. The overall relative Root Mean Square Error for all sampled links was 7%. Based on these validation statistics and the refinements that were made to the Statewide Model, the modeling team believes that the Statewide Model is sufficiently accurate and reliable to be used as a key analysis tool in the I-24 Multimodal Corridor Study.

## Table 3.3: Link Validation of Base Year Traffic Assignment (Statewide Model)

I24 Statewide Model Run #3 %RMSE = 7

| ID | Roadway | Location | Total_Count | Total_Volume | Diff | Ratio |
|---|---|---|---|---|---|---|
| **Statewide Model Border with Montgomery County Border** | | | | | | |
| 60525 | TN12 | Montgomery-Cheatham | 3,623 | 2,896 | -727 | -0.201 |
| 51693 | TN112 | Montgomery-Cheatham | 4,190 | 4,115 | -75 | -0.018 |
| 51694 | SBI24 | Montgomery-Robertson | 23,006 | 23,658 | 652 | 0.028 |
| 58003 | NBI24 | Montgomery-Robertson | 23,006 | 26,389 | 3,383 | 0.147 |
| 58324 | TN76 | Montgomery-Robertson | 882 | 853 | -29 | -0.033 |
| 51683 | US41 | Montgomery-Robertson | 2,699 | 2,738 | 39 | 0.014 |
| 60644 | SBI24 | Montgomery-Robertson | 16,580 | 17,220 | 640 | 0.039 |
| 60325 | NBI24 | Montgomery-Robertson | 16,580 | 17,099 | 519 | 0.031 |
| | | | 90,566 | 94,968 | 4,402 | 0.049 |
| **Inside Montgomery County** | | | | | | |
| ID | Roadway | Location | Total_Count | Total_Volume | Diff | Ratio |
| 60226 | SBI24 | Clarksville Hi-Load Links | 26,628 | 27,751 | 1,123 | 0.042 |
| 60230 | NBI24 | Clarksville Hi-Load Links | 26,628 | 26,386 | -242 | -0.009 |
| 59686 | US41A | KY border | 37,139 | 36,795 | -344 | -0.009 |
| 59802 | US41A | No of downtown area | 47,838 | 48,192 | 354 | 0.007 |
| 59840 | US41A | East of downtown area | 20,276 | 19,374 | -902 | -0.044 |
| 60228 | US41A | SE of TN76 | 18,249 | 18,815 | 566 | 0.031 |
| 60348 | US41ABY | So of downtown area | 18,312 | 16,634 | -1,678 | -0.092 |
| 59761 | TN13 | So of downtown area | 21,903 | 22,547 | 644 | 0.029 |
| 60146 | TN12 | SE of US41BY | 5,880 | 6,310 | 430 | 0.073 |
| 61096 | TN76 | W of I24 Interchange | 26,093 | 26,473 | 380 | 0.015 |
| 60878 | TN374 | TN374-Warfield | 18,281 | 17,739 | -542 | -0.030 |
| 60677 | TN374 | TN374-101 Airborne | 31,070 | 30,079 | -991 | -0.032 |
| 60835 | TN374 | TN374-Purple Heart | 10,710 | 11,210 | 500 | 0.047 |
| 60255 | TN237 | W of I24 Interchange | 9,093 | 9,450 | 357 | 0.039 |
| 59643 | US79 | Wilma Rudolf s of I24 | 36,729 | 36,095 | -634 | -0.017 |
| 60053 | US79 | NE of downtown | 34,934 | 35,186 | 252 | 0.007 |
| 60160 | TN236 | S of KY border | 23,300 | 23,168 | -132 | -0.006 |
| 60204 | TN48 | S of TN236 | 15,477 | 15,595 | 118 | 0.008 |
| | | | 428,540 | 427,799 | -741 | -0.002 |
| **Statewide Model Border with Nashville MPO Model Border (North)** | | | | | | |
| ID | Roadway | Location | Total_Count | Total_Volume | Diff | Ratio |
| 51791 | SBI24 | Cheatham-Davidson | 27,048 | 26,596 | -452 | -0.017 |
| 57992 | NBI24 | Cheatham-Davidson | 27,048 | 23,891 | -3,157 | -0.117 |
| 51768 | US41A | Cheatham-Davidson | 3,759 | 4,779 | 1,020 | 0.271 |
| 58231 | TN249 | Cheatham-Davidson | 2,457 | 620 | -1,837 | -0.748 |
| | | | 60,312 | 55,886 | -4,426 | -0.073 |
| **Statewide Model Border with Nashville MPO Model Border (South)** | | | | | | |
| ID | Roadway | Location | Total_Count | Total_Volume | Diff | Ratio |
| 52302 | SBI24 | Bedford-Rutherford | 19,016 | 19,562 | 546 | 0.029 |
| 57989 | NBI24 | Bedford-Rutherford | 19,016 | 18,201 | -815 | -0.043 |
| 52193 | US231 | Bedford-Rutherford | 15,236 | 15,011 | -225 | -0.015 |
| 53698 | US70S | Cannon-Rutherford | 10,437 | 10,360 | -77 | -0.007 |
| 58206 | TN269 | Bedford-Rutherford | 840 | 840 | 0 | 0.000 |
| 58864 | TN99 | Cannon-Rutherford | 588 | 648 | 60 | 0.102 |
| 53668 | US41 | Bedford-Rutherford | 1,649 | 1,649 | 0 | 0.000 |
| | | | 66,782 | 66,271 | -511 | -0.008 |

**Table 3.3: Link Validation of Base Year Traffic Assignment (Continued)**

| Statewide Model Roadways Along I-24 Between Nashville MPO and Chattanooga MPO | | | | | | |
|---|---|---|---|---|---|---|
| ID | Roadway | Location | Total_Count | Total_Volume | Diff | Ratio |
| 58143 | TN55 | No of I24 | 13,986 | 13,837 | -149 | -0.011 |
| 53724 | TN55 | So of I24 | 15,771 | 15,400 | -371 | -0.024 |
| 53729 | SBI24 | TN55-TN127 | 18,212 | 18,862 | 650 | 0.036 |
| 57945 | NBI24 | TN55-TN127 | 18,212 | 15,123 | -3,089 | -0.170 |
| 58120 | TN127 | No of I24 | 3,413 | 3,527 | 114 | 0.033 |
| 55025 | TN50 | No of I24 | 2,678 | 2,667 | -11 | -0.004 |
| 53796 | TN50 | So of I24 | 5,187 | 5,208 | 21 | 0.004 |
| 57844 | SBI24 | No of Monteagle | 16,968 | 17,063 | 95 | 0.006 |
| 57919 | NBI24 | No of Monteagle | 16,968 | 14,217 | -2,751 | -0.162 |
| 53832 | AltUS41 | E of I24 Interchange | 8,012 | 8,142 | 130 | 0.016 |
| 55034 | AltUS41 | W of I24 Interchange | 8,012 | 8,060 | 48 | 0.006 |
| 54963 | TN2 | Dixie Lee Hwy no of I24 | 8,337 | 8,320 | -17 | -0.002 |
| 53939 | SBI24 | So of US72 | 23,625 | 22,231 | -1,394 | -0.059 |
| 57867 | NBI24 | So of US72 | 23,625 | 21,547 | -2,078 | -0.088 |
| 57888 | US72 | No of I24 | 17,997 | 17,944 | -53 | -0.003 |
| 57890 | US72 | So of I24 | 25,326 | 25,221 | -105 | -0.004 |
| 58056 | TN28 | No of I24 | 8,159 | 4,152 | -4,007 | -0.491 |
| | | | 234,488 | 221,521 | -12,967 | -0.055 |
| Statewide Model Border with Chattanooga MPO Model Border (South) | | | | | | |
| ID | Roadway | Location | Total_Count | Total_Volume | Diff | Ratio |
| 57851 | SBI24 | No of GA Border | 24,796 | 24,272 | -524 | -0.021 |
| 54010 | NBI24 | No of GA Border | 24,796 | 23,678 | -1,118 | -0.045 |
| 58033 | TN134 | No of GA Border | 1,355 | 1,272 | -83 | -0.061 |
| 54950 | US41 | Marion-Hamilton | 3,717 | 3,714 | -3 | -0.001 |
| 54969 | TN27 | Marion-Hamilton | 4,484 | 4,626 | 142 | 0.032 |
| 58704 | US127 | Sequatchie-Hamilton | 4,736 | 4,669 | -67 | -0.014 |
| 58476 | TN111 | Sequatchie-Hamilton | 10,133 | 10,122 | -11 | -0.001 |
| | | | 74,017 | 72,353 | -1,664 | -0.022 |

## 3.2 Nashville MPO

This macro-scale model covers the six-county Nashville Metropolitan region. It was supplied to the I-24 Multimodal Corridor Study team by the Metropolitan Nashville Planning Commission. The models furnished to the study team were updated from a base and future year of 2008/2035 to a base and future year of 2010/2040 to study the I-24 Corridor. The MPO model's input data sets were only modified for the base year and future year shifts to 2010 and 2040. This update entailed the following modifications:

- Interpolated and extrapolated zonal socio-economic data from 2008/2035 to 2010/2040;
- Updating the appropriate external trip model parameters to represent 2010 external station volumes; and,
- Reviewing the highway network against TDOT's 2010 'Geometric Characteristics' table and GIS street centerline file.

### *3.2.1 Network Review*

I-24 is modeled in the Nashville network as a set of separate one-way link pairs from the entry point in the northwest (Montgomery County), through downtown Nashville to its exit from the region in Bedford County. High Occupancy Vehicle (HOV) lanes are modeled as separate one way links with short connector links joining them to the general purpose lane links. In the Nashville MPO model region, I-24 has 35 interchanges or access/egress connections and all 35 are included in the base year network.

All 35 interchange points are modeled with one way links representing entry, exit and loop ramps. All major surface roads connecting to/from I-24 are represented in the model. All major surface roads running parallel to I-24 and/or interconnecting to roads connected directly to I-24 are represented in the model. The level of network detail in the Nashville MPO model is sufficient to support the modeling needs of the I-24 Multimodal Corridor Study.

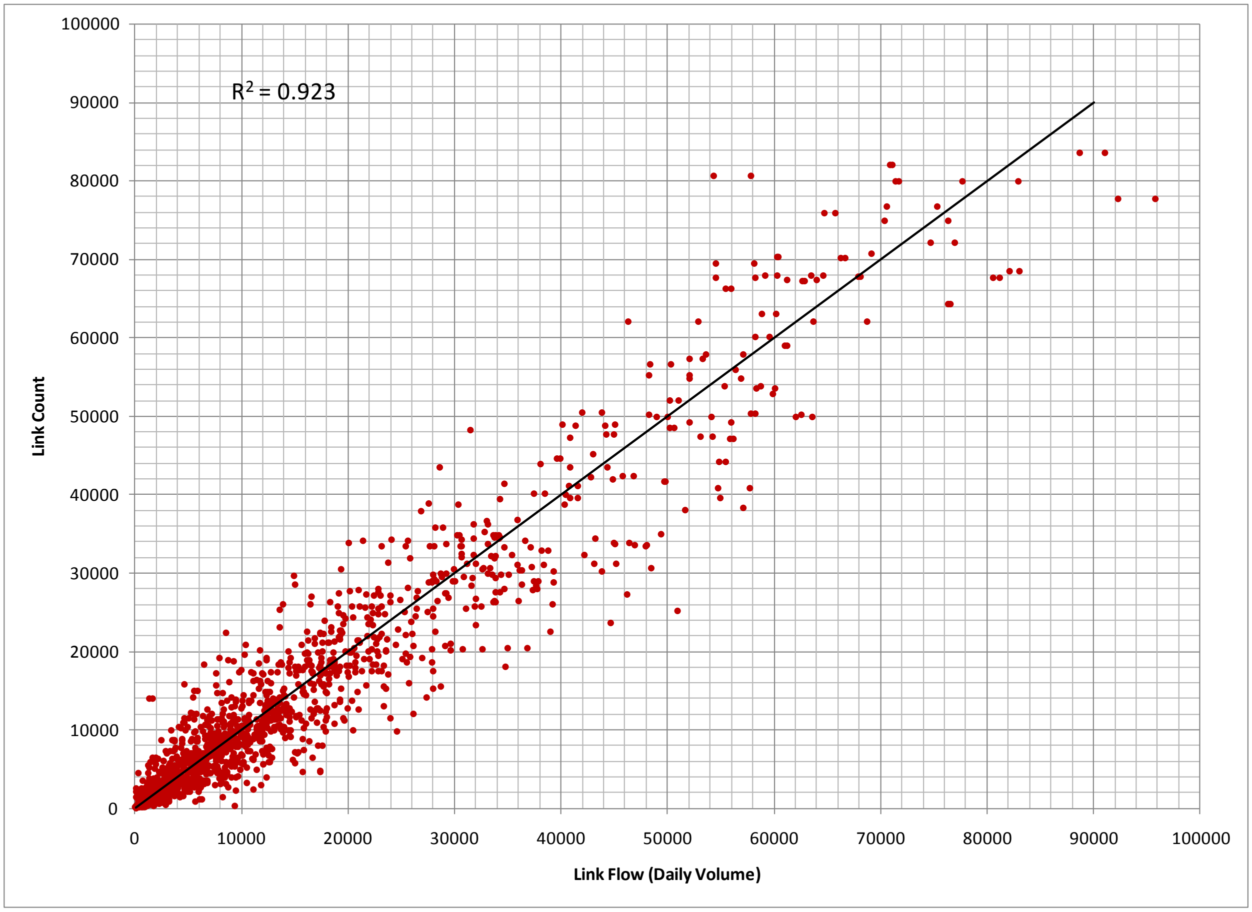
### *3.2.2 Zones Review*

A review of the zonal boundary structure used in the Nashville model shows that there are generally two or more zones on each side of I-24 located between most pairs of consecutive interchanges. The locations where this is not the case are generally near downtown Nashville where zones are already relatively small and well connected to the main roadways interchanging with I-24. It is recommended that these zones be left as currently coded for the study of I-24.

### *3.2.3 2010 Update Process*

Upon completing the model update, a “Counted Volume” equals “Modeled Volume” line diagram with plotted modeled volumes was assembled from the updated base year 2010 traffic assignments. This was performed to ensure that the study team did not inadvertently worsen the modeling capabilities of the Nashville MPO travel demand model in the process of updating it. Results of the line diagram and plotted points diagram are displayed in Figure 3.5. The model appears to be generating sufficiently accurate and reliable traffic assignments to proceed with it in the I-24 Multimodal Corridor Study.

**Figure 3.5: Line Diagram and Scatter Plot of Modeled Volumes (Nashville MPO Model)**




Source: Metropolitan Planning Commission and Atkins for I-24 Multimodal Corridor Study

## 3.3 Chattanooga MPO

The I-24 Multimodal Corridor Study modeling team did not have to make adjustments to this MPO model because it was recently updated to 2010 and 2040 base and future horizon years.

### *3.3.1 Network*

I-24 is modeled in the Chattanooga network as a set of one-way link pairs from the entry point in the west, just north of the Georgia border, to its junction with I-75 on the east side of downtown and near the Georgia border. In the Chattanooga MPO model region, I-24 has 14 interchanges or access/egress connections and all 14 are coded in the modeled network.

All 14 interchange points are modeled with one way links representing entry, exit and loop ramps. All major surface roads connecting to/from I-24 are represented in the model. All major surface roads running parallel to I-24 and/or interconnecting to roads that interchange with I-24 are represented in the model. The I-24 corridor analysis area should include I-75 segments both north and south of the I-24 interchange because traffic operations on those sections could impact the quality of travel on I-24. Review of the I-75 coding found that the level of detail included in the network is the same as for I-24. South on I-75 from the I-24 merge to the model boundary in Georgia there are 6 interchanges and all 6 are included in the model network. North on I-75 from the I-24 merge to the model boundary there are 7 interchanges and 6 of these are represented in the model network. The one interchange not included in the model network appears to be a relatively new interchange at Apison Pike/County Hwy 387/Volkswagen Drive that supports a new Volkswagen facility to the west of I-75. If this interchange was operational in 2010 it should be added to the 2010 base year network. The level of network detail in the Chattanooga MPO model is sufficient to support the modeling needs of the I-24 Multimodal Corridor Study.

#### *3.3.2 Zones*

A review of the zonal boundary structure used in the Chattanooga model shows that there are generally two or more zones on each side of I-24 located between most pairs of consecutive interchanges. The locations where this is not the case are at the outer edge of the network between I-59 and SR-299 and are mostly rural/agricultural in character with very little additional roadway infrastructure beyond what is already in the model network. Another area is in downtown Chattanooga along I-24 between the US-27 merge and 4th Avenue. In this area the zones are relatively small and well connected to the main roadways intersecting I-24. It is recommended that these zones be left as currently coded. The level of zonal disaggregation used in the Chattanooga MPO model is sufficient to support the modeling needs of the I-24 Multimodal Corridor Study.

### 3.4 Application

The modeling team was not able to summarize results from the three separate traffic assignment models without applying a uniform method of calculating link-level travel speed, congestion and delay statistics. Link-level performance attributes output by the respective models' traffic assignments are calculated differently and would not provide the I-24 Multimodal Corridor Study team with effectiveness measures for links with similar geometric and volume attributes in Chattanooga as in Nashville or Coffee County. To resolve this incompatibility, post traffic assignment processing of highway link performance attributes in all three macro-scale models used the Tennessee Statewide Model methodology.

System-level traffic assignment results are presented in Table A-1 in the appendix for the base year 2010 and future year 2040 baseline model scenarios. These performance measures include "Total Daily VMT", "Daily Truck VMT" and "Total Daily Vehicle Hours of Delay" grouped by generalized functional classification and by Model Analysis Subarea. Although specific performance measures are being vetted by the study team at this particularly time, some of the model-related performance measures being considered are listed in Table 3.4.

**Table 3.4: Potential Macro-scale Model Performance Measures**

| No. | Descriptive Name |
|---|---|
| 1 | Vehicle miles of travel by facility type |
| 2 | Vehicle hours of travel by facility type |
| 3 | Vehicle hours of delay by facility type |
| 4 | Average system speed by facility type |
| 5 | Percent trucks |
| 6 | Vehicle hours of delay per 1000 vehicle miles of travel |
| 7 | Operating Costs |
| 8 | Travel Time Costs |
| 9 | Percent of households having access to jobs within 30 minutes via automobile |
| 10 | Vehicle miles of travel by trucks |
| 11 | Truck vehicle hours of travel |
| 12 | Truck vehicle hours of delay per 1000 vehicle miles of travel |
| 13 | Tons of freight moving through the study area by truck |
| 14 | Tons of freight moving through the study area by rail and |
| 15 | Tons of freight moving through the study area by water |

Two thematic maps illustrating the adequacy of existing capacity on sections of I-24 are depicted in Figures 3.6 and 3.7 for 2010 and 2040, respectively. The capacity maps are not intended to illustrate performance measures. They are only presented to show modeled congestion and delay using a prominent facility as an example. The reliability of system-level performance measures are predicated on reasonable link-level model results. There are three different colored bands indicating different levels of capacity sufficiency based on the daily traffic assignments of autos and trucks and the daily capacity.

**Figure 3.6: Modeled Base Year 2010 Capacity Sufficiency on I-24**

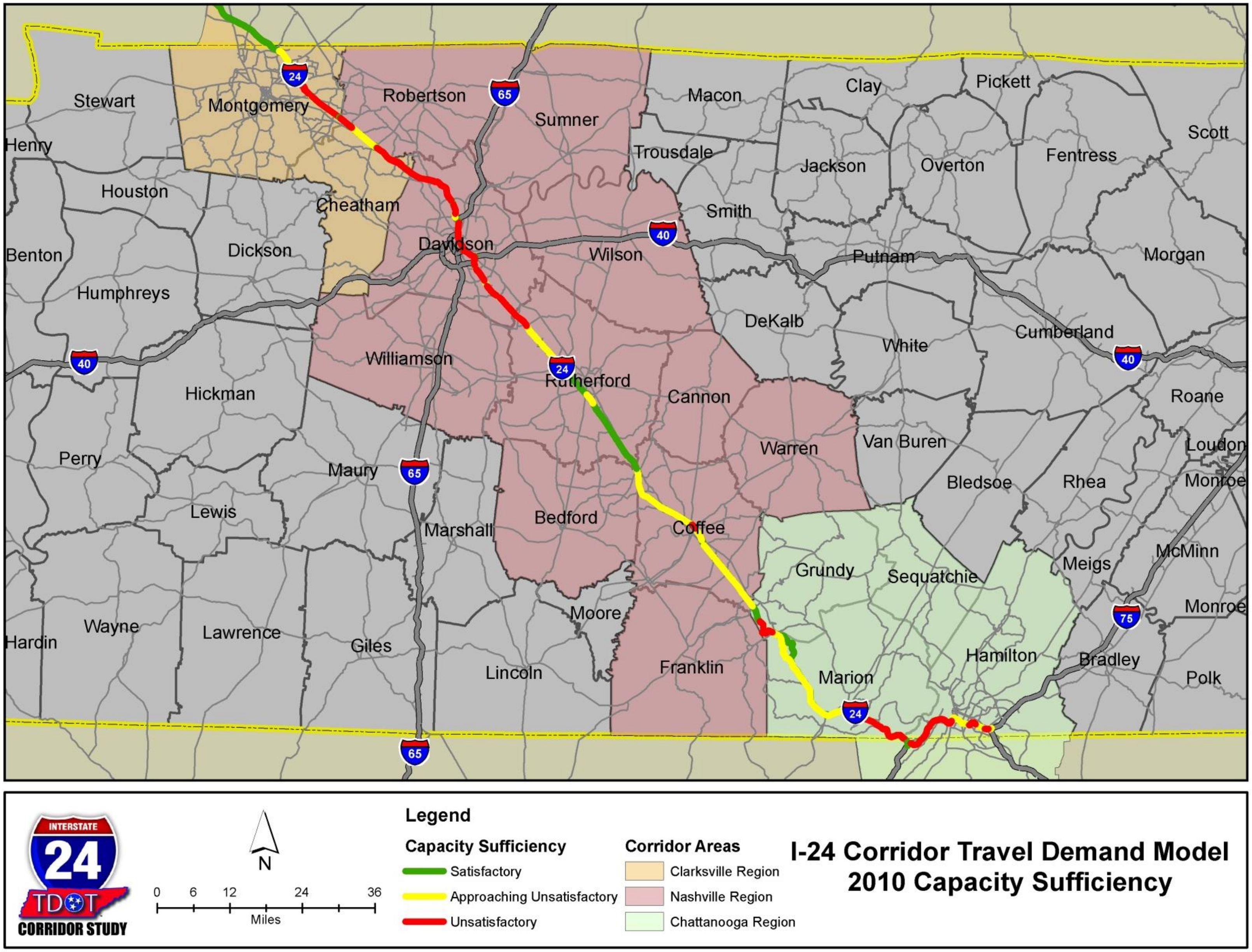
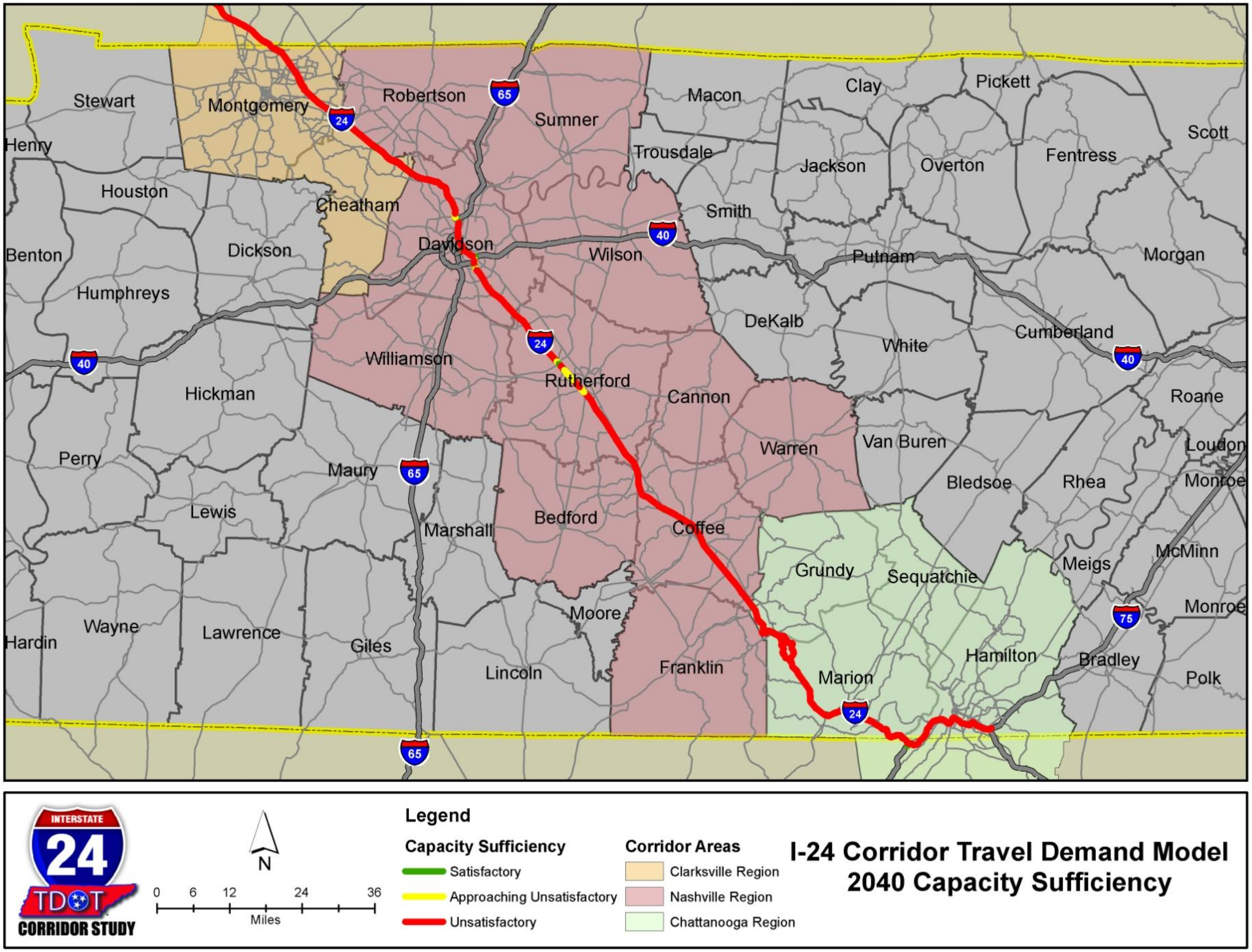


**Figure 3.7: Modeled Future Year 2040 Capacity Sufficiency on I-24**



# 4.0 Tier II Consolidated I-24 Corridor Model

This phase of the I-24 Multimodal Corridor Study modeling process is designed to convert trip and network data from the Tier I macro-scale process into a mesoscopic-scale model for an analysis area defined by a narrow bandwidth along the entire length of the study corridor.

## 4.1 Macro-Model Consolidation

The first step in building the mesoscopic model is converting individual networks and trip tables into a single, consolidated macro-scale model whose analysis area is coincident with a union of the three macro-scale models. This task will include a validation test to ensure that the consolidated macro-scale model produces traffic assignment output that is essentially the same or equivalent to the traffic assignment data generated individually by the Statewide, Nashville MPO and Chattanooga MPO models.

### *4.1.1 Network*

Constructing a single model network for the entire model study area is a simple GIS merge process using the three macro-scale model highway line files, in theory. This assumes that portions (subareas) of the Statewide Model network overlaying the Nashville and Chattanooga MPO model areas are removed from the Statewide Model network.

In practice, the most difficult part of this task was indentifying the highway line file and endpoint file attributes from each macro-model that would go into the consolidated I-24 Corridor model and then populating those attributes. This is not a trivial task because some of the variable attributes selected to be in the consolidated I-24 Corridor Model network were coded differently in their respective macro-scale model network files.

### *4.1.2 Trip Tables*

Auto and truck trips going into the new consolidated trip table will come from all three macro-models. The long distance trips that hold the consolidated model's trip table together will come from the Statewide Model since that is the only source of full-length trips that have origins and/or destinations external to the MPO regions. Just like the process of building the consolidated network, where links and endpoints inside MPO areas needed to be removed, Statewide Model trips that are totally internal to the Nashville and Chattanooga MPO regions will be removed from the Statewide Model prior to consolidation. These specific trips, in turn, will be replaced by the corresponding internal trips from the MPO model trip tables. This cut, paste and merge process will produce full-coverage auto and truck trip tables of 24-hour, daily travel patterns.

### *4.1.3 Validation*

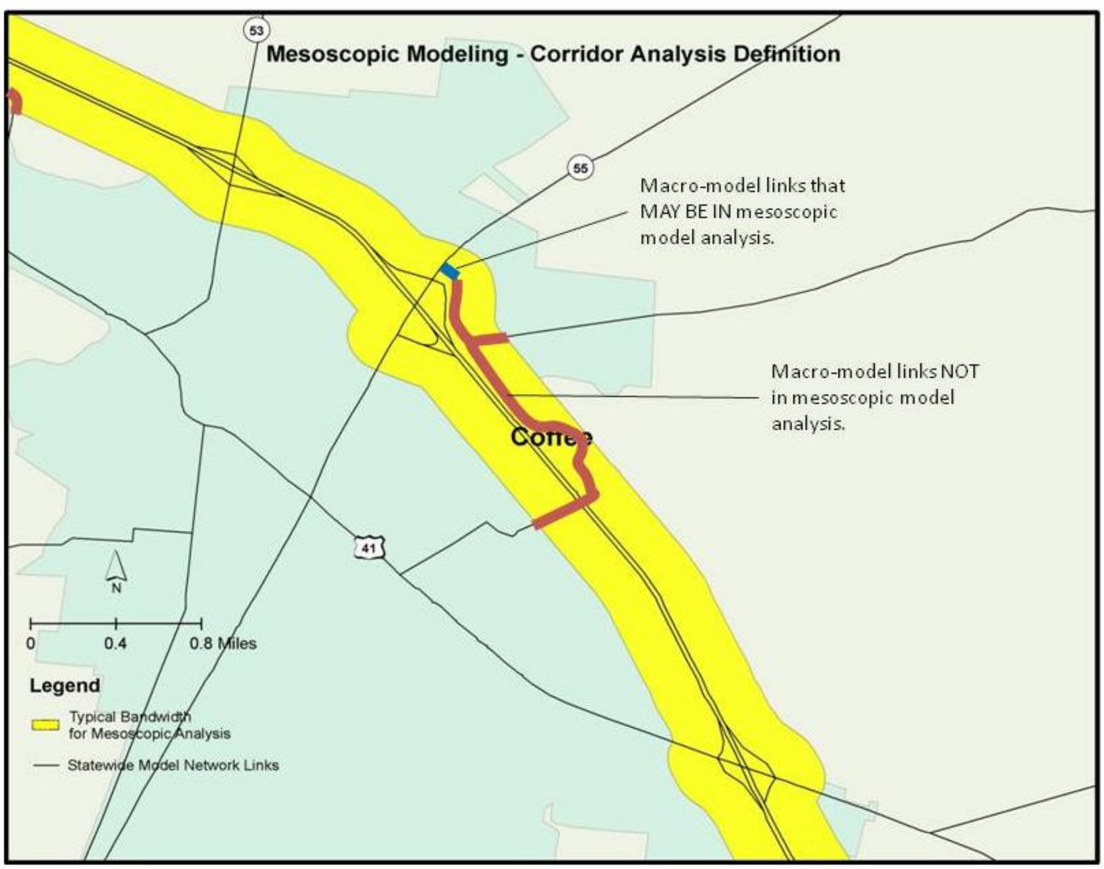
A Root Mean Square Error (RMSE) test will be done comparing modeled daily traffic assignment volumes from the consolidated model with their counterparts in the macro-scale traffic assignment files. The RMSE sample of links will predominantly be comprised of directional, I-24 mainline links and freeway-to-freeway ramp locations in the I-24 Corridor but will also include other high volume roadways that interchange with I-24. The sample will also reflect spatial considerations over the length of the corridor.

## 4.2 Mesoscopic Model

Operational performance measures on I-24, itself, will be calculated using a mesoscopic-scale modeling process. TransModeler (TM), another product in Caliper Corporation's family of traffic analysis software, simulates the movements of all vehicles modeled through a network for a defined model time period and for defined time intervals within the model period. TM computes simulation segment and node characteristics during a given time interval to determine how a particular vehicle should progress in its path at one of three levels of fidelity (detail): Macro, Meso or Micro. Operational performance on sections of I-24 will be analyzed using the meso-level of fidelity in its segments and nodes.

A bandwidth map depicting the anticipated corridor analysis area is presented in Figure 4.1 for a section of I-24 skirting Manchester in Coffee County. Roads located inside the yellow corridor band but that are not explicitly legs of intersections formed by the ramp termini, like the blue and rust colored lines, will be evaluated separately by the model team to determine their presence or absence in the mesoscopic simulation network.

**Figure 4.1: I-24 Corridor Band Defining Mesoscopic Analysis Links**



The steps required to implement the recommended mesoscopic modeling in the I-24 Multimodal Corridor Study are listed below:

1. Define a subarea network along the I-24 corridor (as depicted by Figure 4.1) and run the Tier II model to extract a 24-hour trip table for the subarea;
2. Import the corridor subarea network into TM as the simulation network, setting all freeway, ramp and interchanging cross-streets to the mesoscopic fidelity-level and all other links and nodes as macro fidelity;
3. Apply time-of-day (TOD) factors to the corridor's subarea trip table to produce hourly trip tables. The TOD factors will be consistent with peak hour factors in TDOT's traffic database as well as travel demand model TOD factors used in the Chattanooga MPO and Nashville MPO models;
4. Select a 3 hour peak period to model based on the 3 sequential hours with the most trips, most likely the PM peak period from 3:00 to 6:00, and create peak period trip table matrices for autos and trucks;
5. Import the period trip tables to TM and define traffic distribution curves for the peak period to create trip table matrices by time segment (15 minute segments);
6. Initially, using all default settings and parameters suitable for the meso-level of TM fidelity, setup and run a dynamic traffic assignment (DTA) for the 3-hour PM peak period;
7. Evaluate results and make adjustments as needed. The modeling team will make decisions about making refinements to add more detailed information to the network or to possibly scale-back the mesoscopic model size depending on the outcome of testing the entire I-24 corridor for a 3-hour PM peak period. The test may reveal that computer processing is too intensive for this prototype model to be an effective analysis tool;
8. Validation: The study team has access to estimated, as opposed to observed, peak hour volumes on all sections of I-24 from TDOT's traffic database. There are also available counts for most of the interchange ramps. The study team will make comparisons of mesoscopic model flow results in the corridor to the available count data and make adjustments to the model as appropriate;
9. Summarize selected output performance measures for the corridor. Identifying exactly what output data to summarize will need to focus on stated performance measures. However, there will be a substantial amount of additional information available from the mesoscopic simulation analysis, as well.

#### *4.2.1 Network*

Mesoscopic simulation in TransModeler (TM) is different from a traditional planning model's traffic assignment. Some of the network-related properties in TM simulation are explained below. A TM simulation network can be created by importing a TransCAD (TC) line network but requires some additional user input to make this happen. On input, the correspondence information between the functional class system in the input network and TM Road Class system must be provided; this includes the classification of centroid connectors. On import, TM creates a classification lookup table to maintain the correspondence between what is in the network and the TM Road Class system. TM has a set of predefined characteristics associated with its internal Road Class system that can be modified by the user for a given project.

A selection set of the nodes that are centroid nodes need to be created from the input network and this selection set is used on import to define the centroids and connectors in the simulation network. Lastly the modeling fidelity to be used in the simulation needs to be defined in the node table.

A TM simulation network includes a segment table that creates an association between links and nodes. A segment in TM is a little different than a segment in a planning network. In TM, a link is always made up of one or more segments. If the nodes at the opposite ends of a link have the same fidelity setting, then on import, TM will create one segment associated with the link in the segment table and give it the same fidelity setting as the nodes. If the nodes have differing fidelity settings, then TM will create two segments in the segment table (essentially a split of the link but in the link table the link remains whole) each having the fidelity of the node to which it is connected. The segment table then includes both a segment ID and the link ID to which it is associated.

The simulation is applied at the segment level, so individual vehicles progress in the simulation from segment to segment. When importing from a TC network, a link would have at most two segments associated with it however more segments could be defined for a given link if needed.

#### *4.2.2 Intersections*

For mesoscopic and macroscopic modeling in TM, detailed intersection models can be coded but are not required. For this level of modeling it is recommended that a turning movement file be used and saturation flow rates be coded for all movements. In the absences of coded saturation flows for the movements, TM will apply default calculations of saturation flows and use these to compute an estimated delay for the turning movements. This is an aspect of model calibration and validation where the modeling team anticipates making some refinements, if the corridor study schedule permits.

#### *4.2.3 Trip Demand*

TM uses what it refers to as a Trip Data Table to represent demand which is not a trip table in the planning model context. A TM Trip Data Table can be created from one or more traditional trip tables but also requires paths and time period information. The Trip Data Table is a table of vehicle IDs containing a record for every trip to be simulated including Origin, Destination, Path and Departure Time.

Initially, the modeling team will have a 24-hour trip table for the subarea to be modeled that can be extracted from the Tier II model. TOD factors will be developed and applied to the 24-hour trip table to produce hourly trip tables. From the hourly trip tables, peak period auto and truck trip tables will be assembled and brought into TM. The definition of the model period will be based on an evaluation of the hourly trip tables but it is envisioned that a 3-hour peak period will be used. Within the model period, vehicle movements are simulated for a defined time interval and trip tables or trip flow rates need to be defined for each time interval. Initially, a 15 minute time interval will be used resulting in 12 modeled time intervals across the 3-hour model period. Depending on the computational and run time requirements of the model, it may be necessary to use 20 minute time intervals resulting in 9 modeled time intervals across the model period. TM allows the modeler to specify curves that can be applied to input trip tables to factor them by time interval. This allows for additional refinement of the vehicle trip flows within the model period.

#### *4.2.4 Simulation*

When a simulation is run, the modeler can either simulate the movement of vehicles based on the trips and paths that already exist in the TM Trip Data Table, which assumes the modeler has already run a simulation to generate the paths, or the modeler can generate a new set of paths to the Trip Data Table based on a new or updated set of path costs run in TM. Simulating from a Trip Data Table that already contains path information allows the application to bypass path building which is computationally intensive.

When running the simulation and building paths, there are three path building methods available: Deterministic, Stochastic and Probabilistic. All of these methods require an initial set of path costs (by time segment). It is recommended that a good set of observed segment travel times be used as the initial path costs; however, in the absence of this type of observed speed or time information free flow can be used but is not recommended. TM includes an initialization option which allows the simulation to run partially through the model period until the network reaches an initialized state. At this point travel costs are updated/initialized based on this level of network loading and the simulation is restarted and paths are rebuilt on this updated set of path costs. To reach a balanced or converged set of path costs the simulation can be run iteratively and path costs from successive iterations can be averaged until some defined level of convergence is reached. This is effectively dynamic traffic assignment and TM has built-in functionality for running the simulation iteratively to a converged state as a form of dynamic traffic assignment.

# 5.0 Appendix A

## Table A.1: System-level Highway System Performance by Model Analysis Subareas

| CLARKSVILLE REGION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | TOTAL VMT | | | TOTAL VHD | | | TRUCK VMT | | |
| **Functional Class** | **2010** | **2040** | **% Diff** | **2010** | **2040** | **% Diff** | **2010** | **2040** | **% Diff** |
| Interstates | 1,360,084 | 2,781,031 | 104% | 463 | 13,487 | 2812% | 335,028 | 1,174,374 | 251% |
| Expressway | - | - | - | - | - | - | - | - | - |
| Arterials | 2,739,820 | 5,007,252 | 83% | 5,512 | 45,414 | 724% | 213,269 | 289,743 | 36% |
| Collectors | 678,042 | 1,488,474 | 120% | 1,003 | 6,747 | 573% | 50,520 | 62,161 | 23% |
| Total | 4,777,945 | 9,276,756 | 94% | 6,978 | 65,647 | 841% | 598,817 | 1,526,278 | 155% |
| **NASHVILLE REGION** | | | | | | | | | |
| | TOTAL VMT | | | TOTAL VHD | | | TRUCK VMT | | |
| **Functional Class** | **2010** | **2040** | **% Diff** | **2010** | **2040** | **% Diff** | **2010** | **2040** | **% Diff** |
| Interstates | 18,591,435 | 23,799,767 | 28% | 16,878 | 48,146 | 185% | 3,346,178 | 5,042,903 | 51% |
| Expressway | 2,977,113 | 5,232,130 | 76% | 475 | 2,962 | 524% | 332,335 | 742,987 | 124% |
| Arterials | 18,059,410 | 25,303,668 | 40% | 32,913 | 86,784 | 164% | 465,610 | 867,142 | 86% |
| Collectors | 5,053,238 | 8,799,514 | 74% | 1,696 | 5,765 | 240% | 81,364 | 149,869 | 84% |
| Total | 44,681,196 | 63,135,079 | 41% | 51,962 | 143,657 | 176% | 4,225,487 | 6,802,901 | 61% |
| **CHATTANOOGA REGION** | | | | | | | | | |
| | TOTAL VMT | | | TOTAL VHD | | | TRUCK VMT | | |
| **Functional Class** | **2010** | **2040** | **% Diff** | **2010** | **2040** | **% Diff** | **2010** | **2040** | **% Diff** |
| Interstates | 5,816,941 | 8,307,495 | 43% | 4,829 | 24,002 | 397% | 1,132,292 | 2,073,651 | 83% |
| Expressway | 1,792,812 | 2,532,663 | 41% | 231 | 646 | 180% | 86,981 | 143,880 | 65% |
| Arterials | 6,368,580 | 9,196,307 | 44% | 5,030 | 23,781 | 373% | 172,190 | 268,031 | 56% |
| Collectors | 1,258,361 | 2,045,255 | 63% | 104 | 998 | 860% | 23,666 | 46,288 | 96% |
| Total | 15,236,694 | 22,081,719 | 45% | 10,193 | 49,427 | 385% | 1,415,129 | 2,531,849 | 79% |
| **TOTAL** | | | | | | | | | |
| | TOTAL VMT | | | TOTAL VHD | | | TRUCK VMT | | |
| **Functional Class** | **2010** | **2040** | **% Diff** | **2010** | **2040** | **% Diff** | **2010** | **2040** | **% Diff** |
| Interstates | 25,768,460 | 34,888,293 | 35% | 22,170 | 85,635 | 286% | 4,813,498 | 8,290,927 | 72% |
| Expressway | 4,769,925 | 7,764,793 | 63% | 705 | 3,609 | 412% | 419,316 | 886,867 | 112% |
| Arterials | 27,167,810 | 39,507,227 | 45% | 43,454 | 155,978 | 259% | 851,069 | 1,424,916 | 67% |
| Collectors | 6,989,640 | 12,333,243 | 76% | 2,803 | 13,510 | 382% | 155,551 | 258,317 | 66% |
| Total | 15,236,694 | 22,081,719 | 45% | 10,193 | 49,427 | 385% | 1,415,129 | 2,531,849 | 79% |