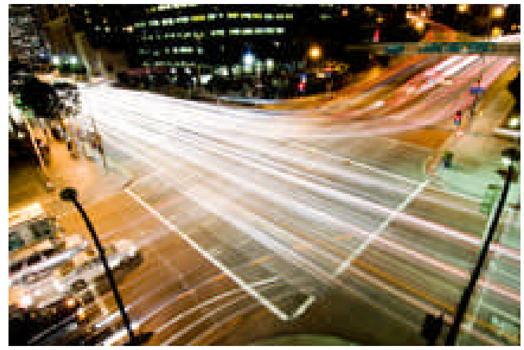
Prepared for:

SMTC

Prepared by:

RSG INC.
TRANSPORTATION



SMTC Travel Demand Model Version 3.023 Documentation

April 2012

DATA ■ ANALYSIS ■ SOLUTIONS

SMTC Travel Demand Model Version 3.023 Documentation

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

The Syracuse Metropolitan Transportation Council (SMTC) is the designated Metropolitan Planning Organization (MPO) for the greater Syracuse Metropolitan Region, which includes the City of Syracuse, Onondaga County, and small portions of Madison and Oswego Counties. SMTC is responsible for the development of the region's Long Range Transportation Plan (LRTP), Transportation Improvement Program (TIP) and Unified Planning Work Program (UPWP). These three items serve as the basis for transportation planning and programming in the region. This also involves conducting transportation planning and needs assessment studies as well as ensuring the LRTP and TIP conform to Air Quality Standards.

To assist with the conduct of these responsibilities SMTC maintains a Travel Demand Model ("the model"). The model was originally run in the Tmodel2 software package, which was installed and calibrated for the Syracuse region in the early 1990's. In 2004 SMTC retained the transportation consulting firm of Edwards and Kelcey to update the region's travel demand forecasting capabilities and build a new model using the TransCAD modeling platform. The completed model was installed onto the SMTC computers in 2005.

In 2009, SMTC retained Resource Systems Group (RSG) under the I-81 Travel Demand Modeling contract to review and update the model for use in the I-81 Alternatives Analysis project and to support the SMTC's other planning needs.

The purpose of this SMTC Travel Demand Model Documentation is to:

- Describe in detail the updated model's structure, input data, and parameter estimation,
- Present model validation results that demonstrate that the model is suitable for use as the SMTC's travel demand modeling tool, and
- Describe how the model meets the minimum requirements of and responds to the suggested good practices of federal and state guidelines.

2.0 MODEL OVERVIEW

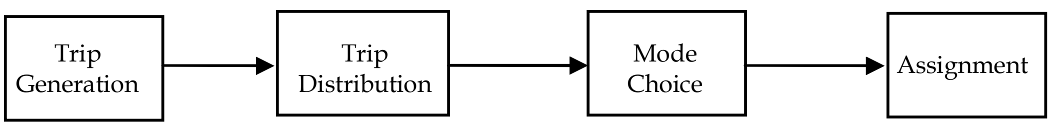
The model, now known as "SMTC Travel Demand Model, Version 3.023", estimates the movement of people and vehicles within the region during an average fall weekday in 2007. The 2007 model is a daily model that calculates daily traffic volumes based on four single hour traffic assignments. The 2007 model is based on updated housing and employment estimates from 2007, and includes revised highway and transit networks. The model uses the TransCAD 5.0 platform.

The model includes 972 internal Transportation Analysis Zones (TAZs) covering the City of Syracuse, Onondaga County, and small portions of Madison and Oswego Counties. Traffic entering and exiting the region does so through 51 external zones. Figure 3 shows the municipalities covered by the model.

2.1 Model Structure

The model is based on a four-step modeling process: trip generation, trip distribution, mode choice, and vehicle assignment (Figure 1). At the start of a full model run, trip generation uses land use data to calculate person trip ends at the TAZ level. These person trip ends are then paired into origins and destinations in the distribution model. In the next step, the person trips are split into each respective mode (e.g. auto, bus). Finally, the vehicle trips are assigned to the highway network in the assignment model.

Figure 1: 4-step Model Concept



The model has an important feedback loop, shown in Figure 2. Accessibility, which is a measure of the relative ease of travel, is calculated based on outputs from the assignment model and is an important determinant of trip distribution. Simply put, the decisions individuals make about where and how far to travel are a function of congestion levels and travel times. Therefore it is customary to iterate between the trip distribution and assignment models in order to reach a convergent solution. The iteration loop in Figure 2 occurs within a given simulation year.

The model is calibrated to reflect traffic conditions on an average weekday in September, 2007. September was chosen because it is a time during which public schools and colleges are in session, while seasonal (summer) traffic is still observed. The model is a daily model that performs a single hour traffic assignment in each of four time periods – AM peak (AM), midday off peak (MD), PM peak (PM) and evening off peak (OP) – so as to account for both travel across an entire day and to adequately depict peak hour congestion and off peak travel conditions. To accomplish this, the model relies on static time of day factors that divide the daily trips by hour for the purposes of assignment (the time of day split step in Figure 2).

Figure 2: SMTC Model Structure

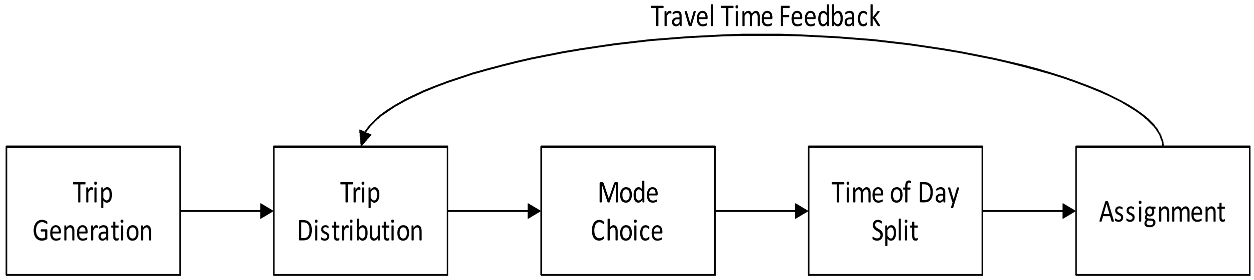


Figure 3: SMTC Model Region

While generally speaking the model is a traditional 4-step model, the modeling process itself consists of several steps worth noting. Each of the steps below will be discussed in-depth later in this report.

- **Daily trip generation**, which calculates the number of person trip ends generated by and attracted to each zone for each of the four trip purposes (home based work, home based shopping, home based other and non-home based trips).
- **Daily trip distribution**, which pairs the trip-ends for each zone for each of the four trip purposes. The result of this is a person trip table for each trip type. One output of trip distribution is the person trip table for home to work that can be compared to the "Journey-to-Work" data provided by the Census Bureau.
- **Mode choice model** calculates which mode the person trips are likely to take based on availability and mode-specific parameters (e.g. time, cost, transit frequency). Mode choice provides a breakdown of person trips by mode. The mode choice model is developed based on observed data on mode preferences and what those preferences imply about sensitivities to mode attributes.
- **Time of day (diurnal) distribution**, which takes the daily trip matrices and converts them to trip matrices by time period (e.g. AM peak hour). Trips by time of day have been estimated using the 2004 SMTC Household Travel Survey and the 2001 National Household Travel Survey (NHTS).
- **Vehicle assignment,** which locates the best routes between each origin/destination pair and assigns the vehicle trips accordingly. Important outputs of this step include the number of vehicles on each roadway segment. Several other pieces of data can be extracted, including operating speeds, travel times, vehicle miles traveled (VMT), vehicle hours traveled (VHT), and volume to capacity ratios (V/C ratios) on links and at intersections.
- **Highway/transit skim builder** finds the best available travel path via auto and transit, and describes the attributes of the best paths for each of those modes (i.e. travel time, cost, distance, etc.). Skims are reasonable approximations of the travel time and cost between all pairs of TAZs. The path-finding algorithms are calibrated based on observed travel paths and observed relationships between volumes and congested speeds.

3.0 ZONE SYSTEM AND DATA

3.1 TAZ System

The SMTC model is a zone-based forecasting tool, modeling traffic flows between transportation analysis zones (TAZs). The model includes a total of 1023 TAZs. Table 1 shows a breakdown of the TAZ structure: 972 cover the 41 municipalities and the Onondaga Nation in the SMTC region, while traffic entering and exiting the region does so through 51 external zones. Of the internal TAZs, most are in Onondaga County, which accounts for the majority of the SMTC region. The quantity of households and employment in each of these zones is used to develop estimates of the trips produced by and attracted to them. Sixteen TAZs are special generators, which are specific locations such as Syracuse Airport, Hospitals and large educational institutions that are modeled differently than zones containing more typical residential and commercial land. External TAZs are used to generate traffic at the cordon of the SMTC region. The 51 external TAZs are located where major roadways cross the SMTC region boundary. Traffic counts recorded at these points are used as input data to modeling trip generation at these locations, which is discussed in Section6.0.

Table 1: TAZ Summary

	Description	Number of Zones
Within SMTC MPA	Onondaga County*	912
	Outside Onondaga County	44
	Special Generators	16
	Total in MPA	**972**
External Stations		51
Total in Model		**1023**

*Excluding special generator TAZs

The previous version of the model included 697 TAZs, of which 646 were internal and 51 external. The model update included splitting internal TAZs at appropriate locations, for example where TAZs were bisected by arterial roads, in order to increase the spatial accuracy of household and employment locations. Figure 4 shows the TAZ structure for the SMTC region.

In the SMTC model, some of the socioeconomic, trip production and trip attraction attributes are maintained in the TAZ geographic file. The attributes associated with the TAZs are listed in Table 2. The development of these data are discussed in Section 3.2.

Figure 4: SMTC Region TAZ Structure

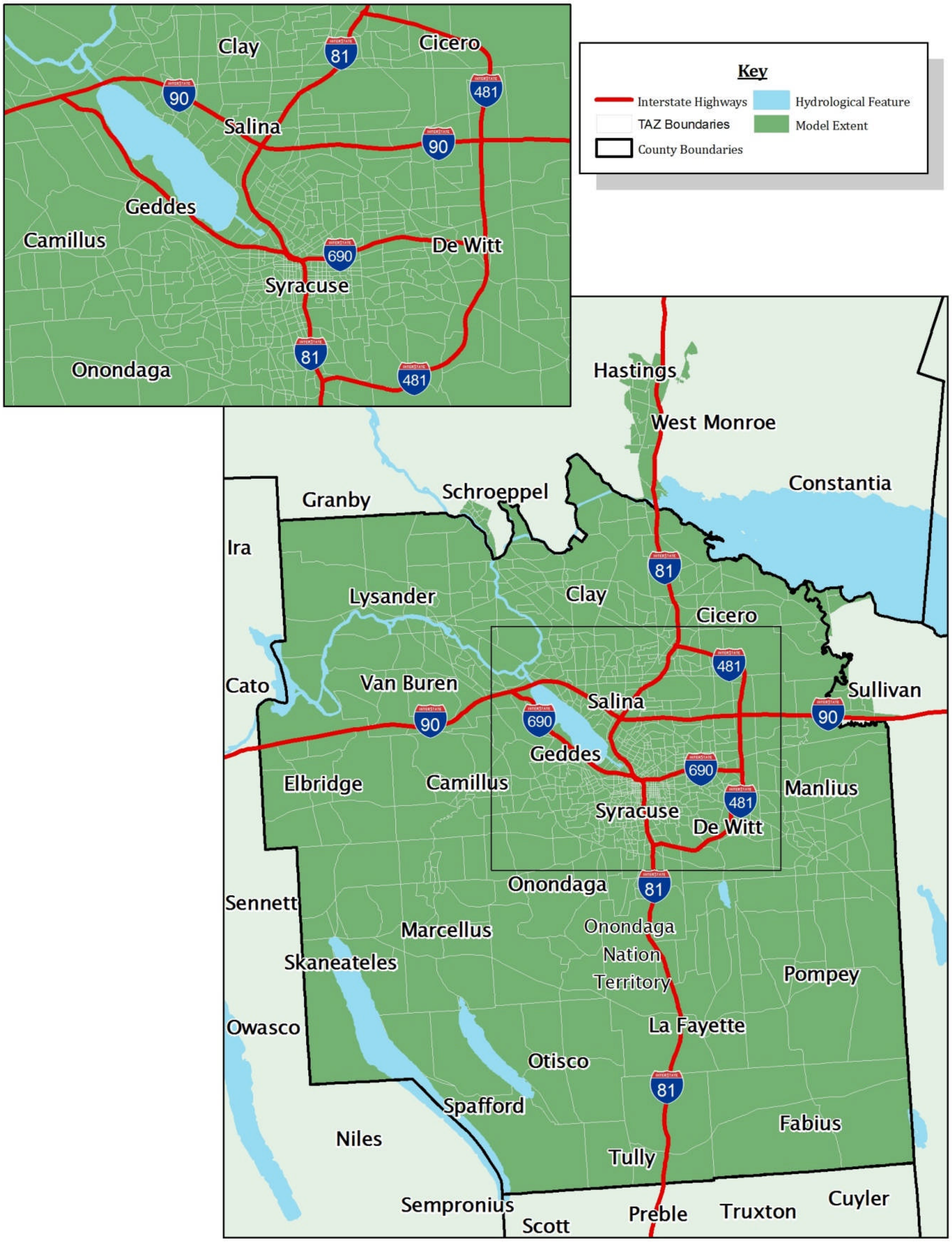


Table 2: TAZ Attributes

Field	Description	Update Type
ID	TAZ identification number	Immutable
AREA	TAZ Area (square miles)	User-maintained
TAZ	TAZ identification number	User-maintained
ZONE_TYPE	Zone type	User-maintained
TOWNEXTSTATION	Town name	User-maintained
DESCRIPTION	Description	User-maintained
OUTSIDE_ONONDAGA	Onondaga Indicator	User-maintained
TRANSIT_ZONE	Transit Zone Indicator	User-maintained
AREA_TYPE	Area Type	User-maintained
POPULATION	Population (persons)	User-maintained
HOUSEHOLDS	Households	User-maintained
VEHICLES	Vehicles	User-maintained
VEHICLES/HH	Vehicles per household	User-maintained
[0_1]	0 vehicle, 1 person households	User-maintained
[0_2]	0 vehicle, 2 person households	User-maintained
[0_3]	0 vehicle, 3 person households	User-maintained
[0_4+]	0 vehicle, 4 or more person households	User-maintained
[1_1]	1 vehicle, 1 person households	User-maintained
[1_2]	1 vehicle, 2 person households	User-maintained
[1_3]	1 vehicle, 3 person households	User-maintained
[1_4+]	1 vehicle, 4 or more person households	User-maintained
[2_1]	2 vehicle, 1 person households	User-maintained
[2_2]	2 vehicle, 2 person households	User-maintained
[2_3]	2 vehicle, 3 person households	User-maintained
[2_4+]	2 vehicle, 4 or more person households	User-maintained
[3+_1]	3 vehicle, 1 person households	User-maintained
[3+_2]	3 vehicle, 2 person households	User-maintained
[3+_3]	3 vehicle, 3 person households	User-maintained
[3+_4+]	3 vehicle, 4 or more person households	User-maintained
HBW_P	Home-based work trip productions	Computed
HBW_A	Home-based work trip attractions	Computed
HBS_P	Home-based shopping trip productions	Computed
HBS_A	Home-based shopping trip attractions	Computed
HBO_P	Home-based other trip productions	Computed
HBO_A	Home-based other trip attractions	Computed
NHB_P	Non-home-based trip productions	Computed

Field	Description	Update Type
NHB_A	Non-home-based trip attractions	Computed
BICYCLE & PEDESTRIAN PERCENT	Walk-bike percentage	User-maintained
BICYCLE & PEDESTRIAN_P	Walk-bike trip productions	Computed
TOTAL_MOTORIZED_P	Total motorized trip productions	Computed
TOTAL_P	Total trip productions	Computed
TOTAL_MOTORIZED_A	Total motorized trip attractions	Computed
AGRICULTURAL	Agricultural sector employees	User-maintained
BUS_LEGAL_PERSONAL	Business, Legal, Personal sector employees	User-maintained
COMMUNICATION	Communication sector employees	User-maintained
CONSTRUCTION	Construction sector employees	User-maintained
EAT_DRINKING	Eating, Drinking sector employees	User-maintained
EDUCATION	Education sector employees	User-maintained
FIRE	Financial, Insurance, Real Estate sector employees	User-maintained
GOVERNMENT	Government sector employees	User-maintained
HEALTH	Health sector employees	User-maintained
HOTELS_LODGE	Hotels, Lodging sector employees	User-maintained
MANUFACTURING	Manufacturing sector employees	User-maintained
MINING	Mining sector employees	User-maintained
NONCLASSIFIABLE	Non-classifiable sector employees	User-maintained
RETAILTRADE	Retail sector employees	User-maintained
SERVICE	Service sector employees	User-maintained
SOCIALSERVICES	Social Services sector employees	User-maintained
TRANSPORTATION	Transportation sector employees	User-maintained
UTILITIES	Utilities sector employees	User-maintained
WHOLESALETRADE	Wholesale sector employees	User-maintained
TOTAL	Total employees	User-maintained
DAILY_TOTAL	Daily total trip productions	Computed
TERMINALTIME	Terminal Time (minutes)	User-maintained
DOWNTOWN_DISTRICT	District Indicator	User-maintained

3.2 Socioeconomic Data

Socioeconomic data are essentially the number of households and jobs that are located in each of the model's TAZs. The number of households and jobs are the key explanatory variables of the number of trips produced and attracted to each TAZ. Therefore, if the model is to reflect travel in the region it is important to correctly locate and quantify households and jobs. Furthermore, the change in land use – growth or decline in the number of household and jobs – is the key driver of changes in the amount of regional travel between the base and future forecast years.

A multistep process was undertaken to develop the base and future year data:

- Conversion of the model's forecast years: the base year was moved forward from 2003 to 2007, and the future year was moved forward from 2027 to 2035.

- The change in forecast years meant that the base year and the future year household and employment data had to be updated. This involved:
    - SMTC holding a series of meetings with municipalities and planning agencies in the region to collect information on housing construction and employment changes between 2003 and 2007, and on forecast changes in housing and employment out to 2035
    - Analysis of other data sources such as 2000 Census and 2010 Census data, parcel data, employment databases, and regional population and employment forecasts
    - The data sources were blended to develop base year TAZ level estimates of housing and employment by industrial classification and future year forecasts of the same variables.
- The addition of more detail to the TAZ system to more accurately place employment and households required the disaggregation of employment and households where TAZs were split.

The remainder of this section describes each step in the process of developing the socioeconomic data in more detail and presents regional summaries of the socioeconomic data.

3.2.1 Data Collection

Collecting and verifying housing and employment data is a very intensive process and requires input from local experts. As was done during the 2004 model update, the SMTC met with local officials and professionals with experience in demographic analysis and/or knowledge of local demographic conditions.

The socioeconomic data update outreach was completed over a several week period in the spring of 2010 and included representatives from various geographic levels. The SMTC met with the Empire State Development Corporation and the New York State Department of Labor to understand current conditions and trends at the state level. The Central New York Regional Planning and Development Board, Syracuse-Onondaga County Planning Agency, Onondaga County Office of Economic Development, CenterState Corporation for Economic Opportunity, City of Syracuse Department of Neighborhood and Business Development, City of Syracuse Industrial Development Agency and the City of Syracuse Bureau of Planning & Sustainability provided feedback on socioeconomic data at the city, county and region level. Additionally, the SMTC collected information from local representatives from the Towns of Camillus, Cicero, Clay, DeWitt, Lysander, Manlius, Onondaga, Salina and Van Buren. These municipalities were determined to be the most dynamic in regards to household and employment change over the 28 year modeling period.

Socioeconomic information that was previously gathered, during a similar effort in 2004, was presented to these representatives in tabular and graphic format. Each representative had the opportunity to review and comment on the previous work to update the datasets to the new base and horizon model years. Comments were collected and compiled into a single database and the appropriate changes were made to the base and horizon year datasets.

The existing 2003 and 2027 model data proved to be a valuable dataset on which to base this model update. The development of these data in 2004 utilized New York State Department of Transportation (NYSDOT) forecasted employment data created by Global Insight. In addition to the database compiled during meetings with local representatives, other datasets were referenced to update the model data to 2007 and 2035:

- 2000 U.S. Census data on households at the block level (U.S. Census Bureau)
- 2010 U.S. Census data on households at the block level (U.S. Census Bureau)
- 2007 U.S. Census American Community Survey (ACS) 3-year data on households (U.S. Census Bureau)
- 2009 parcel data for Onondaga County (Syracuse-Onondaga Planning Agency)
- 2009 Business Location Analysis Tool (BLAT) data on employment (NYSDOT)
- 2007 Onondaga County employment totals by sector (New York State Department of Labor)
- 2006 aerial photography for household and employment location confirmation (NYSDOT)

Future year forecasts:

- 2016 employment projections by sector for Central New York (New York State Department of Labor)
- 2035 employment projections by sector and population projections for Onondaga County (Woods and Poole Economics, Inc.)
- 2035 population projections for Onondaga County (Cornell University Program on Applied Demographics)

3.2.2 Development of Base Year Households & Population

Prior to updating the model base year from 2003 to 2007 the 2003 household data were reviewed for accuracy and completeness. Parcel data and aerial photography were used to validate the placement of households in the 2003 TAZ structure[1].

The 3-year American Community Survey data for 2005-2007 and Census estimates for 2007 were used to develop 2007 control totals (which are totals for a large area that are known with relative confidence against which data from smaller spatial units can be compared and then adjusted to match) at the municipal level (where available) and at the county level. To refine data at the TAZ level a combination of local expert input and parcel data were used. The real property service parcel data includes structure "year built" information as well as land use classification. All residential properties that had a structure built during 2004-2007 were added to the 2003 household information in the TAZ to update to 2007 conditions. Information gathered during the local outreach was used to validate the parcel data at the identified locations. Group Quarters households are explicitly modeled as part of the population. Group Quarter household numbers at a TAZ level were developed by aggregating 2000 Census data.

Several adjustments were made to the 2007 household data for this version of the model, based on a review of 2010 Census data that became available after work on the 2007 socioeconomic data included in version 3.02 of the model. The most significant changes were an increase in the number of households in the City of Syracuse, which the 2010 Census showed did not decline as much as had been forecast and the reclassification of some multi-family housing as Group Quarters.

3.2.3 Development of Future Year Households & Population

The 2027 household and population data served as the basis for updating to 2035 conditions. The 2027 year household and population data were presented to local representatives for review and comment. The general consensus was to retain the 2027 conditions out to 2035 with a few exceptions. The local representatives identified site-specific locations of growth or decline in their geographic areas of expertise. This feedback was applied to the household data at the TAZ level and the remaining growth or decline, projected for 2035, was added and distributed using the previous model (2003-2027) growth rates. The 2027 household totals were used as the 2035 household control totals at the municipal and county level. These control totals (approximately 188,000 total households in Onondaga County - not including group quarters) were validated with results of a trend analysis using Decennial Census data, American Community Survey 3-year data, Cornell University projections, and Woods and Poole Economics projections. The projections for the City of Syracuse were adjusted in this version of the model based on the 2010 Census data showing a lower level of decline than had been expected and that has been incorporated in to the projections.

[1] For more information on how the 2003 household and population data was derived please refer to the SMTC Travel Demand Model Data Development Report (Version 1.2) dated November 2006. This report also describes the development of 2027 household and population data and 2003 and 2027 employment data

3.2.4 Development of Base Year Employment

The base year employment numbers for 2003 were taken from a refinement of the Business Location Analysis Tool (BLAT) data, provided by NYSDOT. The BLAT data are geocoded locations of business which include employment sector and employee information. The 2003 employment data were reviewed for accuracy and completeness prior to growing to 2007 conditions by comparing with the 2003 Census Local Employment Dynamics (LED) data, aerial photos and parcel data to correct any large discrepancies.

Local representatives were presented with employment data tables and maps to review and comment. The goal of this outreach was to review the current model conditions and to determine areas of growth and/or decline in regards to total employment and employment sector for the new model years. In some cases, local representatives were able to identify employment changes that occurred between 2003 and 2007. The remaining employment change, using the same rates as the 2003 to 2027 projections, was applied to the 2007 TAZ structure and then verified with the 2007 Census LED data. Additionally, 2009 BLAT data were used for verifying employer locations, employment sector and number of employees at the TAZ level. The final 2007 employment data were controlled at the county level using 2007 New York State Department of Labor employment data and at the municipal level using 2007 Census LED Data.

The employment sectors used in the 2003 model were retained for the updated employment data. The sectors are combinations of Standard Industrial Classification (SIC) codes. The sectors and corresponding SIC codes are shown in Table 3.

Table 3: Employment Sectors and SIC Codes

Employment Sectors	SIC Codes
Agriculture	0100 – 999
Mining	1000 – 1499
Construction	1500 – 1800
Manufacturing	2000 – 4000
Transportation	4100 – 4799
Communications	4800 – 4899
Utilities	4900 – 4999
Wholesale Trade	5000 – 5199
Retail Trade	5200 – 5799, 5900 – 5999
Eating and Drinking Establishments	5800 – 5899
Financial / Insurance / Real Estate	6000 – 6800
Hotels / Lodging	7000 – 7099
Business / Legal / Personal	7200 – 7400, 8100 – 8200, 8700 – 8799
Service (General)	8400 – 8500, 8600 – 8700, 8800 – 8999
Health Services	8000 – 8100
Educational Services	8200 – 8299
Social Services	8300 – 8399
Government	9100 – 9800
Non-Classifiable	9900+

3.2.5 Development of Future Year Employment

The previous horizon year (2027) employment data were developed using a combination of local knowledge and forecasted employment data created by Global Insight, provided by NYSDOT. Projecting the employment data using only the Global Insight data did not take into account all local considerations related to site-specific development plans. Therefore, during the meetings with local representatives they were asked to provide information on any economic development that had or was likely to occur between 2003 and 2027. These details were incorporated into the final projected 2027 TAZ level employment data.

The effort put into projecting the 2027 employment data was utilized for this current model update. During the outreach effort in the spring of 2010 it was determined that the employment numbers that were projected for 2027 were to be used in 2035. There was an overall consensus on this assumption due to current economic conditions that have slowed growth for several years and in some sectors have created a decline. In addition, local representatives provided updated information on site-specific development plans as well as projected job gains/losses by sector. Large potential but unapproved developments (such as future portions of DestiNY – additional commercial development adjacent to the Carousel Mall) have not been included in the future employment forecasts.

Based on information provided by the New York State Department of Labor, the projected annual growth rate for Central New York is 0.04%, which equals just over 1,000 jobs per year in Onondaga County. The 30,000 jobs (more than 1,000 jobs per year over a 28 year period) were distributed to TAZ's using previously projected rates and site-specific information collected during the outreach effort. Combining the previous efforts to develop 2027 forecasts with updated information resulted in an updated and refined 2035 employment dataset at the TAZ level.

3.2.6 Summary of Socioeconomic Data

The results of the socioeconomic data development process are shown in Table 4, which summarizes household and employment data by municipality[2]. The table shows that the number of households in the model region is projected to grow by 4% from 198,533 in 2007 to 211,603 in 2035, and the number of jobs in the model region is projected to grow by 12% from 252,753 in 2007 to 282,753 in 2035. Figure 5 and Figure 6 show 2007 and 2035 household density by TAZ, and Figure 8 and Figure 9 show 2007 and 2035 employment density by TAZ. Figure 7 and Figure 10 show the change in household density and employment density between 2007 and 2035 respectively. There is, generally, relatively little change in households in the City of Syracuse and growth in communities outside the City. Most employment growth is expected to occur (in absolute terms) in the City of Syracuse and towns such as Dewitt, Clay and Cicero. The growth rates of regional households and employment are lower than incorporated in the previous model, which forecast 5% growth in households and 26% growth in employment in 24 years (2003 to 2027), which conforms to the input received from local representatives.

3.2.7 Cross Classification of Household Data

The socioeconomic data development process created base and future year household numbers by TAZ. For trip generation purposes, the households are cross classified by household size and vehicle ownership (See section 6.2 for more details of the trip generation model). The base year cross classification was controlled using 2000 Census block group data. Each TAZ was joined to one of the 418 block groups composing the SMTC region and assigned with the corresponding block group's joint distribution of household size (1,2,3,4+ person households) and number of vehicles (0, 1, 2, and 3+ vehicles) as documented in Table 74 of the 2000 CTPP. Bucket rounding was applied across joint distributions and across TAZs to round to whole households.

The modeled population of Onondaga County derived from the cross classified households was confirmed to match closely to the 2007 population of 460,000 at an average of 2.42 people per household (based on U.S. Census population estimates). For the future year, forecast population is 470,500 in Onondaga County at an average of 2.37 people per household. The household size distribution was skewed lower in each TAZ so that this region wide population control was matched.

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[2] TAZ geography does not overlay exactly municipal geography; therefore data for certain municipalities may vary from actual conditions

Table 4: Households and Employment by Municipality in 2007 and 2035

		Households*				Employment			
		2007	2035	Change	% Change	2007	2035	Change	% Change
Town /City	Camillus	9,322	10,213	891	10%	5,394	6,433	1,039	19%
	Cicero	11,216	12,841	1,625	14%	11,318	13,198	1,880	17%
	Clay	22,299	24,614	2,315	10%	21,039	23,821	2,782	13%
	Dewitt	11,594	11,933	339	3%	45,091	49,499	4,408	10%
	Elbridge	2,484	2,627	143	6%	1,595	2,453	858	54%
	Fabius	701	834	133	19%	450	474	24	5%
	Geddes	7,531	7,513	-18	0%	8,171	9,017	846	10%
	Hastings	1,910	2,153	243	13%	1,565	1,795	230	15%
	Lafayette	1,939	2,168	229	12%	647	689	42	6%
	Lysander	7,756	9,891	2,135	28%	5,694	6,419	725	13%
	Manlius	13,264	15,031	1,767	13%	9,244	9,924	680	7%
	Marcellus	2,413	2,759	346	14%	1,312	1,434	122	9%
	Onondaga	8,376	10,387	2,011	24%	6,447	7,045	598	9%
	Onondaga Nation	288	317	29	10%	132	144	12	9%
	Otisco	903	1,043	140	16%	145	152	7	5%
	Pompey	2,271	2,602	331	15%	470	505	35	7%
	Salina	14,082	14,248	166	1%	20,815	22,056	1,241	6%
	Schroeppel	1,031	1,109	78	8%	886	940	54	6%
	Skaneateles	3,227	3,270	43	1%	4,533	5,014	481	11%
	Spafford	749	806	57	8%	37	52	15	41%
	Sullivan	1,084	1,311	227	21%	25	174	149	596%
	Syracuse	67,610	66,804	-806	-1%	103,197	116,443	13,246	13%
	Tully	1,116	1,244	128	11%	1,293	1,305	12	1%
	Van Buren	5,248	5,755	507	10%	3,253	3,767	514	16%
	West Monroe	119	130	11	9%	0	0	0	0%
County	Onondaga	194,389	206,900	12,511	6%	250,277	279,844	29,567	12%
	Madison	1,084	1,311	227	21%	25	174	149	596%
	Oswego	3,060	3,392	332	11%	2,451	2,735	284	12%
Total		198,533	211,603	13,070	7%	252,753	282,753	30,000	12%

*Household numbers include group quarters residents, with one group quarters resident equivalent to one household

Figure 5: Household Density in 2007

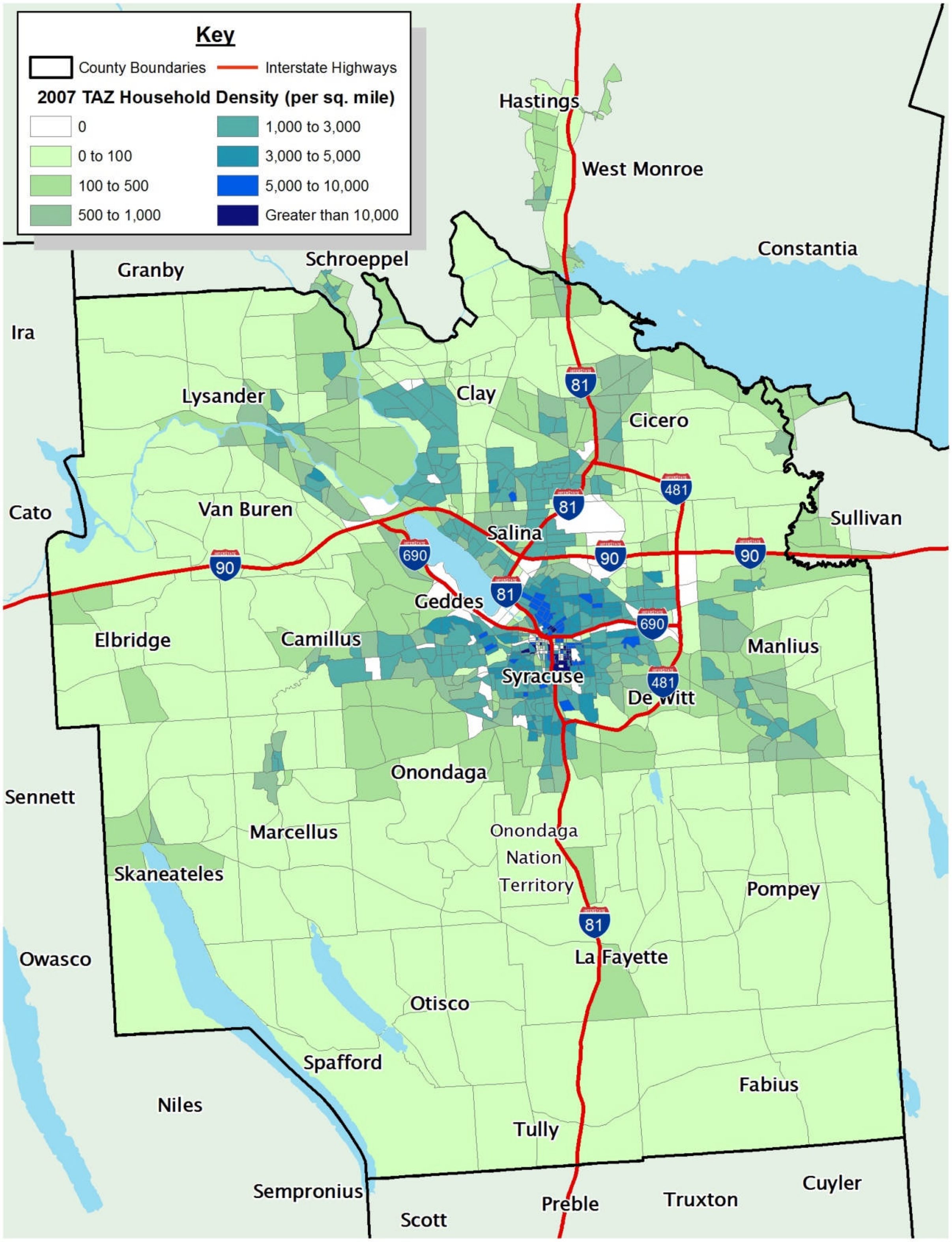


Figure 6: Household Density in 2035

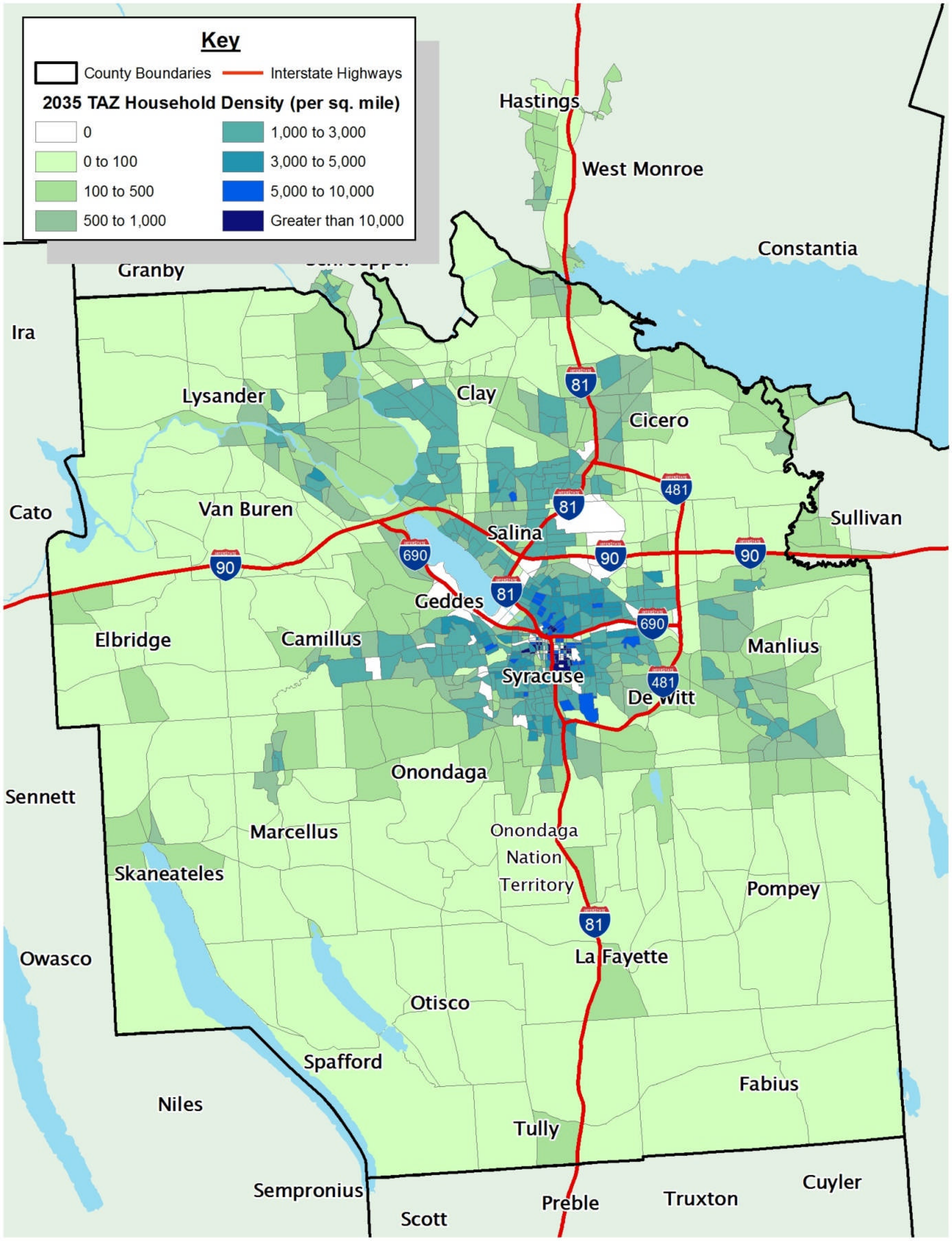


Figure 7: Change in Household Density between 2007 and 2035

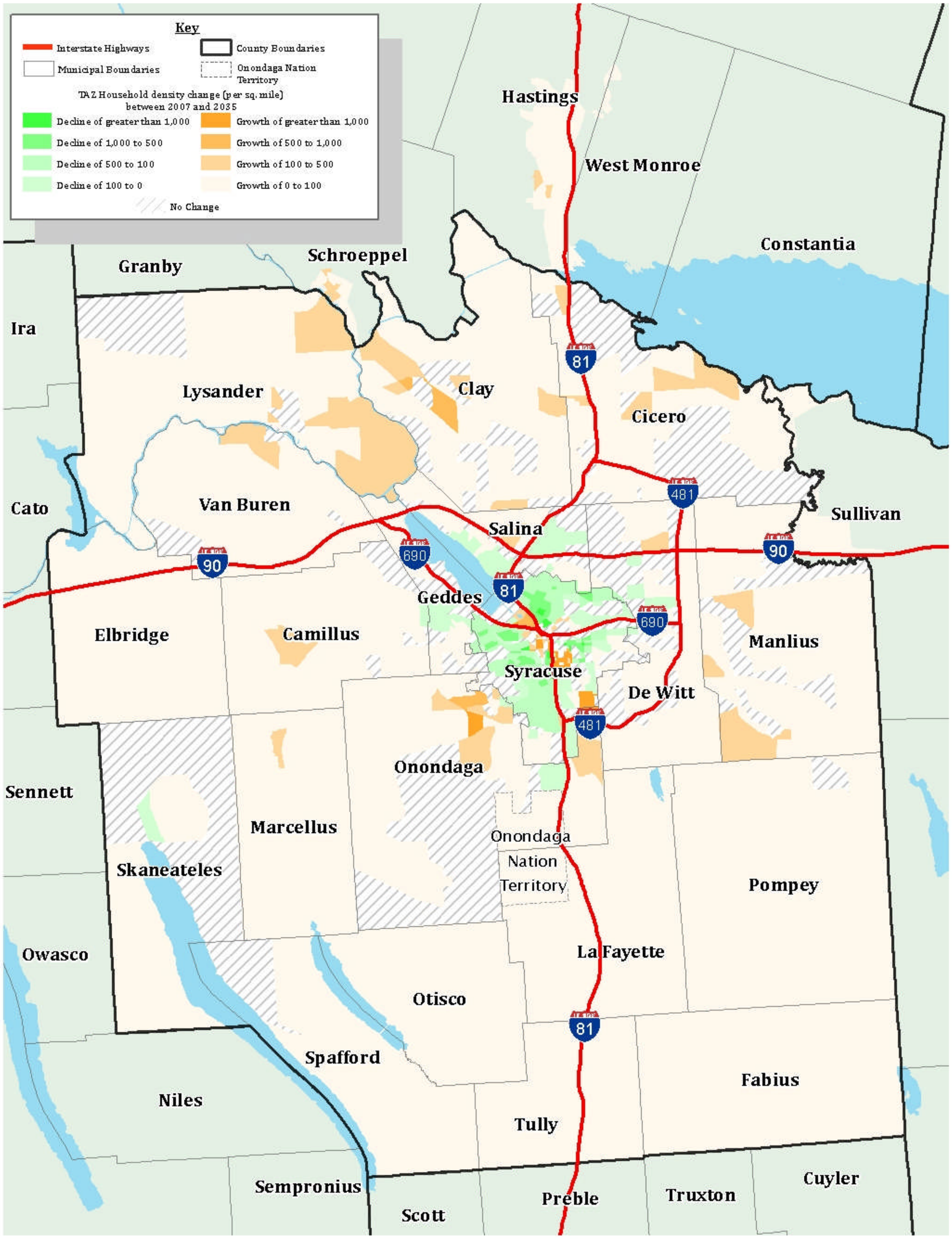


Figure 8: Employment Density in 2007

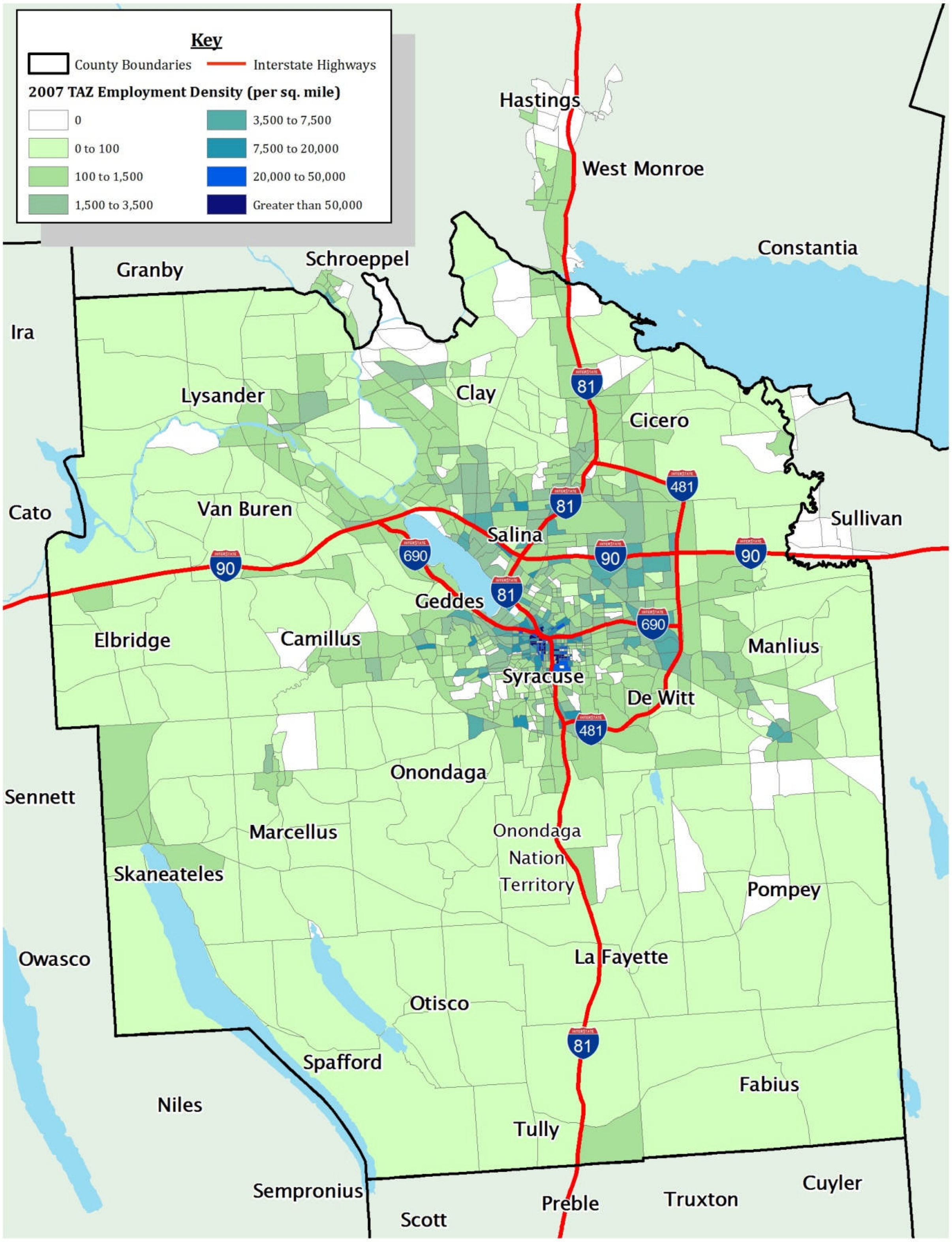


Figure 9: Employment Density in 2035

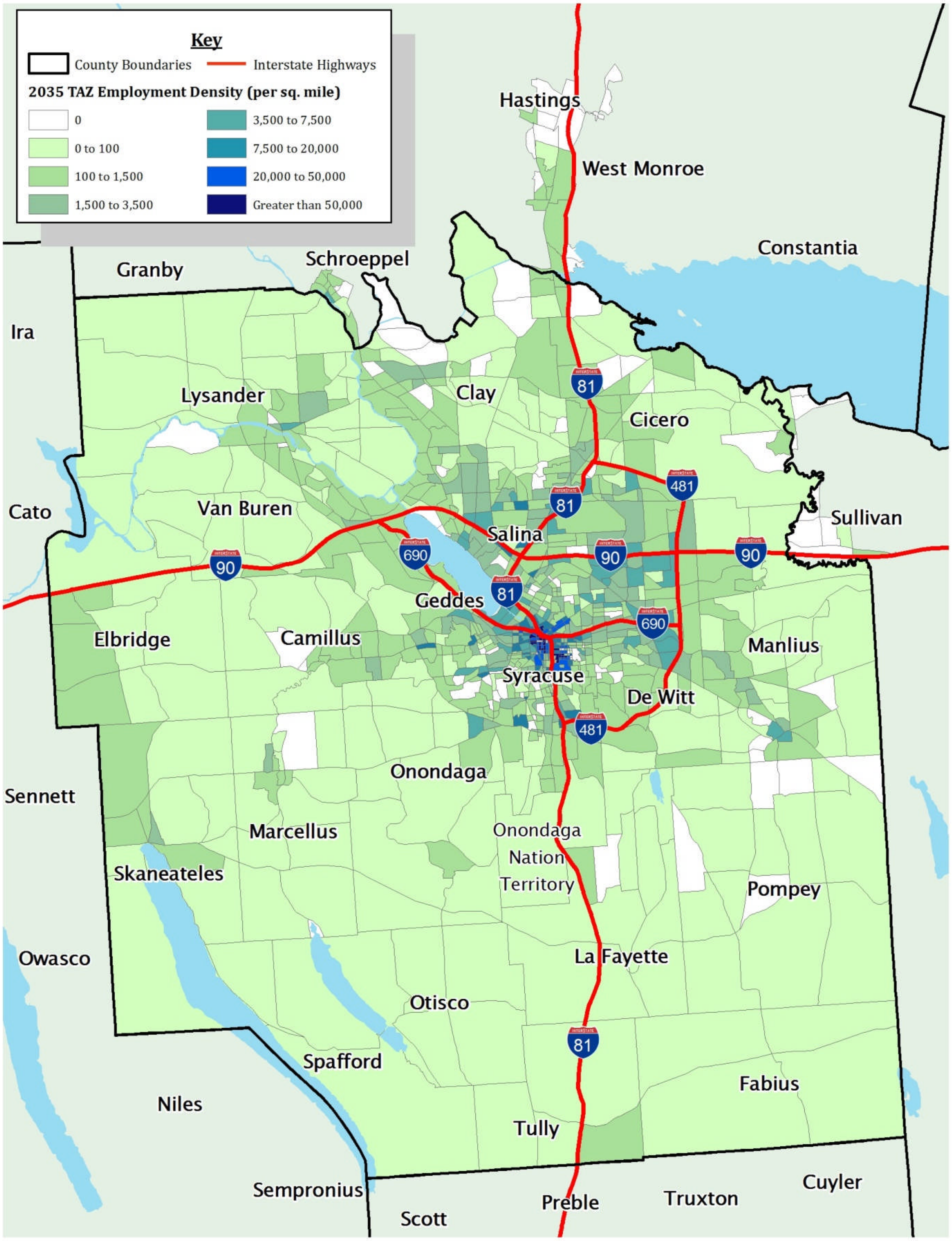
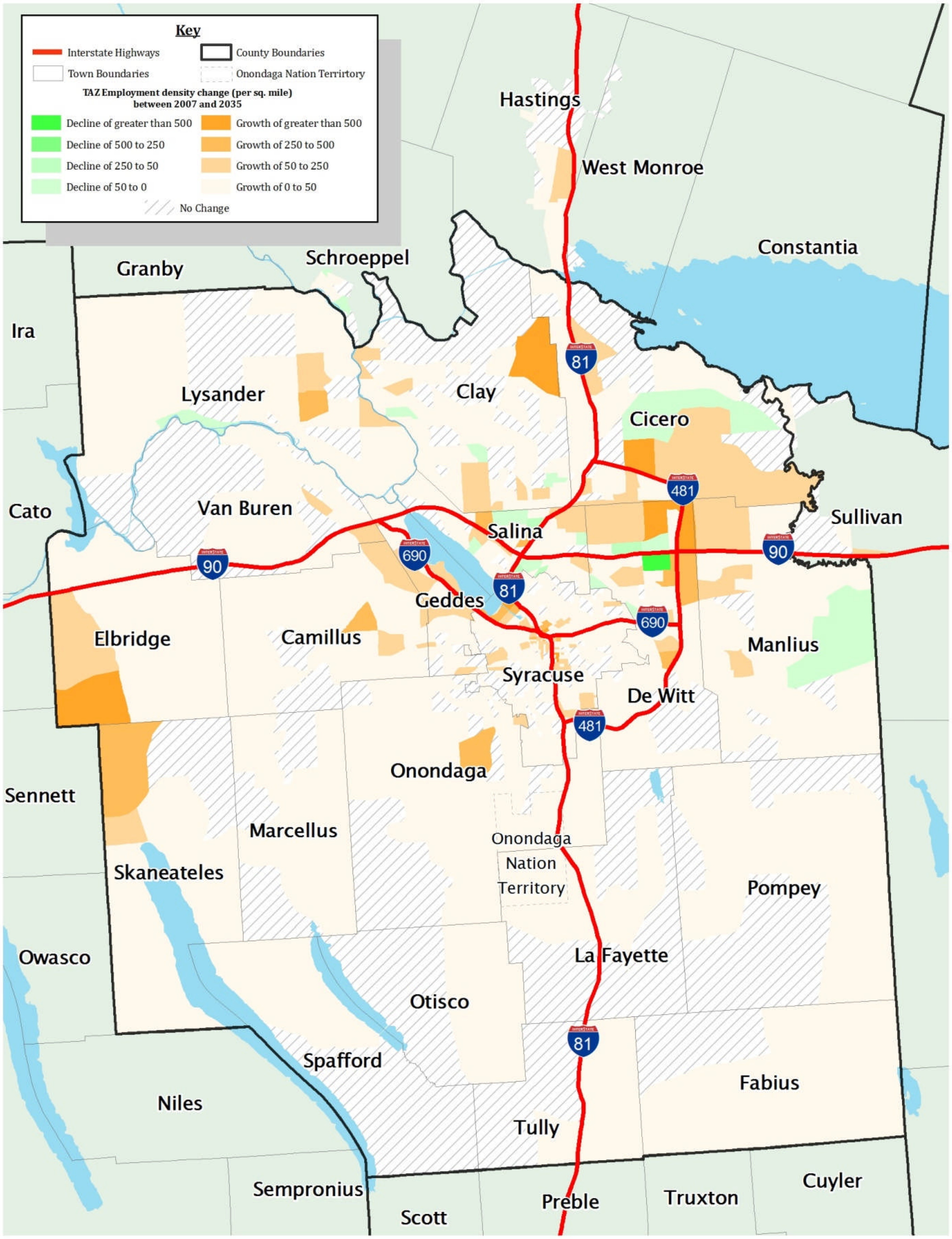


Figure 10: Change in Employment Density between 2007 and 2035



4.0 MODEL HIGHWAY NETWORK

For modeling purposes, a set of roadways within the modeling region was selected to reliably represent the entire highway network. In application, there are over 9,937 road segments represented as links, of which approximately 1,388 are one-way only. The model includes a limited number of local roads – most local roads are represented and accounted for in the model by centroid connectors that link TAZ centroids to the rest of the model's highway network. There are 7,568 endpoints (known as "nodes") in the model, which include intersections and TAZs. Figure 11 shows the highway network in the SMTC region. As part of this model update, SMTC refined the highway network. A combination of field verification and review of orthogonal and oblique aerial images were used to verify network attributes such as number of lanes, posted speeds, turn penalties and intersection types.

4.1 Network Attributes

In the SMTC model, some of the link and node attributes are maintained in the roadway geographic file while other attributes are maintained in lookup tables. The attributes associated with the links and nodes include:

- Functional classification
- Link direction, number of lanes, length, and tolls
- Link and node hourly capacities
- Free flow and congested speeds and travel times
- Turn prohibitions and turn penalties
- Area type, i.e. Syracuse, Urban, Other Census Designated Place, or Rural

Table 5 and Table 6 list the node attributes and the highway link attributes, respectively.

Table 5: Highway Node Attributes

Field	Description	Update Type
ID	Node identification code	Immutable
LONGITUDE	Longitude of node	Immutable
LATITUDE	Latitude of node	Immutable
CENTROID	Highway Centroid	User-maintained
Transit_CE	Transit Centroid	User-maintained
TAZ	TAZ number	User-maintained
MODEL_NODE	Model Node	User-maintained
TRANSIT_NODE	Transit Node	User-maintained
NODE_TYPE	Node type	User-maintained
HCAP	Intersection capacity (vph)	Lookup Table
DAILY_VOL	Daily model volume (vehicles)	Computed
AM_VOL	AM hour model volume (vehicles)	Computed
PM_VOL	PM hour model volume (vehicles)	Computed
AM_VOC	AM hour volume-capacity ratio	Computed
PM_VOC	PM hour volume-capacity ratio	Computed

Figure 11: SMTC Region Highway Network

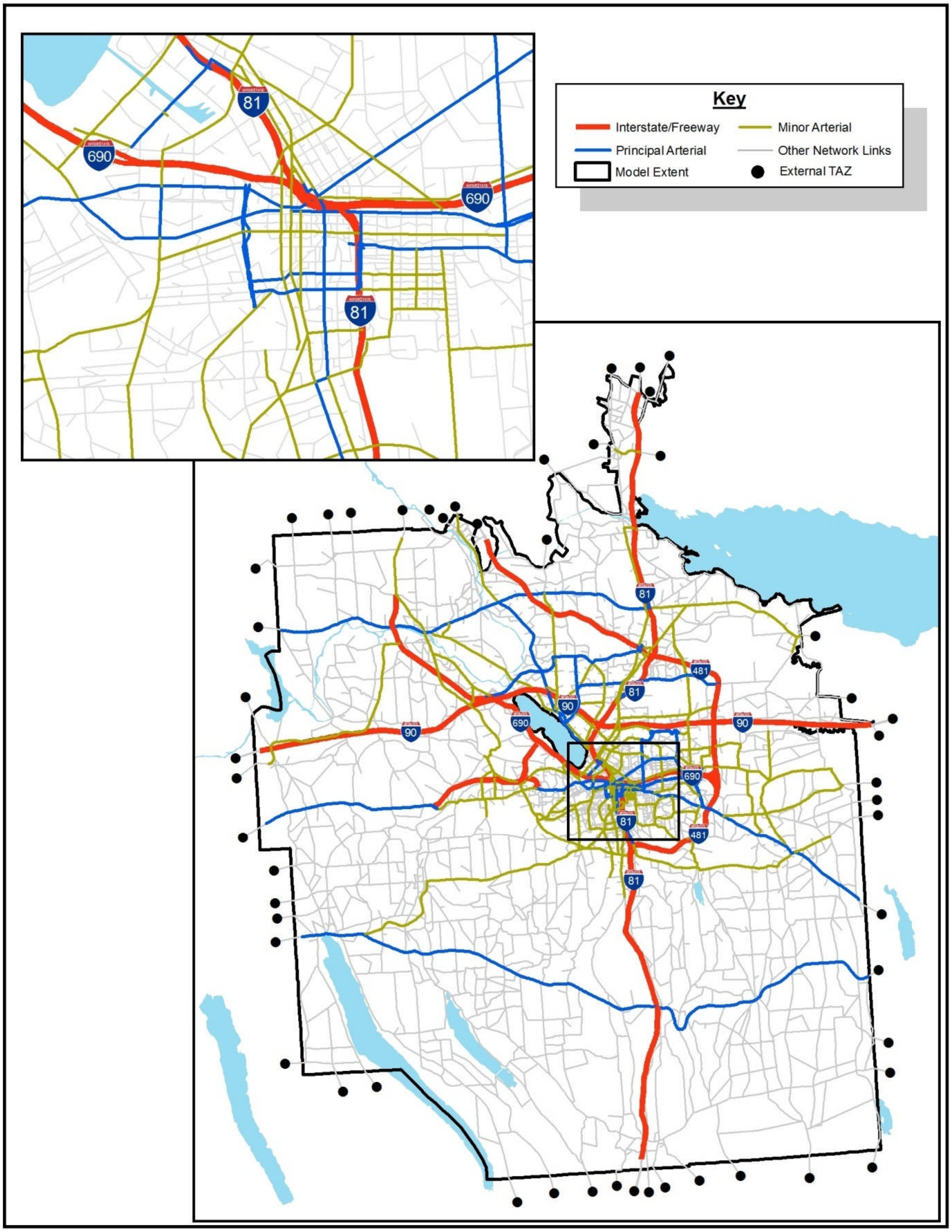


Table 6: Highway Link Attributes

Field	Description	Update Type
ID	Link identification code	Immutable
LENGTH	Link length (miles)	Immutable
DIR	Link Direction	User-maintained
NAME	Road name	User-maintained
FUNCLASS	Link functional class	User-maintained
NEW_UNQ	Join ID to MPA Road Network	User-maintained
MODEL_LINK	Mode link Indicator	User-maintained
CENTROID_CONNECTOR	Centroid Indicator	User-maintained
AB_LANES	Number of AB lanes	User-maintained
BA_LANES	Number of BA lanes	User-maintained
FUNCTIONAL_CLASS	Link functional class	User-maintained
MODELFUNCLASS	Model functional class	User-maintained
CLASS_NUM	Model functional class number	User-maintained
FREEWAY_SEGMENT	Freeway ID (access ramps only)	User-maintained
COUNTY	County	User-maintained
TOWNORCITY	Town	User-maintained
MUNICIPALITY	Municipality	User-maintained
CDP	Census Designated Place Indicator	User-maintained
UZA	Urban Area Indicator	User-maintained
TRANSIT_WALK_LINK	Walk Link Indicator	User-maintained
TRANSIT_WALK_TIME	Walk access/egress time (mins)	Computed
AB_TOLL	AB toll cost (dollars)	User-maintained
BA_TOLL	BA toll cost (dollars)	User-maintained
TOTAL_HCAP_FIXED	ABBA Lane capacity Override (vphpl)	User-maintained
AB_HCAP	AB link capacity (vph)	Lookup Table
BA_HCAP	BA link capacity (vph)	Lookup Table
FF_SPEED_FIXED	ABBA free-flow speed Override (mph)	User-maintained
AB_FF_SPEED	AB free-flow speed (mph)	Lookup Table
BA_FF_SPEED	BA free-flow speed (mph)	Lookup Table
AB_INT_HCAP	AB link intersection capacity (vph)	Lookup Table
BA_INT_HCAP	BA link intersection capacity (vph)	Lookup Table
AB_DAILY_COUNT	AB daily count (vehicles)	User-maintained
BA_DAILY_COUNT	BA daily count (vehicles)	User-maintained
ABBA_DAILY_COUNT	Two-way daily count (vehicles)	User-maintained
AB_AM_COUNT	AB AM hour count (vehicles)	User-maintained
BA_AM_COUNT	BA AM hour count (vehicles)	User-maintained
AB_PM_COUNT	AB PM hour count (vehicles)	User-maintained
BA_PM_COUNT	BA PM hour count (vehicles)	User-maintained
AB_DAILY_VOL	AB daily model volume (vehicles)	Computed
BA_DAILY_VOL	BA daily model volume (vehicles)	Computed
AB_AM_VOL	AB AM hour model volume (vehicles)	Computed

Field	Description	Update Type
BA_AM_VOL	BA AM hour model volume (vehicles)	Computed
AB_PM_VOL	AB PM hour model volume (vehicles)	Computed
BA_PM_VOL	BA PM hour model volume (vehicles)	Computed
QUERYTRIPS	ABBA Select Link Trips	Computed
AB_AM_VOC	AB AM hour volume-capacity ratio	Computed
BA_AM_VOC	BA AM hour volume-capacity ratio	Computed
AB_PM_VOC	AB PM hour volume-capacity ratio	Computed
BA_PM_VOC	BA PM hour volume-capacity ratio	Computed
AB_FF_TT	AB free-flow travel time (mins)	Computed
BA_FF_TT	BA free-flow travel time (mins)	Computed
AB_AM_TT	AB AM hour travel time (mins)	Computed
BA_AM_TT	BA AM hour travel time (mins)	Computed
AB_MD_TT	AB Midday hour travel time (mins)	Computed
BA_MD_TT	BA Midday hour travel time (mins)	Computed
AB_PM_TT	AB PM hour travel time (mins)	Computed
BA_PM_TT	BA PM hour travel time (mins)	Computed
AB_24H_VHT	AB Daily Vehicle Hours	Computed
BA_24H_VHT	BA Daily Vehicle Hours	Computed
MODE_USED	transit mode used (70)	User-maintained

4.1.1 Link Functional Classes

For modeling purposes, links are organized into 10 functional classes (Table 7). Links of the same functional class have similar speeds, capacities, and volume delay parameters. To allow aggregation of VMT for emissions calculations, the FHWA Functional Class designation (including urban/rural designation) is also maintained on the highway network for each link.

Table 7: Link Functional Classes

Model Class Number	FHWA Functional Class	MPA Lane Miles	Onondaga County Lane Miles	City of Syracuse Lane Miles
1	Interstate/Freeway	1,191.34	1,074.82	147.49
2	Principal Arterial	482.95	482.95	123.05
3	Minor Arterial	653.85	644.81	157.90
4	Major Collector	747.48	696.12	66.72
5	Minor Collector	263.7	251.26	0
6	Local	1,396.98	1,365.77	152.40
7	High Capacity Ramp	114.11	111.51	33.25
8	Low Capacity Ramp	27.06	27.06	2.28
9	Centroid Connector	N/A	N/A	N/A
10	External Connector	N/A	N/A	N/A

4.1.2 Link Capacities and Free-flow Speeds

Table 8 and Table 9 show link free-flow speeds and capacity, which are defined by link functional class and area type. The speed and capacity values are stored in lookup tables and automatically imported to the network each time the model runs. The main benefits of importing these data from a lookup table, as opposed to maintaining an explicit speed and capacity for every link within the highway network, are that the user has less data to manage and can easily quote values. However, there are some links in the SMTC network that warrant special attention because their actual speed or capacity is substantially different from what the lookup tables say. Therefore, the SMTC model also supports the ability to code a speed or capacity for each link by entering a value into the "TOTAL_HCAP_FIXED" or "SPEED_FIXED" fields on the network (see). A null value in either of these fields, the default condition, indicates that the lookup table is to be used.

Table 8: Free Flow Speed (mph) Lookup Table

Functional Class	Syracuse	Other CDP	Urban	Rural
Interstate/Freeway	57	67	67	67
Principal Arterial	35	45	50	55
Minor Arterial	30	35	45	55
Major Collector	25	25	35	40
Minor Collector	25	25	35	40
Local	25	25	30	35
High Capacity Ramp	40	40	40	40
Low Capacity Ramp	30	30	30	30
Centroid Connector	30	30	30	30

Table 9: Capacity (vehicles per lane per hour) Lookup Table

Functional Class	Syracuse	Other CDP	Urban	Rural
Interstate/Freeway	1,990	1,990	1,990	1,990
Principal Arterial	1,600	1,600	1,600	1,600
Minor Arterial	1,200	1,200	1,200	1,200
Major Collector	1,000	1,000	1,000	1,000
Minor Collector	950	950	950	950
Local	450	450	450	450
High Capacity Ramp	1,500	1,500	1,500	1,500
Low Capacity Ramp	1,500	1,500	1,500	1,500
Centroid Connector	99,999*	99,999	99,999	99,999

*99,999 = unconstrained capacity

4.1.3 Link Travel Times

The free flow speeds (Table 8) are used along with the link length field to calculate a free flow travel time which is used during the first model iteration in the distribution and mode choice steps. Following an initial highway assignment and feedback step (see section 13.0), congested travels times are loaded onto the network and used in the subsequent iteration through the distribution and mode choice steps.

4.1.4 Intersection Capacities

The SMTC model uses 54 node types (Table 10); 45 of these node types describe different signalized intersections designs. Each node type is associated with a different intersection capacity.

Table 10: Node Classes

Node Description	Node Type Value	Capacity
Signalized Intersections	1-28; 70-86	From Lookup Table
1 or 2 way stop	30	Governed by cap. of local street with stop control
3 or 4 way stop	41-43	From Lookup Table
Ramp Merge/Lane Drop	51	Governed by cap. of entering/exiting segments
Ramp Diverge/Lane Addition	52	Governed by cap. of entering/exiting segments
Tollbooth	61	By Equation: [(1,400* # E-Z Pass Lanes) + (360* # Cash Lanes)] where 1,400 is the hourly capacity of an E-ZPass lane and 360 is the hourly capacity of a cash lane
Internal Centroid	101	N/A
External Centroid	102	N/A

4.1.4.1 Signalized Intersections

A series of capacity analyses were performed in Synchro/SimTraffic (version 5.0) to determine appropriate planning-level capacities for signalized intersections. Several assumptions were necessary:

- Cycle length = 90 seconds
- Traffic volume on the main street is directionally balanced and is distributed among turning movements in the ratio of 1:4:1 (left turns: through vehicles: right turns)
- Traffic volume on the side street is directionally balanced and is distributed in the ratio of 1:2:1
- Capacity is reached when critical movements have a v/c ratio between 1.0 and 1.1

The capacities of the nodes that represent signalized intersections are based on analyses performed in Synchro/SimTraffic (version 5.0). The node capacities for signalized intersections and the intersection codes used to identify the type of signalized intersection in the node attribute table are shown Table 11. The intersection codes are shown in parentheses in each cell in the table and the node capacities are shown as approximate daily capacities, which are calculated as the hourly capacity multiplied by 10.

Table 11: Signalized Intersection Codes and 24-Hour Capacity Values

	Minor Lane Groups									
Major Lane Group		Single	Left Turn Bays	Left & Right Turn Bays	Left & 2 Through	Left, Right & 2 Through	2 Throughs	3 Throughs	Left & 3 Through	Left, Right and Three Through
	Single	(1) 23,000								
	Left Turn Bays	(2) 28,000	(3) 33,000							
	Left & Right Turn Bays	(4) 31,000	(5) 36,000	(6) 38,000						
	Left & 2 Through	(7) 40,000	(8) 44,000	(9) 49,000	(10) 53,000					
	Left, Right & 2 Throughs	(11) 46,000	(12) 50,000	(13) 54,000	(14) 58,000	(15) 62,000				
	2 Throughs	(16) 29,000	(17) 33,000	(18) 37,000	(19) 39,000	(20) 43,000	(21) 35,000			
	3 Throughs	(22) 32,000	(23) 36,000	(24) 40,000	(26) 46,000	(26) 46,000	(27) 38,000	(28) 40,000		
	Left & 3 Through	(70) 48,000	(71) 52,000	(72) 56,000	(73) 60,000	(74) 64,000	(75) 50,000	(76) 54,000	(77) 66,000	
	Left, Right and Three Through	(78) 50,000	(79) 54,000	(80) 58,000	(81) 62,000	(82) 66,000	(83) 52,000	(84) 56,000	(85) 68,000	(86) 72,000

4.1.4.2 Unsignalized Intersections

Unsignalized intersections are separated into two types: two-way stop controlled and four-way stop controlled. Delay at a two-way stop-controlled intersection is typically much greater on the stop sign controlled approaches than the uncontrolled (no stop sign) approaches. Since stop controlled approaches are generally local streets which intersect with each other or higher functional class roadways, the link capacity of local streets was set at 450 vehicles per lane per hour to reasonably replicate the capacity of stop controlled approaches. In this way, delay is attributed to the local street links that are stop controlled, and no delay is attributed to the uncontrolled approaches. Four-way stop control intersections have more uniform delay for the intersection because all approaching vehicles must stop. Capacity analysis runs were performed for four-way stop control intersections to develop hourly intersection capacities; the daily node capacities shown in Table 12 are calculated as the hourly capacity multiplied by 10. The table also shows, in parentheses in each cell, the intersection codes used to identify the type of unsignalized intersection in the node attribute table.

Table 12: Unsignalized 4-Way Stop Intersection Codes and 24-Hour Capacity Values

	Minor Lane Groups		
Major Lane Group		Single	2 Throughs
	Single	(41) 14,000	
	2 Throughs	(42) 19,000	(43) 24,000

4.1.4.3 Ramp Junctions

Ramp junctions are found where a ramp joins either another ramp or a freeway. Ramp junctions can be classified as either "merges" or "diverges". A merge is where traffic flows come together, such as an onramp, and a diverge is the opposite. The Highway Capacity Manual (HCM) indicates that the capacity of a merge or diverge area is controlled by the capacity of the freeway segments upstream and downstream of the merge/diverge area, or the ramp itself.[3] Therefore, since the freeway segments and ramp both have link capacities, it is redundant to also apply a capacity restraint to the merge point. Ramp junctions are identified using a unique value for the "node type" field for tracking purposes, but are not given capacity values independent of the adjacent links.

4.1.4.4 Lane Additions/Drops

Similar to ramp junctions, the HCM indicates that lane additions and drops are controlled by the lower of the capacity of either the segment upstream or downstream of the lane addition/drop.[4] In the case of a lane addition, the governing capacity is the upstream link; vice versa for a lane drop. Since these capacity values are contained in the roadway links themselves, it would be redundant to also include a capacity restraint at the lane addition/drop, and these situations were treated in a similar manner to ramp junctions.

4.1.4.5 Tollbooths

Tollboths are found in the SMTC area only at the entrances/exits to the NY Thruway. The on and off toll plazas are modeled separately. Capacity is determined by the following equation:

Hourly Directional Capacity = [1,400 * (# E-Z Pass Lanes)] + [360 * (# Cash Lanes)]

Where 1,400 is the hourly capacity of an E-ZPass lane and 360 is the hourly capacity of a cash lane.

4.1.4.6 Allocation of Intersection Capacity to Links

Intersection delay is calculated separately for each of the approach links and necessitates having an "intersection" capacity, separate from the "link" capacity of each link. The delay calculations are described in Section 11.0. For signalized intersections, each approach link is awarded a share of the total intersection capacity based on the shares of link capacity between the approaches. Table 13 presents a sample calculation of node capacity allocation, showing what the intersection capacity for each of four approaches to a intersection would be, based on assumed link capacities. This method was adopted because it awards intersection capacity based on the expected shares of green time between the approaches and their ability to move vehicles through the intersection.

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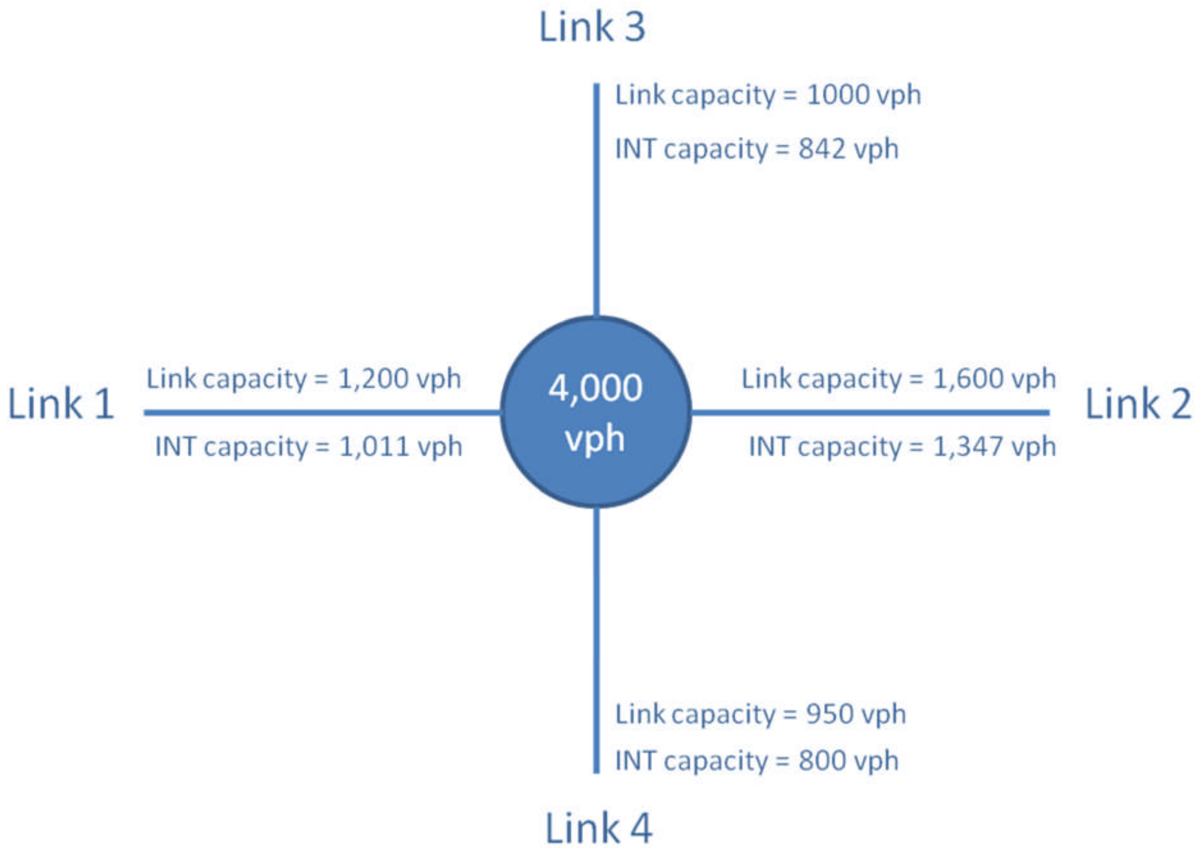
[3] HCM 2000 Edition; page 25-3

[4] HCM; page 25-9

Table 13: Sample Allocation of Node Capacity



Link Segment	Link Capacity (vph)	Share	Node Capacity (vph)	INT Capacity (vph)
1	1,200	25%		1,011
2	1,600	34%	x 4000 =	1,347
3	1,000	21%		842
4	950	20%		800
Total	4,750	100%		4,000

4.1.5 Turn Penalties and Prohibitions

Turn penalties were included in the model for two general reasons. First, turn penalties were included to simulate the extra time typically needed to make a left or right turn at an intersection. Second, turn penalties were included to discourage the model from building routes with abrupt or complicated movements. In the absence of turn penalties, the route builder may select a zigzagging shortcut to save a few seconds of travel time, while in reality drivers generally prefer simpler routes with few turns. A 1/6 minute penalty was applied to left turns, and a 1/12 minute penalty was applied to right turns.

Freeway ramp penalties were also added to discourage trips from switching to the freeway for short distances, Since the ramp penalties are a constant amount of time they have the most impact on short (one or two exit) freeway trips. Switching to the freeway for these small distances will typically only gain a small time saving compared to the best arterial path, and so adding the ramp penalty maintains most of these trips on the best arterial path. Trips that might benefit from longer freeway segments, spanning several exits, which have a large time savings compared to the best arterial path, are less likely to be pushed to the best arterial path by the ramp penalties.

The ramp penalties vary by location and freeway and are either 0, 0.67 or 2 minutes. The ramp penalties were adjusted during the model calibration process to improve the goodness of fit compared to observed data. The different values do not suggest behavioral differences amongst drivers taking trips in the different parts of the region but are rather a response to the different network characteristics such as highway exit spacing and the presence or not of competing arterial routes. The calibration effort suggested that I-90 should not have a ramp penalty, which is reasonable because there is generally no competitive arterial alternative and the exits are well spaced, and furthermore, I-90 is a toll road and so all trips using I-90 receive a distance based toll that will discourage any trips that do have a competitive arterial alternative from using I-90. A complete list of ramp penalties is presented in Table 14.

The model also includes a number of turn prohibitions. The list of turn prohibitions includes all of the posted, illegal movements, U-Turns, and other link-to-link movements that involve greater than ninety degree turns.

Table 14: Freeway Ramp Penalties

Freeway Segment	Minutes
I-90	0
I-481 South of I-90	0.67
I-481 North of I-90	2
I-690 East of I-81	0.67
I-690 West of I-81	2
I-81 South of I-481 (south)	0.67
I-81 North of I-481 (south)	2

5.0 MODEL TRANSIT NETWORK

Transit routes were coded into the model based on information obtained from the SMTC region's transit operator, CENTRO, including routes, fare, and headway information. The service offered by CENTRO is represented in the model by 94 routes serving 7562 stops. Figure 12 shows the model's transit network.

5.1 Transit Network Design

The model's transit network is built at run-time from a series of text files that enumerate the routes (Table 16), stops (Table 15), and stops visited by each route in the region (Table 17). This design, as opposed to one where the transit network is pre-compiled to a geographic database, allows for better data management and ease and flexibility in making edits. The transit network is built on top of the highway network and has access to all of the highway network attributes (Table 6).

5.1.1 Route Simplifications

The CENTRO bus system is quite detailed, with base routes and multiple route deviations/extensions for most of the base routes. In general, the route deviations associated with a base route overlap to a large degree with each other and serve largely the same population, but the deviations provide infrequent service to some riders/destinations which otherwise are not as well served. Because transit modeling methodologies used in regional models are not sensitive to the very precise detail in CENTRO's bus system, minor and infrequent deviations of primary routes were grouped into one or two routes to represent bus service in a corridor. Therefore, although the model route system is a simplification of the CENTRO bus system, the forecasting results are similar to results that would have been achieved if the full detail of the route network had been included.

5.1.2 Stop Simplifications

Local bus service is assumed to stop at every model node, while express service only stops at specified locations. This assumption was made to ease the burden of managing the stops layer. For local services, key stops (those indicated in the CENTRO schematic maps) visited by local bus routes are indicated and the route building procedure adds in the intermediate stops. Although this assumption leads to an over prediction in the number of local bus stops, the transit travel times are not altered by this procedure (see section 5.2.1).

5.1.3 Route Building

The transit route system is built by the following procedure:

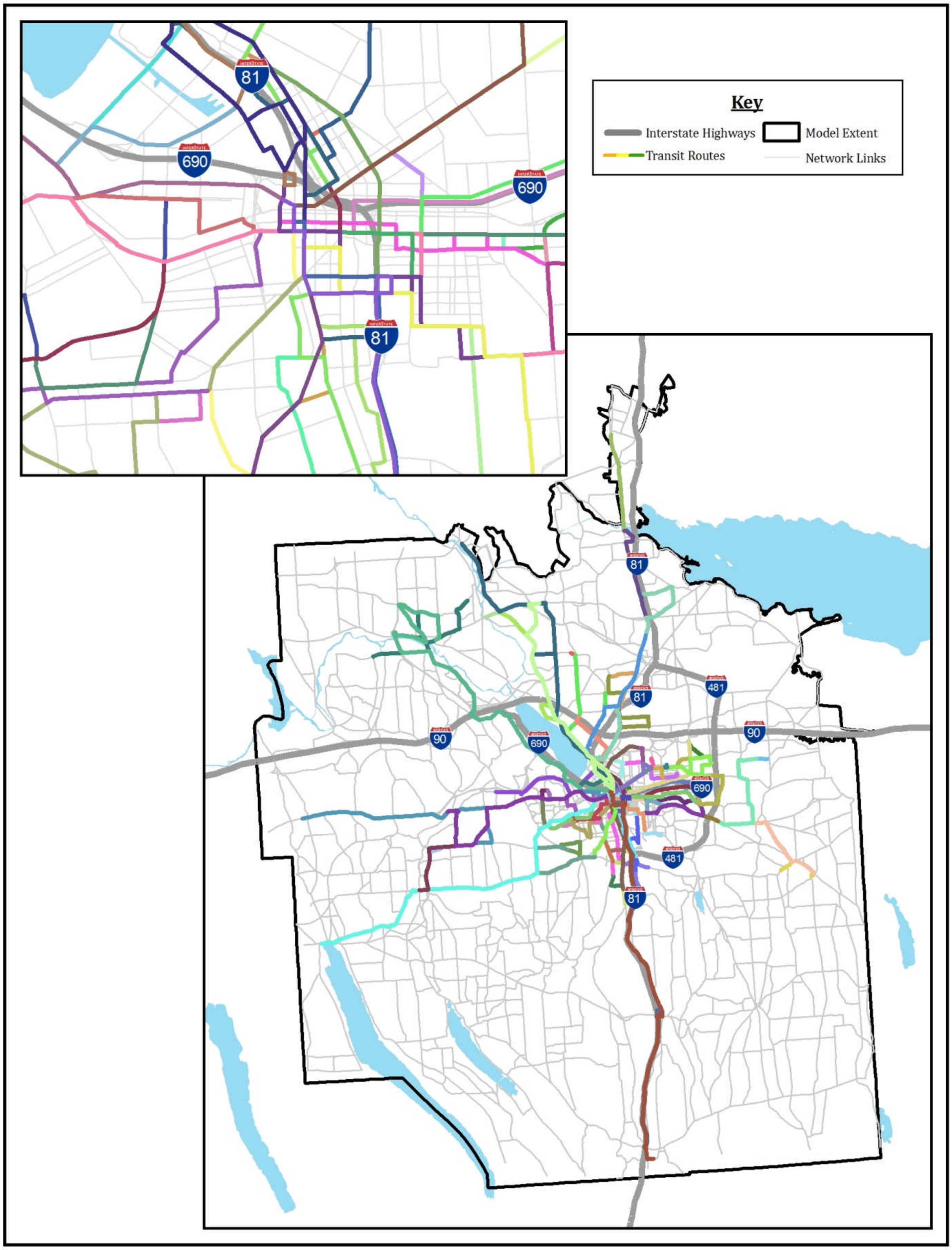
Each stop in the stops file (Table 15) is coded to the closest node in the highway network.

1. For each route, the schedule of bus stops (Table 17) is translated into a schedule of highway nodes.
2. The shortest path between successive stops is calculated by minimizing generalized cost.
3. For local bus routes, stops are added in at each highway node along the traversed path.

5.1.4 Walk Access/Egress/Transfers Links

Transit models need a set of links to support the access/egress/transfer walk movements made in traveling to a destination. In this model, the highway network doubles as the set of valid walk links.

Figure 12: SMTC Region Transit Network



5.2 Transit Network Attributes

Some of the attributes of the transit network, such as travel times, are inherited from the highway network, while others are maintained in either the transit routes table (Table 16), transit stops table (Table 15), transit route-stops table (Table 17), or the transit mode table (Table 18). The key variables in the transit network are travel times (peak and off-peak), walk times, headways (peak and off-peak), and fares.

5.2.1 Travel Times

Transit travel times were estimated by scaling up auto travel times. The auto travel times were scaled to account for time lost by transit vehicles as they are making stops (deceleration before the stop, dwell time at the stop, and acceleration away from the stop) and their slower speeds than autos in general. The scale factors were estimated by taking scheduled travel times for a set of transit routes, and dividing these times by the modeled auto travel times for the corresponding paths. Local bus service was set to travel at 60% of the congested auto speed and express bus service was set to travel at 95% of the congested auto speed. Peak transit travel times were developed using the AM auto travel times and off-peak transit travel were developed using the midday highway auto travel times.

5.2.2 Walk Times

Transit walk times (access/egress/transfer) were calculated for each link by assuming a 4 mph walk speed, which was retained from the previous version of the SMTC model.

5.2.3 Headways

Peak and off-peak headway times were developed for each route by considering the route schedules obtained from CENTRO. Two estimates of the headway time were calculated and judgment was used to select between them. The traditional method of dividing the period length by the number of buses run in that period was used to obtain one estimate, but also, the route schedules were inspected to see if a mode (highest frequency) time interval appeared between subsequent runs. For instance, if the first half-hour of the AM period had no transit trips, but the service then ran at regular 15 minutes intervals for the rest of the period, then 15 minutes would have been selected as the headway time.

5.2.4 Fares

The model assumes a one dollar fare with free transfers. The one dollar fare is less than the generic, one-ride fare because there are a number of special deals for children, students, the elderly, and frequent riders, that would drive the realized average cost down.

Table 15: Transit Stops Table

Field	Description	Update Type
ID	Transit stop identification number	Immutable
STOP_ID	Transit stop identification number	User-Maintained
STOP	Transit stop name	User-Maintained
DIRECTION	Transit stop direction (inbound, outbound)	User-Maintained
LONGITUDE	Longitude of stop	User-Maintained
LATITUDE	Latitude of stop	User-Maintained
NODE_ID	Highway node identification number	Computed

Table 16: Transit Routes

Field	Description	Update Type
RTE_ID	Transit route identification number	User-Maintained
RTE_NAME	Transit route name	User-Maintained
INOUTBOUND	In-bound (In) or Out-bound (Out)	User-Maintained
CENTRO_BASE_NUM	Centro route number	User-Maintained
CENTRO_RTE_NUM	Centro route number	User-Maintained
PEAK_BUSES	Number of buses in peak period	User-Maintained
OFFPEAK_BUSES	Number of buses in off-peak period	User-Maintained
PEAK_HEADWAY	Peak headway (mins)	User-Maintained
OFFPEAK_HEADWAY	Off-Peak headway (mins)	User-Maintained
MODE_USED	Mode Used = 1	User-Maintained

Table 17: Transit Route Stops

Field	Description	Update Type
RTE_ID	Transit route identification number	User-Maintained
CENTRO_BASE_NUM	Centro route number	User-Maintained
CENTRO_RTE_NUM	Centro route number	User-Maintained
RTE_NAME	Transit route name	User-Maintained
DIRECTION	Router direction (inbound, outbound)	User-Maintained
STOP_ID	Transit stop identification number	User-Maintained
NODE_ID	Node identification code	User-Maintained
STOP_NAME	Transit stop name	User-Maintained
VALID_STOP	0=invalid stop, 1=valid stop	User-Maintained

Table 18: Mode Attributes

Field	Description	Update Type
MODE_NAME	Transit mode name	User-Maintained
MODE_ID	Mode identification number	User-Maintained
TYPE	Mode type (1, 2, 70)	User-Maintained
FARE_TYPE	Fare type	User-Maintained
SPEED	Default mode speed (mph)	User-Maintained
P_HEADWAY	Default peak headway (mins)	User-Maintained
OP_HEADWAY	Default off-peak headway (mins)	User-Maintained
FARE	Mode fare (dollars)	User-Maintained
MODE_USED	0=no, 1=yes	User-Maintained
MODE2	0=no, 1=yes	User-Maintained
IMP_FIELD	Network impedance field	User-Maintained
MODE_ACCESS	0=no, 1=yes	User-Maintained
MODE_EGRESS	0=no, 1=yes	User-Maintained

6.0 TRIP GENERATION

The trip generation model estimates person trips produced in and attracted to each TAZ in the model. These estimates result from multiplying the land use data for each TAZ, such as the number of dwelling units and employment numbers, by regional trip generation coefficients.

6.1 Trip Purpose and Model Structure

The model has four internal trip purposes (which include trips with one trip end outside of the model region) and external to external trips. These trip purposes are shown in Table 19.

Table 19: Trip Purpose Definitions

Trip Purpose	Abbreviation	Description
Home Based Work	HBW	A trip where one end is home and the other end is work
Home Based Shopping	HBS	A trip where one end is home and the other end is a shopping location
Home Based Other	HBO	A trip where one end is home and the other end is NOT work or shopping
Non Home Based	NHB	A trip where neither end is home
External to External	XX	A trip originating and terminating outside of the model, but passing through the model en route

Productions and attractions are most useful in describing home-based trips. For home-based trips, the production ends occur at the trip maker's residence. Trip productions are estimated from the number and type of housing units within a TAZ. Non home based (NHB) trips do not feature a "trip maker's residence" and so the production end is defined as being the origin end. Attraction ends are estimated from the quantity of trip-attracting land uses in the TAZ, including workplaces, shops, other residences and schools. For home-based trips, the attraction end is defined as the end that isn't the trip maker's residence. For NHB trips, the attraction end is defined as being the destination end. The total number of attractions for each trip type must equal the total number of productions; if productions and attractions are out of balance, the total regional attractions are adjusted to match total regional productions.

Productions and attractions are different from origins and destinations in that productions and attractions do not indicate the direction of travel for 1-way trips. When one leaves home for work in the morning, the origin (home) is also the production. In the afternoon, when one returns home from work, it is the destination (home) which is the production. The origin end is defined as the starting point of any 1-way trip, and the destination end is defined as the ending point of any 1-way trip.

Daily trip production and attraction models were developed for the 2007 model from a combination of sources, including the 2004 SMTC Household Travel Survey, the 2001 NHTS, and the Institute of Transportation Engineers (ITE) trip generation manual.

6.2 Trip Production Rates

The model uses a cross-classification approach to estimate trip productions. For each TAZ, households are cross-classified according to size (1 person, 2 persons, 3 persons, or 4+ persons) and auto ownership (0 auto, 1 auto, 2 autos, or 3+ autos). Separate trip production estimates are used for each of the 16 household types and for each trip purpose. Table 23 shows the trip production rates for internal HBW, HBS, HBO and NHB trip productions, and the total trip production rates.

6.2.1 Estimation

An initial estimate of the trip production rates was calculated from the 2004 SMTC Household Travel Survey by dividing the number of survey trips by total households for each cross-class (Table 20). A number of refinements were then made to the initial estimates. It was asserted that as household size increases, the production rate must also increase, and as number of vehicles increases, the production rate must not decrease. This assertion was important for obtaining reasonable production rates for cross-class combinations that were poorly represented in the survey, such as one person, 2+ vehicle households. The production rates were smoothed manually, but the general heuristic applied was that cross-class combinations involving more survey records, such as one person, one vehicle households, should be used as the guide values on which to base the row and column trends. The 2004 SMTC production rates were also checked for reasonableness against the 2001 NHTS production rates (Table 21) for Rochester, NY, a city of comparable size.

Table 20: Initial Daily Trip Production Rates

	HH VEHICLES			
HH SIZE	0	1	2	3+
1	1.6	4.0	3.4	3.7
2	4.3	7.2	7.7	7.3
3	6.2	12.0	10.2	8.6
4+	10.2	12.9	17.1	16.0

Table 21: 2001 NHTS Daily Trip Production Rates for Rochester, NY

	HH VEHICLES			
HH SIZE	0	1	2	3+
1	3.4	4.5	3.9	6.0
2	4.5	6.8	7.2	7.8
3	7.0	9.7	11.2	12.6
4+	10.8	13.2	13.8	15.4

Each trip in the 2004 SMTC Household Travel Survey was classified as belonging to one of the four model trip purposes, and then trip purpose shares were calculated for each household size group as shown in Table 22. These trip purpose shares were then multiplied into the smoothed daily trip production rates to calculate the number of trip productions by purpose, household size, and auto occupancy presented in Table 23.

Table 22: Trip Purposes Shares by Household Size

HH SIZE	HBW	HBS	HBO	NHB	Total
1	19.8%	24.1%	28.9%	27.1%	100%
2	21.3%	22.0%	33.1%	23.6%	100%
3	22.3%	10.8%	43.1%	23.8%	100%
4	18.0%	7.9%	52.3%	21.8%	100%

Table 23: Production Rates (trips/household/day) by Trip Purpose, Household Size and Household Vehicles

	HH SIZE	HH VEHICLES 0	1	2	3+
HBW	1	0.4	0.5	0.6	0.6
	2	0.6	1.1	1.1	1.1
	3	1.0	1.6	1.8	1.8
	4+	1.3	1.7	2.0	2.1
HBS	1	0.6	1.0	1.0	1.1
	2	1.0	1.7	1.7	1.7
	3	0.7	1.2	1.3	1.3
	4+	0.9	1.1	1.3	1.4
HBO	1	0.8	1.2	1.2	1.3
	2	1.5	2.5	2.6	2.6
	3	2.9	4.6	5.1	5.2
	4+	5.7	7.3	8.4	9.0
NHB	1	0.7	1.1	1.1	1.2
	2	1.1	1.8	1.8	1.9
	3	1.6	2.5	2.8	2.9
	4+	2.4	3.0	3.5	3.7
Total	1	2.5	3.8	3.9	4.1
	2	4.2	7.0	7.2	7.4
	3	6.2	9.9	10.9	11.1
	4+	10.3	13.1	15.1	16.2

6.2.2 Adjustments to Trip Productions

A number of adjustments to the trip productions are made at run-time. These adjustments were made to help calibrate the model, discard trips using special, non-auto modes, and/or compensate for biases typically introduced into household travel surveys (the model production rates are based on household travel survey data). The following cumulative changes are made to the initial productions totals:

- School bus trips are removed from the initial production because they represent a negligible number of vehicle trips and would otherwise add unneeded complexity; in accordance with the number of school bus trips in the 2004 Household Survey, 22.6% of HBO trips are discarded.
- NHB trips are factored up to account for the lack of commercial NHB trips in household surveys, and for the tendency of some respondents to not report all short, NHB trips they make during the course of the day. The model calibration process suggested that a factor of 1.3 was appropriate.
- Trip productions are globally scaled a small amount to lead to assignment results that better match observed, traffic count data. A scale factor of 1.175 was adopted as it is effective in application while not yielding total productions substantially different from what the household survey would imply.

6.3 Trip Attraction Rates

Trip attraction rates for HBW, HBS, HBO and NHB trip purposes were developed using ITE trip generation rates by land-use type and are shown in Table 24. The trip attraction rates are in units of person trips per employee per day (or person trips per housing unit per day in the case of households). The attraction rates vary across trip purposes and (possibly) within each trip purpose to reflect the nature of the trip in conjunction with the nature of the employment class. HBW attraction rates, for instance, do not vary by employment class because the number of trips a worker is expected to make to/from his place of work does not vary much based on what type of job he has. However, HBS/HBO/NHB attractions rates do vary by employment class because certain businesses, such as restaurants, have many more non-work attractions per employee than others, such as factories.

Table 24: Attractions Rates (trips per employee/housing unit per day) by Trip Purpose and Land Use Class

Land Use Employment Class	HBW	HBS	HBO	NHB
AGRICULTURAL	1.45	-	-	1.57
BUS_LEGAL_PERSONAL	1.45	-	1.12	0.75
COMMUNICATION	1.45	-	-	2.55
CONSTRUCTION	1.45	-	-	0.55
EAT_DRINKING	1.45	-	10.83	7.22
EDUCATION	1.45	-	3.63	2.42
FIRE (Financial, Insurance & Real Estate)	1.45	-	1.12	0.75
GOVERNMENT	1.45	-	3.78	2.52
HEALTH	1.45	-	4.48	2.98
HOTELS_LODGE	1.45	-	-	12.98
MANUFACTURING	1.45	-	-	2.55
MINING	1.45	-	-	1.57
NONCLASSIFIABLE	1.45	-	-	1.87
RETAILTRADE	1.45	14.02	-	9.34
SERVICE	1.45	-	-	1.87
SOCIALSERVICES	1.45	-	3.78	2.52
TRANSPORTATION	1.45	-	-	5.54
UTILITIES	1.45	-	-	2.55
WHOLESALETRADE	1.45	4.06	-	2.7
HOUSEHOLDS	-	-	0.84	0.56

6.4 Non-Motorized Trips

Non-Motorized trips (e.g. pedestrian and bicycle trips) are estimated during the trip generation step and then removed from subsequent steps in the model, which deal with motorized trip (by auto and transit). Each TAZ is assumed to produce a fixed percentage of non-motorized trips. Non-motorized percentages were estimated from 2000 CTPP Block Group data, subject to the global constraint that the total non-motorized percentage was 4.2%, the non-motorized percentage in the 2004 Household Survey. These trips are subtracted from an initial estimate of trip productions before trip balancing. TAZs closer to activity centers have higher non-motorized rates. Table 25 summarizes the non-motorized trip percentages.

Table 25: Non-Motorized Trip Percentages

Location	Average Percent Walk/Bike
University Hill Syracuse	42%
Downtown Syracuse	22%
Census Designated Place (Villages)	6%
Elsewhere in Onondaga County	2%

The number of non-home-based, non-motorized attractions removed from each TAZ is set equal to the number of non-home-based, non-motorized productions that were removed. However the SMTC model does not explicitly remove a set number of home-based, non-motorized attractions from each TAZ, but implicitly controls for these trips by balancing attractions to productions (see section 6.7).

6.5 Special Generators

Special generators are TAZs with unique characteristics and whose trip making is best represented with a custom model. The special generator designation is typically given to land uses that attract or produce an unusually high number of trips, or are characterized by an unusually flat or steep trip distribution (see 8.2), such as airports, which attract auto trips by passengers from near and far, and universities, which predominantly attract short, walk trips by students living on or close to campus.

Attractions to the 16 special generator TAZs (Figure 13) were developed using ITE trip generation rates in conjunction with data collected by the SMTC from the principal employers in each special generator. In most cases, the total attractions to each special generator were calculated by multiplying the amount of a key variable, such as the number of beds in a hospital, into an ITE formula specifically designed for that key variable. The key variable is either a proxy (e.g. the number of square feet in a mall) or related to the actual reason (e.g. the number of students in a university) for why each business attracts trips. The specific key variable selected for each special generator was based both on what data the SMTC could collect from specific employers and what variables the ITE has developed attraction rates for.

For two of the special generators, the normal technique for estimating trip attractions (as described in Section 6.2) of multiplying the number of employees categorized by SIC code by the ITE based rates shown in Table 24 was used. This approach was used where the custom ITE trip generation rate approach did not yield reasonable results. Three of the special generators were not modeled because they attract trips at only infrequent/irregular intervals and are unlikely to impact traffic on a typical weekday. For instance, the Carrier Dome is not modeled because it attracts a significant number of trips only when it hosts events. Table 26 presents the type of calculation ("type"), which indicates whether the special generator is modeled by a key variable or based on employment by SIC code; if there is a key variable, then the table presents that variable ("key variable"), the key variable amount ("VAR Amount"), and the corresponding formula ("Trip End Formula"); finally, the table presents the resulting number of total attractions ("Attractions").

The SIC employment data were used to allocate special generator attractions among the four trip purposes. First, the standard technique, as described in Section 6.2, of estimating trip attractions from SIC data was used to calculate total attractions by trip purpose. Then, these shares were multiplied into the total trip ends presented into Table 26. Finally, the resulting trip purpose splits were adjusted using judgment.

For special generators containing households, home-based productions were estimated using the same methodology as employed for internal TAZs (see Section 6.2). Non-home based productions were set equal to the number of non-home based attractions.

As described in Section 6.4, a fixed percentage of non-motorized productions were removed from each of the special generators (see Table 27), based on the non-motorized percentages developed for their related Census block group(s). A number of NHB attractions were then immediately removed equal to the number of NHB productions removed.

With two exceptions, all home-based attractions to each special generator were assumed to be motorized. Accounting for the small share of non-motorized attractions to these specials generators would have demanded more data collection and added more complexity to the model. For instance, accounting for the very small number of trips that walk to Hancock Airport would have added unnecessary complexity to the model. However, it would have been unreasonable to assume 100% motorized attractions to Syracuse University and to the Syracuse Hospitals. Therefore, an effort was made, in the absence of detailed mode choice data, to estimate a share of non-motorized attractions to these special generators. Section 8.2 describes in detail how a percentage of non-motorized attractions were estimated for these two special generators.

Figure 13: Special Generators

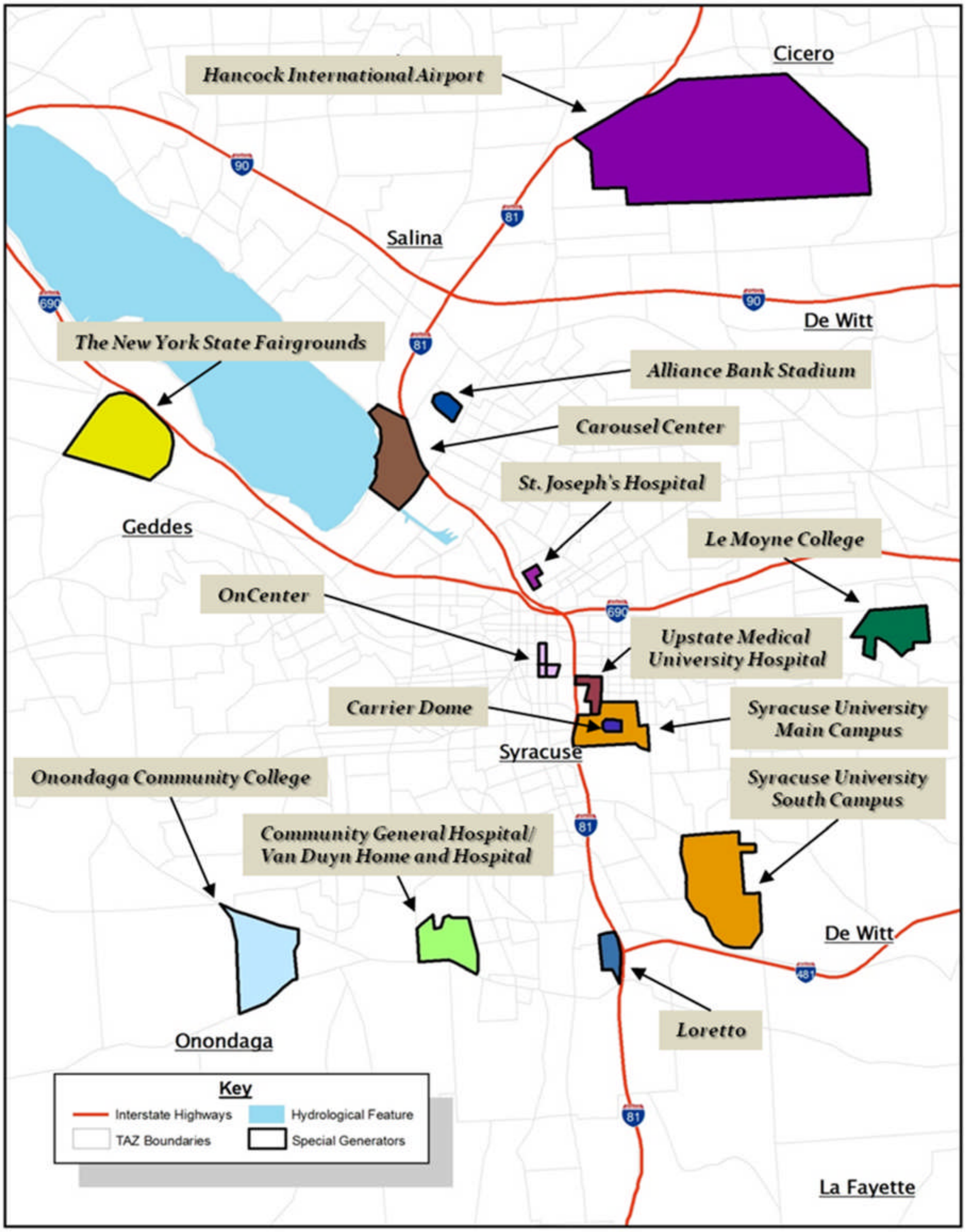


Table 26: Total Attractions by Special Generator

TAZ	Name	Type	Key Variable	VAR Amount	Trip End Formula	Attractions
8001	NY State Fairgrounds	Not Modeled	-	-	-	-
8002	Carousel Center	Key Variable	000s sq ft	1,500	2.718^(0.65*LN(VAR)+5.83)	39,438
8003	Onondaga Community College	Key Variable	Students	8,979	2.718^(0.89*LN(VAR)+1.24)	11,389
8004	Van Duyn Home & Hospital	Key Variable	Beds	882	-	5,591
	Van Duyn Home	-	Beds	526	(2.3*VAR) +6.07	-
	Community General Hospital	-	Beds	356	(7.42*VAR)+1733.31	-
8005	Loretto	Key Variable	Beds	820	(2.3*VAR)+6.07	1,892
8006	SU South Campus	SIC Based	-	-	-	2,891
8007	OnCenter	Key Variable	-	-	Trip Ends * Share of Attractions	23
8008	OnCenter	Key Variable	-	-	Trip Ends * Share of Attractions	17,506
8009	OnCenter	Key Variable	-	-	Trip Ends * Share of Attractions	3,453
	OnCenter	-	Employees	2,615	7.75*VAR	-
	OnCenter	-	Employees	80	3.32*VAR	-
	OnCenter	-	Visitors	225	2*VAR	-
8010	Lemoyne College	Key Variable	Students	3,309	(2.23*VAR)+440	7,819
8011	University Hill Hospitals	SIC Based	-	-	-	40,703
8012	Syracuse University	Key Variable	Students	18,767	(2.23*VAR)+440	42,291
8013	Carrier Dome	Not Modeled	-	-	-	-
8014	St. Joe's Hospital	Key Variable	Beds	431	(7.42*VAR)+1733.31	4,931
8015	P & C Stadium	Not Modeled	-	-	-	-
8016	Hancock Airport	Key Variable	Employees	1,300	18.1*VAR	23,530

Table 27: Special Generator Non-Motorized Productions and Attractions

TAZ	Special Generator	Productions	Attractions*
8001	NY State Fairgrounds	0.0%	0.0%
8002	Carousel Center	0.0%	0.0%
8003	Onondaga Community College	0.0%	0.0%
8004	Van Duyn Home & Hospital	0.0%	0.0%
8005	Loretto	3.0%	0.0%
8006	SU South Campus	3.0%	0.0%
8007	OnCenter	20.0%	0.0%
8008	OnCenter	20.0%	0.0%
8009	OnCenter	20.0%	0.0%
8010	Lemoyne College	2.5%	0.0%
8011	University Hill Hospitals	15.0%	27.1%
8012	Syracuse University	15.0%	100.0%
8013	Carrier Dome	15.0%	0.0%
8014	St. Joe's Hospital	15.0%	0.0%
8015	P & C Stadium	0.0%	0.0%
8016	Hancock Airport	4.0%	0.0%

* Only applied to TAZs in same ZIP Code to represent non-motorized accessible TAZs

Table 28 summarizes the motorized trip productions and attractions in the special generator TAZs.

Table 28: Special Generator Productions and Attractions

TAZ	Special Generator	Productions	Attractions
8001	NY State Fairgrounds	(SE)	(SE)
8002	Carousel Center	9,995	29,444
8003	Onondaga Community College	3,836	7,553
8004	Van Duyn Home & Hospital	541	4,342
8005	Loretto	604	1,814
8006	SU South Campus	5,188	2,862
8007	OnCenter	5	15
8008	OnCenter	2,283	14,081
8009	OnCenter	778	2,286
8010	Lemoyne College	5,593	5,018
8011	University Hill Hospitals	14,337	38,054
8012	Syracuse University	7,354	20,304
8013	Carrier Dome	(SE)	(SE)
8014	St. Joe's Hospital	268	4,888
8015	Alliance Bank Stadium	(SE)	(SE)
8016	Hancock Airport	5,073	18,034

(SE): Special Event locations that are not included in a model run that represents a typical day

6.6 External Trips

Trips can be categorized based on whether both the origin and destination are internal to the model region, or whether the trip has an external trip end. External trips can be classified as internal-to-external (IX), external-to-internal (XI), and external-to-external (XX). In the SMTC model, IX and XI trips are classified as being HBW, HBS, HBO, or NHB, and are treated no differently from internal-to-internal (II) trips in model distribution. XX trips, on the other hand, are a modeled as a fifth trip purpose and have a fixed distribution.

In the base year, the total IX, XI and XX trips are set to match base year traffic count data at the 51 external stations (shown in Figure 11). The percentage of XX trips is derived in large part from an external license plate survey conducted as part of the I-81 Corridor Study[5]. The license plate survey recorded and matched vehicles at several locations on the interstate network to identify whether they were passing through the region or destined for a location inside the region (however, the survey did not capture I-90 pass through trips). The remaining external trips are split among IX and XI trips based on the AM and PM directional imbalance observed in traffic counts as a proxy for the home-end (production) locations of the trips. We assume for external TAZs that the IX and XI trips will be 33% internal-to-external (IX) and 67% external-to-internal (XI) for home-based work trips and 50% IX and 50% XI for non-work trips. Base year IX and XI trips are set to match base year traffic count data (less XX trips) at the external stations. There are a total of 160,230 external productions and attractions per day in the base year model. Future year external trips are assumed to grow annually at a rate of 1% per year, based on historical growth rates calculated using NYSDOT traffic count data.

6.7 Trip Balancing

It is common practice in transportation modeling to balance attractions to productions. The rationale is that productions are more fundamental. More housing will produce more trips; more retail space, for example, may simply draw customers from other retail space.

This practice has important implications for using the model to analyze regional traffic impacts emanating from changes in employment land use. For example, if traffic impacts of a proposed major employer are to be analyzed, the projected amount of new employment must be inserted into appropriate TAZ in the socio-economic database. These new jobs will attract new trips. However, without also increasing by some amount the number of residences in the region, no net increase in trips will result. Thus, these types of scenarios must be carefully considered as to their employment and residential impacts in order for the model to lend proper insight into transportation implications.

Incorporating special generator attraction rates introduces some complexity to the balancing calculations. Balancing adjustment factors are calculated for each of the trip purposes. It is not desirable to factor the special generator attractions because they are based on location specific traffic counts that reflect the unique trip making characteristics of the land use. Therefore, only attractions that are not special generators are factored in the balancing process. The following general formula is used to calculate the balancing factors for each trip type:

> Balancing Adjustment Factor = (Productions – Special Generator Attractions)/(Non Special Generator Attractions)

For NHB trips, where the connection to home-based productions is less obvious, the destination trip end (an attraction) is balanced to the origin trip end (a production) and then productions are set equal to attractions in each TAZ.

[5] See Draft Final Technical Memorandum #1: Physical Conditions Analysis, pp 2-25 to 2-31, available at: http://thei81challenge.org/cm/ResourceFiles/resources/Technical_Memorandum_s.pdf

6.8 Trip Generation Summary

Table 29 summarizes the number of motorized trips produced by trip purpose inside the SMTC model region for the 2007 base year, and those produced externally to the SMTC model region but attracted to locations inside the SMTC model region. External to external travel is not included in this table (see Section 6.6), nor is non-motorized travel (see Section 6.4).

Table 29: Total Motorized Trip Productions by Trip Purpose

Purpose	Internal Trips*	Trips/HH**	External Trips	Total Trips	% Trips
HBW	263,477	1.3	36,673	300,150	15%
HBS	277,619	1.4	18,473	296,092	15%
HBO	643,277	3.2	83,676	726,953	37%
NHB	621,174	3.1	34,668	655,842	33%
All Purposes	1,805,547	9.1	173,490	1,979,037	100%

* Internal trip productions include trips that are attracted to externals (IX trips)
**Trips/HH = internal trips per household in the model region (there are 198,533 households in 2007)

7.0 NETWORK SKIMMING

Network skimming is the model process that traces the shortest path (highway skims) or composite path (transit skims) between every TAZ pair, and then writes out the quantity of key attributes, such as travel times, costs, and distances, "skimmed" between each TAZ. These "skims" are used in the trip distribution (highway skims only) and mode choice models.

7.1 Highway Network Skimming

The highway skims are built by minimizing a simple "generalized cost" formula, a metric that accounts for the out-of-pocket costs (tolls), implied costs (travel times, operating expenses) and biases (turn penalties) that are incurred in traveling between each TAZ pair.

7.1.1 Auto Generalized Cost

The formula for auto generalized cost is presented in Figure 14. Because in-vehicle travel time varies by model period, the generalized cost equation is solved 4 times, once for each of the model periods (AM, MD, PM, OP). The asserted value of time, used to convert monetary values to time values in the generalized cost calculation, is $10/hour.

Figure 14: Auto Generalized Cost

GC = IVT + OVT + .6*DIST + 6*TOLL + TP

Where: GC = Generalized Cost (minutes)

IVT = In-Vehicle Time (minutes)

OVT = Out-of-Vehicle Time (minutes)

Dist = Distance (miles)

Toll = Toll fare (dollars)

TP = Turning penalties

Value of Time = $10/hour

Operating Cost = $.10/mile

7.1.1.1 Tolls

The SMTC network features one toll road, I-90. The assumed toll rate along I-90 is $.048/mile, based on an average of the per mile rate of exit to exit tolls charged on I-90.

7.1.1.2 Operating Costs

The assumed average auto operating cost is $.10/mile and represents just fuel costs and not long term costs such as vehicle costs or maintenance costs. In reality, operating cost varies depending on speed and acceleration/deceleration, fluctuations in gas costs, and variations in vehicle fuel economy from vehicle to vehicle, but basing operating cost only on distance is a reliable simplification and helps bias the model towards picking more direct paths with fewer turns. The value of $.10/mile is equivalent to a fuel cost of $2.10 per gallon with fuel economy of 21 miles per gallon, the approximate fleet average in 2008[6],[7].

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[6] National Transportation Statistics (2011), Tables 4-11 and 4-12

[7] For forecasting purposes, operating cost assumptions remain static, i.e. base year values are used in the future. Future forecasts of vehicle operating costs are uncertain, and the relationship between future vehicle operating costs, future household income, and resulting route choice behavior are sufficiently uncertain and complex to make any adjustments for forecasting unsupportable.

7.1.1.3 In-Vehicle Travel Times

In the first iteration of the model, the in-vehicle times for all four generalized cost equations (AM, MD, PM, OP) is assumed to be the free flow travel times. After the first iteration, in-vehicle travel times vary by time period depending on the results of the assignment model. Section 11.0 explains how these congested travel times are calculated.

7.1.1.4 Out-of-Vehicle Travel Times

An auto walk access/egress time is assumed for each TAZ. TAZs located in the downtown or University Hill area of Syracuse are assumed to have 3 minute access/egress times and all other TAZs are assumed to have 1 minute access/egress times; for instance, a trip from outside of Syracuse to the downtown area would be assigned 4 minutes of total out-of-vehicle time. The out-of-vehicle time for trip ends in the downtown or University Hill area is assumed to be greater than elsewhere in the region, because travelers to those areas may often need to park off-site and walk to their destination.

7.1.1.5 Turning Penalties

Turning penalties, as discussed in Section 4.1.5, are added are used to guide the model towards tracing a particular shortest path that tends to avoid a lot of zigzagging movement. Although these turning penalties are expressed in minutes, they do not represent actual travel time and they are not added to the In-Vehicle Travel Time or Generalized Cost skims so as not to affect the results of the trip distribution or mode choice models. .

7.1.2 Skimmed Variables

For each of the four time periods (AM, MD, PM, OP) the model creates the following skims:

- Distance
- Toll
- IVTT (In-Vehicle Travel Time)
- OVTT (Out-of-Vehicle Travel Time)
- Operating Cost
- Generalized Cost (where generalized cost does not include any biases such as turning penalties)

From these skims, a set of “work” and “non-work” skims, and a set of “peak” and “off-peak” skims are created for use in application where the work and non-work skims are used in the distribution model, and the peak and off-peak skims are used in the mode choice model. However, at this time, the work and peak skims are simply duplicates of the AM skim, and the non-work and off-peak skims are duplicates of the MD skim.

7.2 Transit Network Skimming

The transit skims are built by minimizing a generalized cost formula, subject to a number of special constraints and the possibility of combining service across alternative routes to create a more favorable, composite path. The composite path (if one exists) is solved by Caliper’s Pathfinder algorithm.

7.2.1 Transit Generalized Cost

The generalized cost formula used in creating the transit network is presented in Figure 15. The transit generalized cost formula uses a lower value of time ($8/hour) than is used for highway generalized cost ($10/hour) because transit users tend to have a lower income and are more sensitive to cost. The transit generalized cost formula also double weights OVT, which is the standard convention.

Figure 15: Transit Generalized Cost

GC = IVT +2*OVT + 7.5*Fare

Where: GC = Generalized Cost (minutes)

IVT = In-Vehicle Time (minutes)
OVT = Out-of-Vehicle Time (minutes)

Fare = Transit Fare (dollars)

Value of Time = $8/hour

7.2.1.1 In-Vehicle Travel Times

Transit in-vehicle travel times are created by factoring up the auto in-vehicle times. The model does not explicitly assume a dwell time at each stop or model deceleration/acceleration when visiting stops, so these factors are needed to decrease the average speed of the transit service. Local bus service is assumed to travel at 60% of the auto speed, and express bus service is assumed to travel at 95% of the auto speed, as explained in Section 5.2.1.

7.2.1.2 Out-of-Vehicle Travel Times

The out-of-vehicle time in the transit network is composed of:

- Walk access time
- Initial wait time
- (Possible) Transfer walk and wait times
- Walk egress time

The wait times are calculated by taking 50% of the route headway, subject to a few constraints (see section 7.2.2). Out-of-vehicle times are all double-weighted to account for the fact that out-of-vehicle time is perceived as more onerous to riders than in-vehicle time.

7.2.1.3 Fare

Transit fares are discussed in section 5.2.4. However, because all transit fares were assumed to be $1 with free transfer, at this point, fares do not have an impact on the transit skimming.

7.2.2 Path-Finding Parameter Constraints

The transit path-finding algorithm is subject to a number of constraints that may disallow certain paths or constrain attributes used in the generalized cost formula or written to the skims. The constraints are presented within Figure 16. For a path to be allowed by the model, the total travel time must be less than 180 minutes, there must be fewer than 3 transfers, and the walk access and egress times must be less than 20 minutes. Disallowing these paths ensures that the model will award zero trips to these paths instead of some small number.

The transit path-finder puts a floor/ceiling on the range of values certain attributes can take on. In particular, the maximum wait time for a transit trip is 45 minutes and the minimum initial wait time is set to 2 minutes.

Figure 16: Transit Path-Finding Parameter Constraints

Parameter	Value	Units
Max Xfers	2	
Value of Time	.133	$/Minute
Flat Fare	1	$
Xfer Cost	0	$
Weighting Factors		
Fare	1	
Link Time	1	
Init Wait Time	2	
Xfer Wait Time	2	
Dwell Time	0	
Walk Time	2	
Headway	Route Specific	Minutes
Max Init Wait Time	45	Minutes
Max Xfer Wait Time	45	Minutes
Min Init Wait Time	2	Minutes
Min Xfer Wait Time	0	Minutes
Dwelling Time	0	Minutes
Max Access Walk Time	20	Minutes
Max Egress Walk Time	20	Minutes
Max Total Time	180	Minutes
Park and Ride	No	
Interarrival Parameter	0.5	
Path Threshold	0	

7.2.3 Pathfinder

Pathfinder is the route-building algorithm developed by Caliper to solve for composite, transit paths where having several options for how to go from A to B would allow the transit user to pick the first available service, and reduce average wait times. In the SMTC transit model, the "combination factor" parameter is set to 0, the minimum level, where a composite path will be created only if there are two or more equally fast paths (i.e. there is more than one, single "best path"). The skims generated from composite paths have reduced wait times according to their combined headway.

8.0 TRIP DISTRIBUTION

Trip distribution is the pairing of productions and attractions to form complete trips. The pairing is done separately within each trip purpose. For example, HBW productions from residences are paired with HBW attractions at work places. The trip distribution within a trip purpose is done using a gravity model. The concept underlying a gravity model is that trip end locations that are closer together will exhibit a stronger attraction than those that are farther apart, and that trip end locations with higher trip generation will be more attractive than trip end locations with lower trip generation.

8.1 Gravity Model

The functional form of the distribution model is shown in Figure 17. The model uses a doubly constrained gravity model for the HBW trip purpose and a singly constrained gravity model for the other trip purposes. To doubly-constrain a trip distribution an iterative process is used that alternatively balances productions by evaluating the first equation and then balances to attractions by evaluating the second equation. This function is applied separately for each of the trip types.

Figure 17: Gravity Model Functional Form

$$T_{ij} = P_i * \frac{A_j * f(d_{ij})}{\sum_{all\ zones\ z} A_z * f(d_{iz})} \quad \text{(Constrained to Productions)}$$

$$T_{ij} = A_j * \frac{P_i * f(d_{ij})}{\sum_{all\ zones\ z} P_z * f(d_{iz})} \quad \text{(Constrained to Attractions)}$$

Where:	T_{ij}	=	the forecast flow produced by zone *i* and attracted to zone *j*
	P_i	=	the forecast number of trips produced by zone *i*
	A_j	=	the forecast number of trips attracted to zone *j*
	d_{ij}	=	the impedance between zone *i* and zone *j*
	$f(d_{ij})$	=	the friction factor between zone *i* and zone *j*

The inputs to trip distribution include productions and attractions by TAZ, and a generalized cost impedance matrix representing the cost of travel between each pair of TAZs. The impedance is used in the trip distribution model to estimate friction factors, which represent the impact of travel time on the likelihood of travel and are calibrated so that observed trip lengths and times are reasonable and match patterns in survey data. Observed trip length distributions were estimated using 2004 SMTC Household Travel Survey.

The friction factor equations take the form shown in Figure 18, with the estimated parameter values shown in Table 30 and are plotted in Figure 19, with the values scaled between 0 and 1 to be comparable across trip purposes. HBW trips tend to be longer than NHB, HBO, or HBS trips, and this is reflected in the calibrated friction factors.

Figure 18: Friction Factor Functional Form

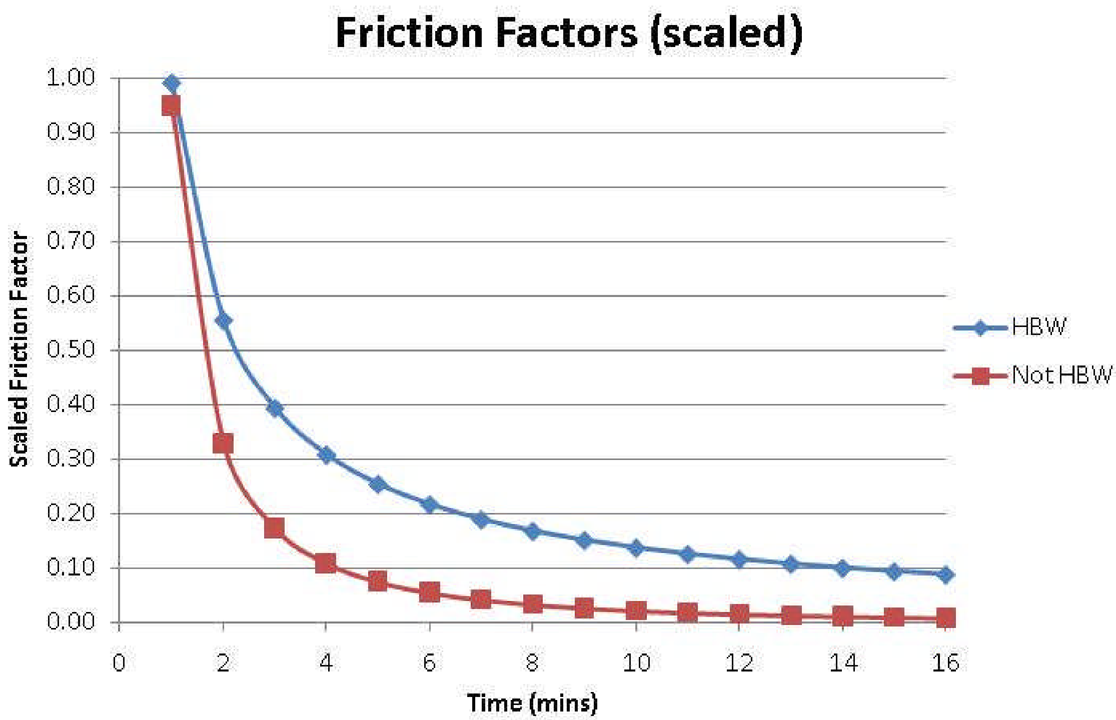
$$f(d_{ij}) = \frac{a}{d_{ij}^{\ b} * e^{c(d_{ij})}}$$

Where:	$f(d_{ij})$	=	the friction factor between zone *i* and zone *j*
	d_{ij}	=	the impedance between zone *i* and zone *j*
	a,b,c	=	constants derived for each trip type to replicate survey data

Table 30: Estimated Friction Factor Parameters

Trip Type	A	B	C
HBW	28,507	0.823	0.010
HBS	139,173	1.456	0.052
HBO	139,173	1.456	0.052
NHB	219,113	1.456	0.052

Figure 19: Friction Factors Curves by Trip Purpose



8.2 Special Generators

During summer 2010, SMTC collected trip distribution data from many of the major employers that comprise the special generators. Data requested from the employers included the home ZIP code of employees and visitors to the special generators, such as patients, students, shoppers, or air travelers. Where data were received, fixed trip distributions were developed to replace the gravity model approach to distributing the trips. The fixed trip distributions are preferred since, by definition given their unusual nature, trips to the special generators often do not match closely with observed travel patterns to more typical locations.

The type of data collected from special generators falls into three groups: data about employees, data about students of large educational institutions, and data about the customers or patients of special generators such as the hospitals in Syracuse. Table 31 shows a summary of the data collected, including the data type, spatial resolution, temporal resolution and any additional notes about data assumptions. Useful data were not collected from Crouse Hospital, Syracuse VA Medical Center, Loretto, or from the OnCenter. Since Crouse Hospital and Syracuse VA Medical Center are in the same TAZ as SUNY Upstate Medical University, it was assumed that employee and patient distributions for SUNY Upstate Medical University could be applied to Crouse Hospital, and Syracuse VA Medical Center. Data from Syracuse University included data describing the South Campus. The New York State Fairgrounds, Carrier Dome and Alliance Bank Stadium are not included in this table because they are special event locations that are not included in a model run that represents a typical day. However, data were collected for these locations and is available for special event modeling.

Table 31: Summary of Special Generator Data

Special Generator	Trip Types	Data Type	Spatial Resolution	Total Records	Temporal Resolution	Additional Information
Carousel Center	HBO	Surveyed vehicle registration home locations	ZIP Code	6,000	Visits from a single day in December 2007	Scaled to the reported average of 50,000 visitors a day
Onondaga Community College	HBW	Employee home locations	ZIP Code	2,200	2010 Employees	Out of state employees were omitted
	HBO	Enrolled student home locations	ZIP Code	12,000	Student Enrollment from 2009	ZIP codes outside of central New York were omitted, all other records were scaled to 2010 enrollment figures (12,753 students)
Van Duyn Home & Hospital	HBW	Employee home locations	ZIP Code	559	2010 Employees	
Lemoyne College	HBW	Employee home locations	ZIP Code	652	2010 Employees	Employees were assumed to make 1 trip to campus per day
	HBO	Student home locations	ZIP Code	3,322	Student enrollment from Spring 2010	Students living on-campus were assigned to ZIP Code 13214. ZIP Codes outside of central New York were omitted; all other records were scaled to total records.
SUNY Upstate Medical University Hospital (does not include Crouse or VA Hospitals)	HBW	Employee home locations	ZIP Code	6,916	2009 Employees	Full-time employees were assumed to make 1 trip per day while all other employees were assumed to make 0.5 trips per day. ZIP codes outside of central New York were omitted; all other records were scaled to total records.
	HBO	Patient home locations	ZIP Code	427,406	Patients making a visit in the 2009 calendar year	In-Patients were assumed to make 0.5 trips per day while Out-Patients were assumed to make 1 trip per day. ZIP codes outside of central New York were omitted; all other records were scaled to total records.
Syracuse University Campuses	HBO	Mailing addresses for all students and camp attendees	ZIP Code	73,910	Unknown period of time	ZIP codes outside of the model region were omitted; all other records were scaled to the 19,500 students and split between the Main and South Campus sites using University provided student breakdowns.
St. Joe's Hospital	HBW	Employee home locations	ZIP Code	3,952	2010 Employees	
Hancock Airport	HBO	Surveyed passenger home locations	ZIP Code	10,026	Visits between October 2005 and February 2006	Approximately 1.03% of enplaned passengers were surveyed. Survey data were scaled to match 6,292 average daily enplanement and deplanement.

The data for each individual special generator were isolated and processed separately. The following processing steps were completed for each dataset:

1. Trip productions were grouped by home ZIP code. This was assumed to be synonymous with an individual's trip origin ZIP code. ZIP code data were requested from the special generator institutions to preserve the anonymity of individual employees, students, and customers. Figure 20 shows data for total outpatient visits by ZIP code to the SUNY Upstate Medical University for the 2009 Calendar year.
2. The distribution of trip productions by source ZIP code were then averaged into annual average daily trip productions. The following assumptions (unless otherwise noted in Table 31) were applied:
   - Employee ZIP code distributions represented typical two trip weekday commutes.
   - Hospital and airport data represented a year's worth of patients/traveler visits; they were divided by a factor of 365 to represent a day's worth of patients/travelers trips.
   - Students make two daily trips from their origin zip code to their university (one trip in each direction).
3. In some cases special generators provided total enrollment, employment, patient, or visitor numbers that were greater than or less than the number of individuals for which they provided home ZIP code distributions. In these cases the distributions were scaled to match the control totals. The control totals and the resulting scaling factors are included in the "Additional Notes" column of Table 31.

To assign the ZIP Code data to TAZs the following steps were taken:

1. The data were split into three zones: data in ZIP codes wholly within the model extent ("Internal"), partially within the model extent ("Partial External" and wholly outside of the model extent ("External"). Figure 21 displays the three distribution zones.
2. Internal ZIP code data were assigned to internal TAZs. The ZIP code data were allocated to TAZs based on the proportions of households within the ZIP code that were in each TAZ. The locations of university dormitories were used to guide the allocation of ZIP code level student data to TAZs.
3. Partial external ZIP code data were first split based on the proportions of the ZIP codes' area that were within and outside the model area.
4. The share of data within the model area was then processed in the same fashion as step 2 above.
5. The share of data outside the model area was assigned to the external TAZs that were within the ZIP code. If more than one external TAZ was within the ZIP code, data were allocated in proportion was to traffic volumes at the external stations represented by the TAZs.
6. Logical corridors for long distance trips into the model region were established for all external ZIP codes. The corridors were designed to model the likely routing of traffic to higher capacity highways and freeways, as shown in Figure 22. Trips assigned to these corridors were then assigned to the external TAZ for the location where that corridor crosses the model boundary.

Figure 20: SUNY Upstate Medical University Outpatient Visits for the 2009 Calendar year by ZIP Code

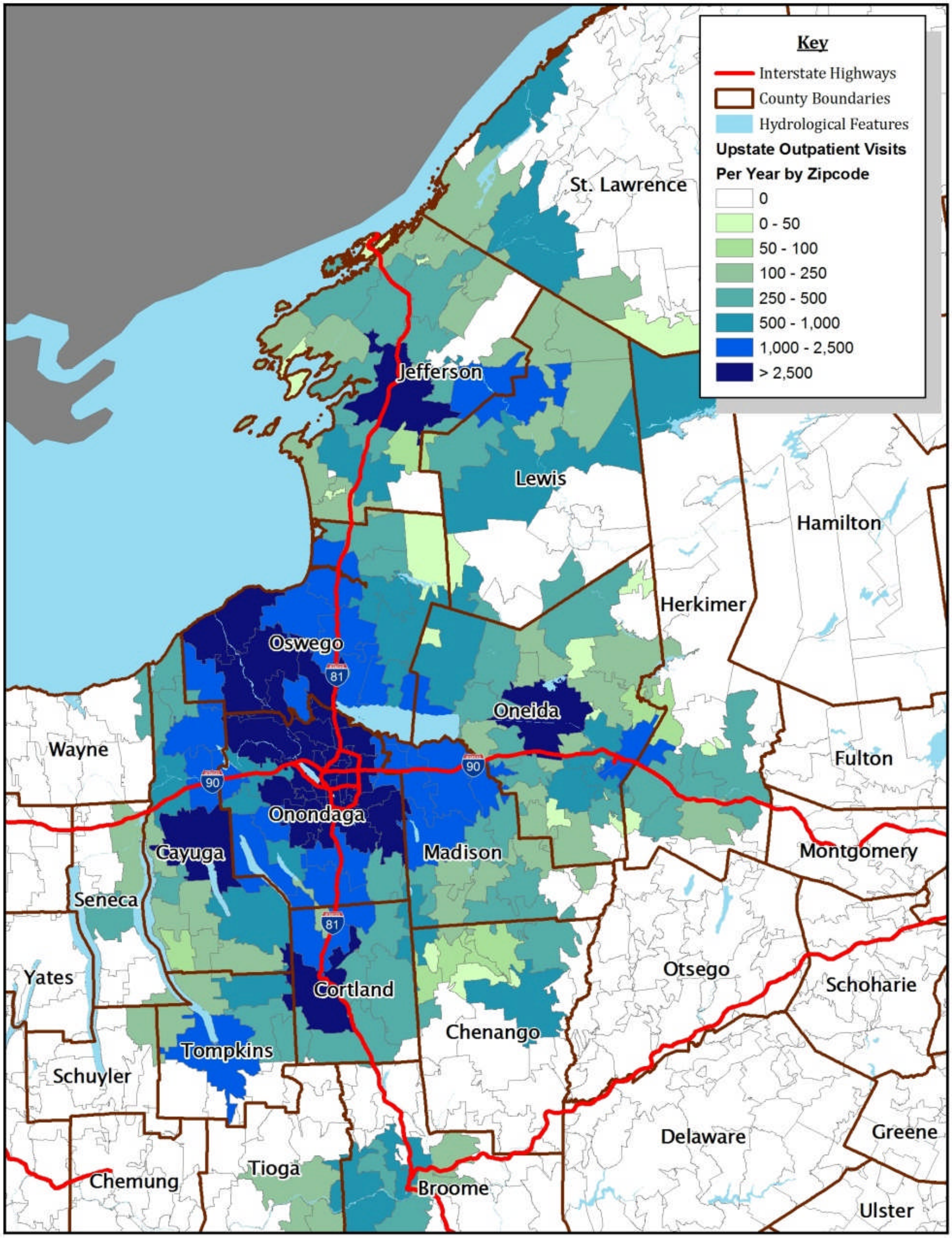


Figure 21: Zip Code Distribution Relating to Model Extent

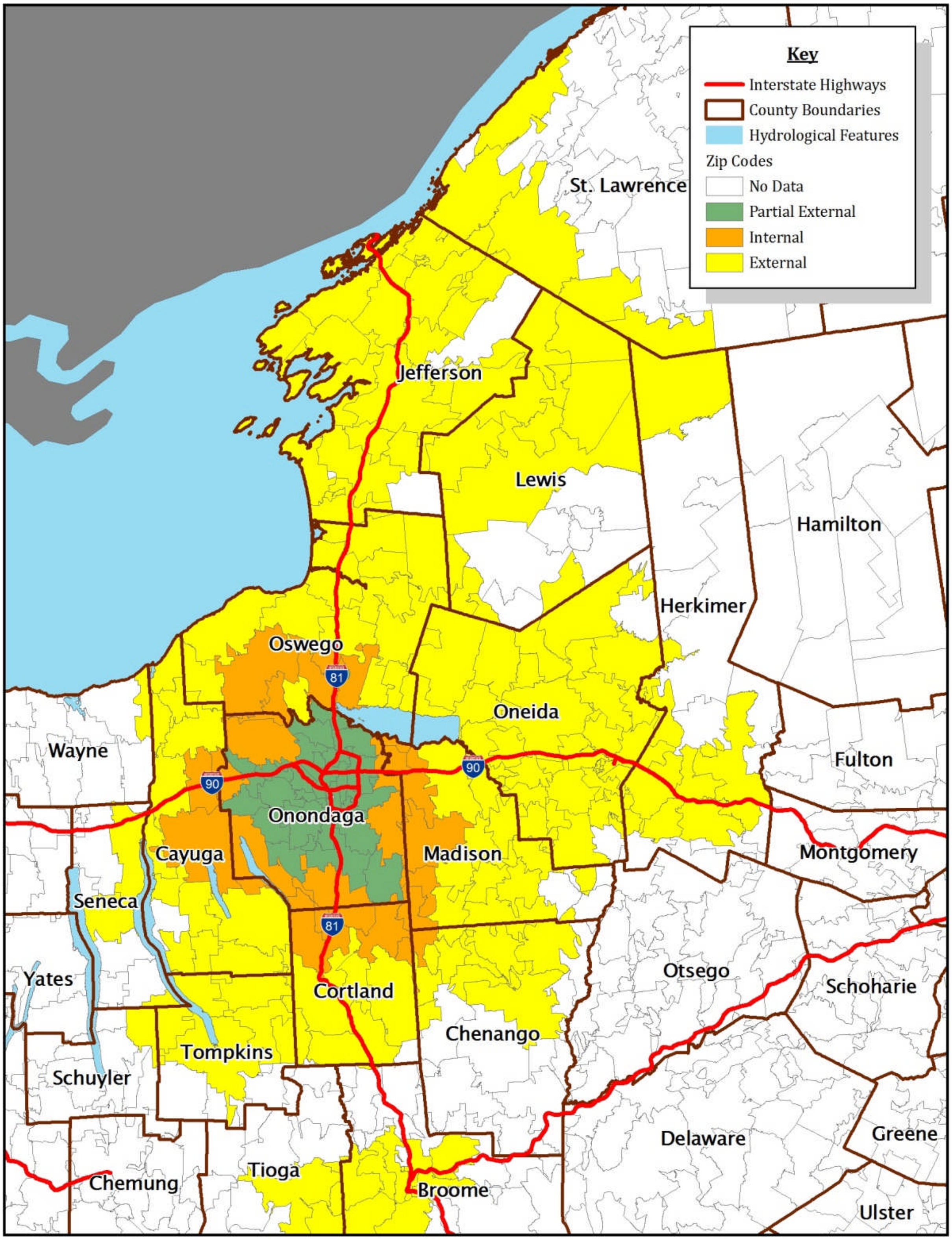
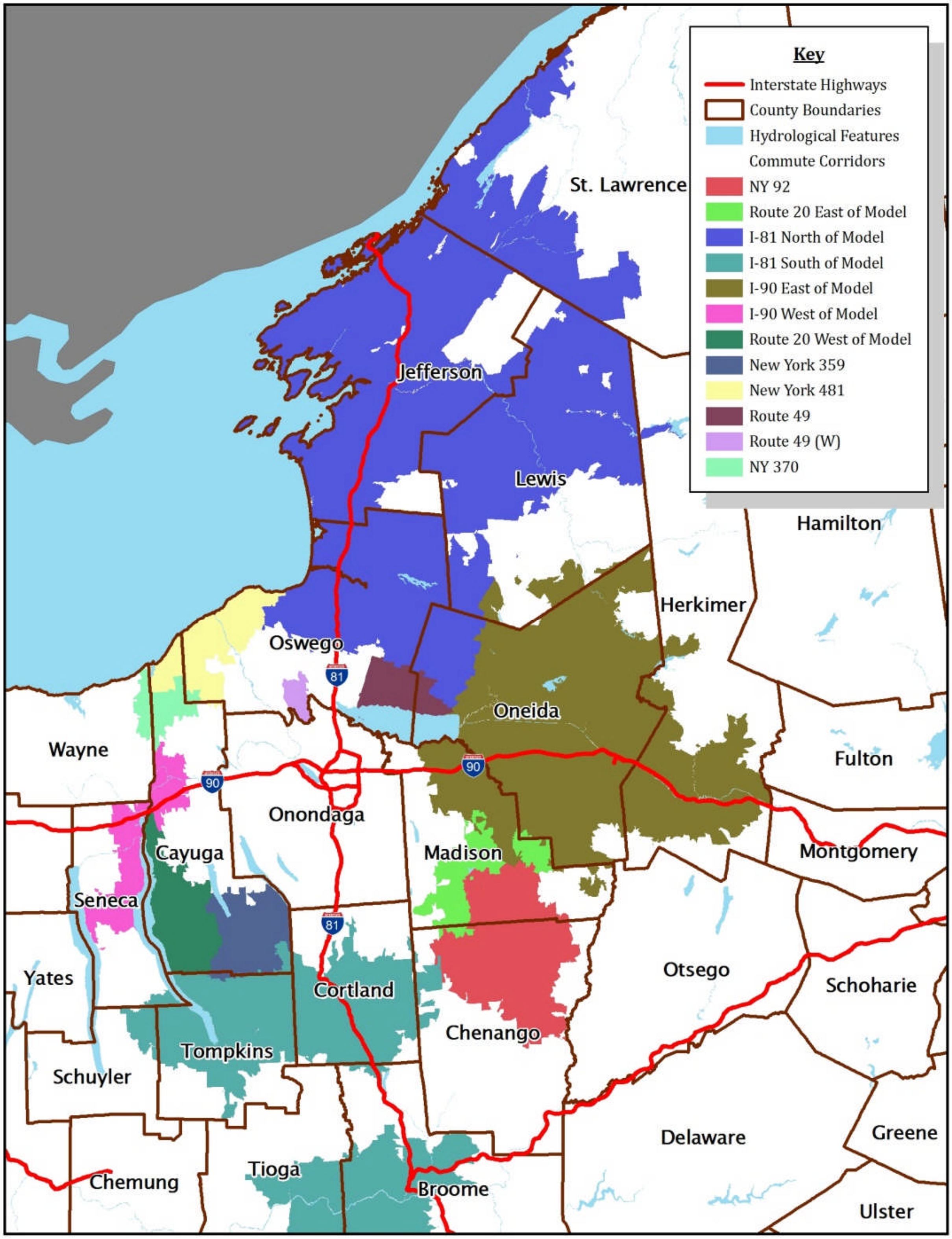


Figure 22: Long Distance Commute Corridors for External TAZs



After having coded each observed trip to a TAZ, the trips were then scaled to meet the total motorized attractions by special generator indicated in Table 28. As mentioned in section 6.5, the percent motorized was assumed to be 100% for all but two special generators, the Syracuse hospitals and Syracuse University given that they are surrounded by more active and urban land use and it was demonstrated in the collected trip distribution data, that many trips came from the same zip code. For both special generators, it was assumed that only trips attracted from the same zip code were within a "walking distance" and therefore eligible to be non-motorized. For the Syracuse hospitals, a 15% overall non-motorized attraction rate was assumed (the same percentage that was assumed for productions), leading to a removal of 27.1% of attractions from its own ZIP code. For Syracuse University, the data collected by SMTC indicated that approximately 72.8% of student trips were non-motorized. However, the 72.8% non-motorized share was a little greater than the share of trips originating in the same ZIP code, 64.3%, and it was assumed that 100% of the attractions from the same ZIP code were non-motorized (see Table 27). Although this assumption helped simplify the model and eliminated the need to collect detailed student, mode choice data, it likely caused a slight over-prediction of non-motorized trips coming from within the same ZIP code, and a slight under-prediction of non-motorized trips coming from different ZIP codes.

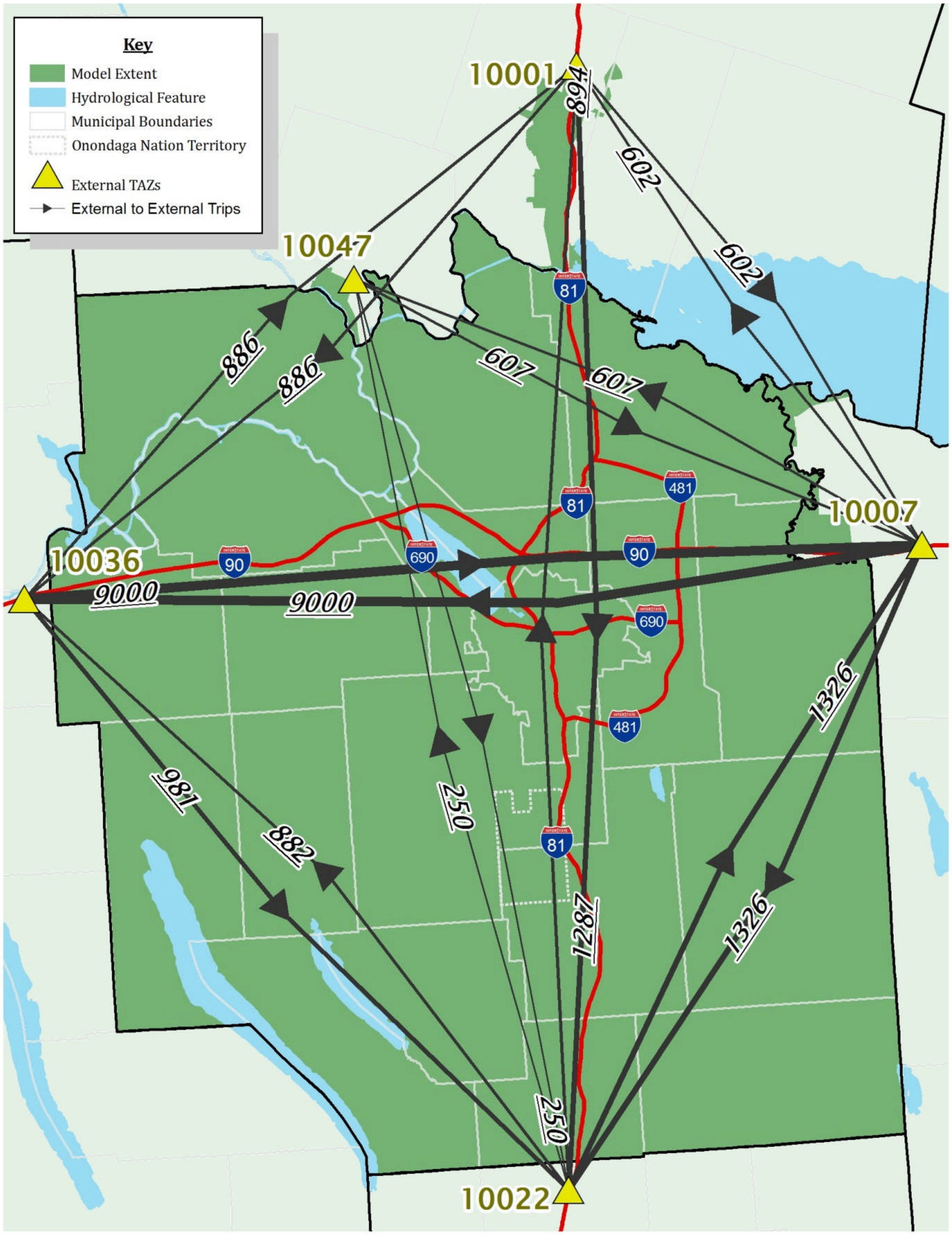
8.3 External Trips

The distribution of external to external trips is input to the model as a fixed trip table. Only major externals – I-81 North and South, the New York State Thruway East and West, and Route 481 – have any external to external trips. Table 32 and Figure 23 show the flow of external to external trips. As part of the I-81 planning effort that is currently underway, NYSDOT conducted a pass through study, using license plate capture at several locations on the Interstate Highway system, to identify the number of trips passing through the area using I-81. The results of this study were used during the development of the external to external trip table.

Table 32: External to external trips

External Origin TAZ	Origin Highway	External Destination TAZ	Destination Highway	AM Trips	PM Trips	Daily Trips
10001	I-81 (N)	10007	I-90 (E)	35	43	602
10001	I-81 (N)	10022	I-81 (S)	75	92	1,287
10001	I-81 (N)	10036	I-90 (W)	52	63	886
10007	I-90 (E)	10001	I-81 (N)	35	43	602
10007	I-90 (E)	10022	I-81 (S)	78	95	1,326
10007	I-90 (E)	10036	I-90 (W)	526	644	9,000
10007	I-90 (E)	10047	Route 481	35	43	607
10022	I-81 (S)	10001	I-81 (N)	52	64	894
10022	I-81 (S)	10007	I-90 (E)	78	95	1,326
10022	I-81 (S)	10036	I-90 (W)	52	63	882
10022	I-81 (S)	10047	Route 481	15	18	250
10036	I-90 (W)	10001	I-81 (N)	52	63	886
10036	I-90 (W)	10007	I-90 (E)	526	644	9,000
10036	I-90 (W)	10022	I-81 (S)	57	70	981
10047	Route 481	10007	I-90 (E)	35	43	607
10047	Route 481	10022	I-81 (S)	15	18	250
			TOTAL	1,718	2,102	29,386

Figure 23: External to External Trips



9.0 MODE SPLIT

The mode choice model estimates the fraction of person-trips between each origin and destination that use public transit vs. auto. Auto trips are then converted to vehicle trips using an auto occupancy factor and the resulting auto vehicle-trips are loaded onto the highway network.

The split of person-trips among modes is estimated using a logit model. A logit model is shown in Figure 24. The share of trips using each mode in the mode choice model is a function of the relative attractiveness of each mode. The attractiveness of each mode is a function of the characteristics of the mode and the preferences of different travelers.

Figure 24: Example Logit Model

$$Transit\ \ Mode\ \ Share\ = \frac{1}{1 - e^{(V_{auto} - V_{transit})}}$$

$$Auto\ \ Mode\ \ Share\ = 1 - Transit\ \ Share$$

$$\begin{aligned} Where:\ V_{auto} &= f(auto\ \ service,\ traveler\ \ attributes) \\ V_{transit} &= f(transit\ \ service,\ traveler\ \ attributes) \end{aligned}$$

The utility functions (Vs) in this equation can contain mode-specific travel time, cost and access variables as well as traveler-specific variables, each multiplied by parameters.

The multinomial logit model is an extension of this form that allows comparisons among more than two alternative modes. A further extension, the nested logit model allows for differential competition among modes. A multinomial logit model assumes that each alternative mode draws in fixed proportions from all other alternatives. This is an appropriate assumption when the alternatives are substantially unique but becomes less appropriate when subsets of the alternatives have important shared attributes.

The SMTC mode choice model is not estimated from survey data as survey data of the type typically used to estimate mode choice models, such as a transit on-board origin-destination survey coupled with a stated preference survey taken by transit riders, are not available. Instead, it is asserted based on professional judgment and experience estimating mode choice models in dozens of U.S. cities. The parameters are consistent with FTA guidance and are defensible representations of mode choice behavior. The mode choice model is calibrated to match the observed regional shares of trips between transit and auto.

The mode split macro skims the network for the optimal path in each mode. In the current version of the model, this includes an auto path and a bus path. The mode skims are then input to the mode split model and the trips are divided among the available modes. The auto and bus skimming process are described in Section 7.1 and Section 7.2 respectively.

The utility equations used in the mode choice model are shown in Figure 25 and the mode choice model parameters are shown in Table 33.

Figure 25: Mode Choice Model Utility Equations

$$V_i = \alpha + \beta_1 * IVTT + \beta_2 * OVTT + \beta_3 * OperatingCost + \beta_4 * Fare + \beta_5 * Xfer$$

i= auto, bus

IVTT = in-vehicle time (minutes)

OVTT = out-of-vehicle time (minutes)

OperatingCost = auto operating cost (minutes)

Fare = Transit Fare (dollars)

Xfer = Number of Transit transfers

Table 33: Mode Choice Model Coefficients

			Θ_a	β_1	β_2	β_3	β_4	β_5	α
HBW	Motor	Auto	1	-0.03	-0.06	-0.03	--	--	0
		Bus	1	-0.03	-0.06	--	-0.225	-0.3	-0.9
Non-HBW	Motor	Auto	1	-0.02	-0.04	-0.02	--	--	0
		Bus	1	-0.02	-0.04	--	-0.3	-0.2	-2.7

The auto person trips calculated by the mode choice model are converted to auto vehicle trips using the occupancy factors shown in Table 34. These rates were estimated from the 2004 Household Survey.

Table 34: Auto Occupancy Factors by Trip Purpose

Trip Purpose	Average Auto Occupancy
HBW	1.14
HBS	1.37
HBO	1.55
NHB	1.37

10.0 DIURNAL DISTRIBUTION

The trip generation, trip distribution and mode split models estimate daily trips. The traffic assignment model then assigns traffic by time period. Trips from each trip purpose are allocated to each time period based on time-of-day factors derived from the 2004 SMTC Household Travel Survey (and adjusted to more closely match observed traffic counts and following comparison to the 2001 NHTS data). For home-based trips, the time-of-day (diurnal) distribution is unique by direction (e.g. home-to-work vs. work-to-home), but for NHB trips the directionality of the trip matrix does not vary by time of day. The estimated diurnal distribution for all trips is shown in Figure 26. "DEP" stands for departing trips and implies trips from the production TAZ (home for home-based trips) to the attraction TAZ. Conversely, "RET" stands for returning trips (from attraction to production).

Figure 26: Diurnal Distribution for All Trips

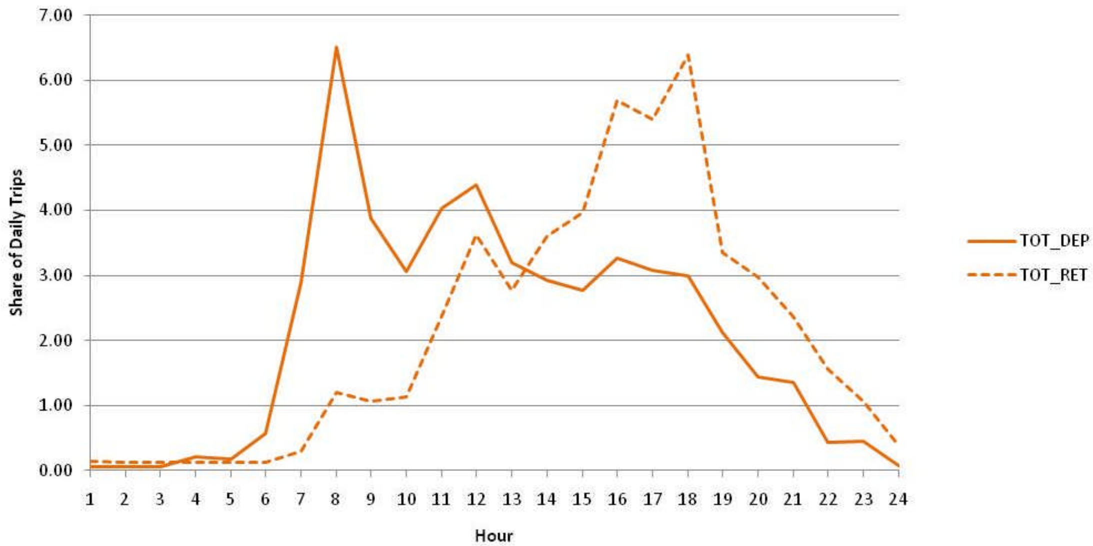


Figure 27: Diurnal Distribution of Home Based Work (HBW) Trips

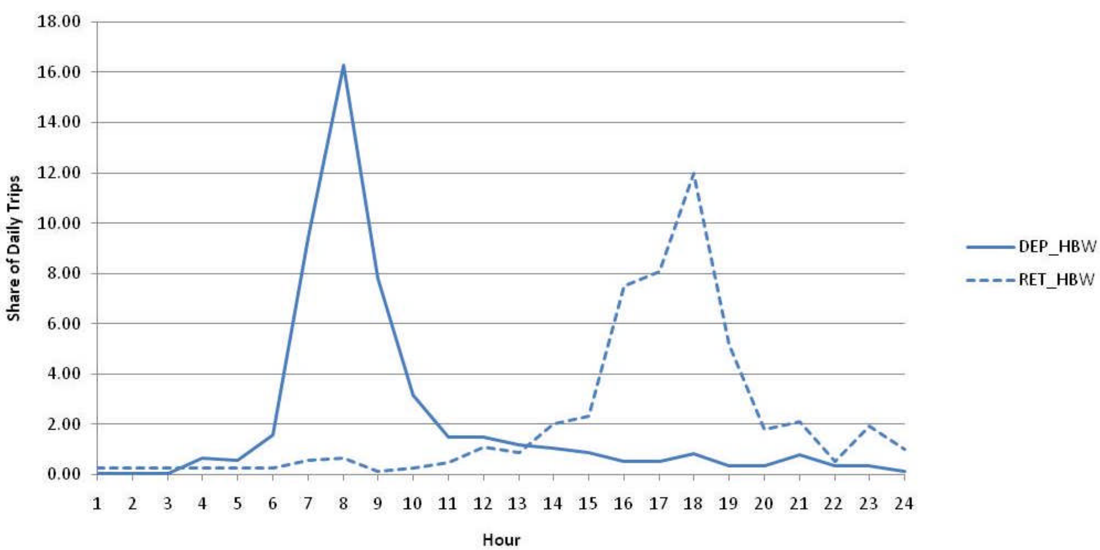


Figure 28: Diurnal Distribution of Home Based Shopping (HBS) Trips

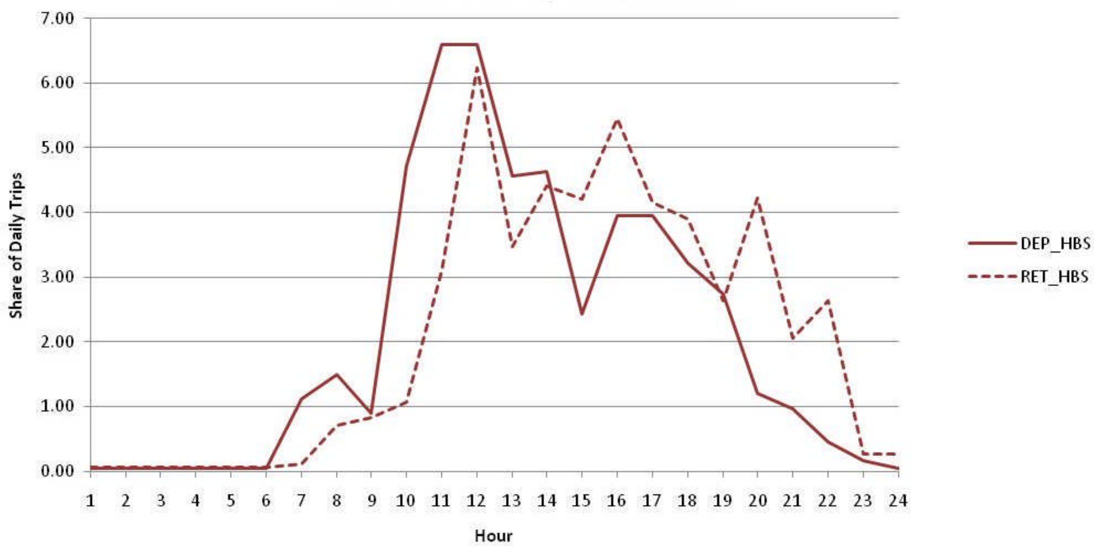


Figure 29: Diurnal Distribution of Home Based Other (HBO) Trips

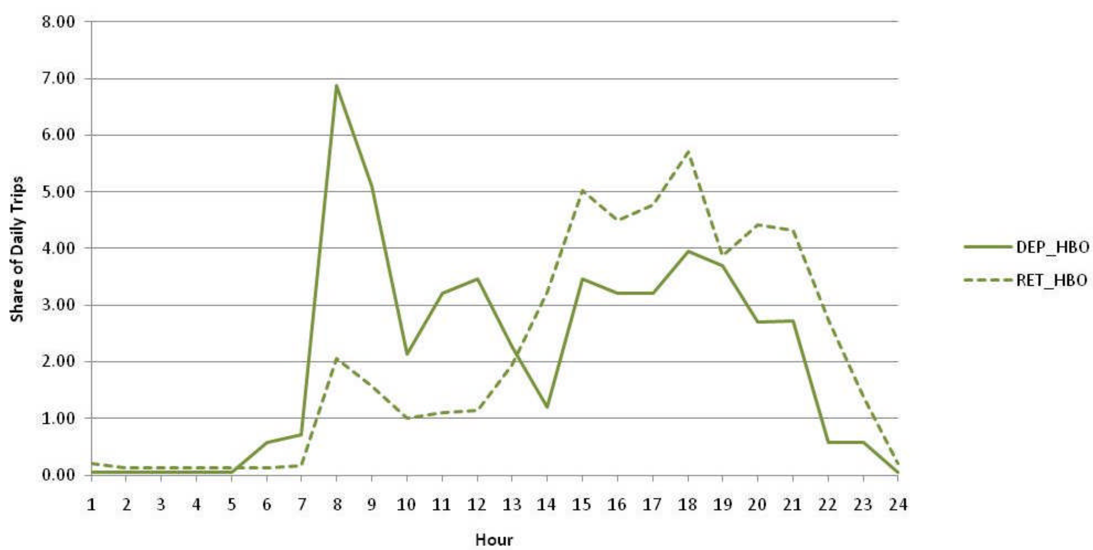
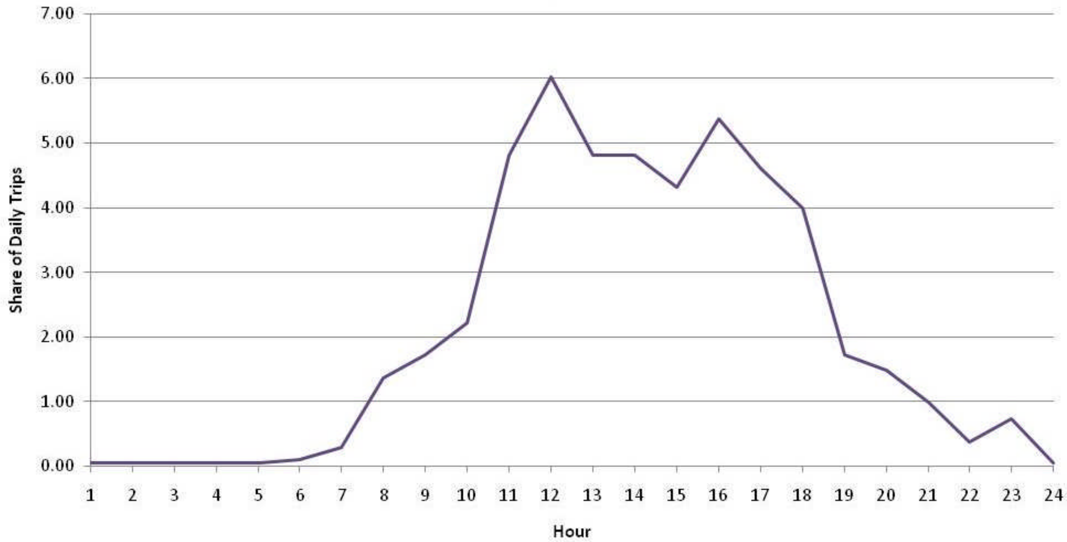


Figure 30: Diurnal Distribution of Non-Home Based (NHB) Trips



11.0 HIGHWAY ASSIGNMENT

The purpose of the assignment model is to locate a specific route along links and through intersections for every vehicle trip. The vehicle trips calculated in the mode split model, which are in the form of an origin/destination matrix, are "assigned" to the network based on a user equilibrium model. The user equilibrium model is an iterative process that finds a convergent solution in which no travelers can improve their travel times by switching to another route.

The assignment model includes travel delay from five sources:

- Volume-Dependant Link Delay – calculated using volume delay functions described below.
- Volume-Dependant Node Delay – calculated using volume delay functions described below.
- Global Turn Penalties – specified as 10 seconds per left turn, 5 seconds for right and through movements. U-turns are prohibited.
- Facility Type Penalties – specified in seconds for ramp access from arterials, collectors, and locals to reduce the number of very short trips routed via interstates/freeways (see Table 14).
- Specific Turn Prohibitions – these are specified in the Turn Penalty Table.

The model was calibrated to 2007 AM and PM peak hour and daily traffic conditions. The assignment calibration is assessed based on how accurately the model output link volumes match observed traffic counts and speeds by direction and time of day. Calibration of the assignment model involves adjusting the delays for turning movements and on links.

The volume delay function used in the SMTC model estimates both link and node delay. The function equations are shown in Figure 31. Table 33 shows the volume delay function parameters for interstates/freeways and all other roads. The parameters are the values that, when entered into the equations of the volume delay function, affect its shape and hence the relationship between traffic volume and the amount of delay. Interstates/freeways operate very differently in traffic flows terms than other types of road, and in particular intersection delay is not a meaningful concept and speeds fall more slowly as volume to capacity ratios increase.

Figure 31: SMTC Model Volume Delay Function Equations

$$d = D_l + I_l$$

$$D_l = t_0 \cdot c_1 \left[\frac{1}{1 - \frac{c_2}{1 + exp\left(c_3 - c_4 \cdot \frac{x}{C}\right)}} \right]$$

Where:

D_l = link delay

t_0 = freeflow travel time

x = traffic flow

C = link capacity

c_1 , c_2 , c_3 , c_4 = link parameters

$$I_l = d_0 \cdot p_1 \left[1 + \frac{p_2}{1 + exp\left(p_3 - p_4 \cdot \frac{x}{X}\right)} \right]$$

Where:

I_l = node delay

d_0 = freeflow travel time

x = traffic flow

X = node capacity

p_1 , p_2 , p_3 , p_4 = node parameters

Table 35: Volume Delay Function Parameters

Facility Type	Link Parameters				Node Parameters			
	C1	C2	C3	C4	P1	P2	P3	P4
Interstate/Freeway	1	0.975	6.5	6.3	-	-	-	-
All Other Roads	0.9526	1	3	3	0.04046	800	2.5	2.5

Figure 31 and Figure 32 show the elements of the delay function for non-freeway facilities, plotting delay against volume over capacity ratio. More specifically, Figure 31 shows total delay (link plus intersection delay) and link delay plotted against the volume to capacity ratio of the link. Figure 32 shows intersection delay plotted against the volume to capacity ratio of the intersection. The relationship between the link and intersection delay varies according to the relative capacities of the link and the intersection. The plots shown below are based on typical urban conditions where the intersection is the main capacity constraint in the network and provides the majority of the delay. The volume delay function parameters for non-freeway facilities were adjusted to provide reasonable average amounts of delay across the range of volume to capacity ratios, both at intersections and along links.

Figure 33 shows a similar link delay plot against volume to capacity ration for interstates and freeways, in comparison to the shape of a recommended Bureau of Public Roads (BPR) volume delay function and the default IITPR parameters used previously in the SMTC model. Figure 34 shows the resulting link speeds for interstates freeways. The volume delay function's parameters were adjusted to match the shape of the BPR function which had been calibrated to accurately reflect observed interstate speeds.

Figure 32: Link Delay and Total Delay for non-Freeway Facilities

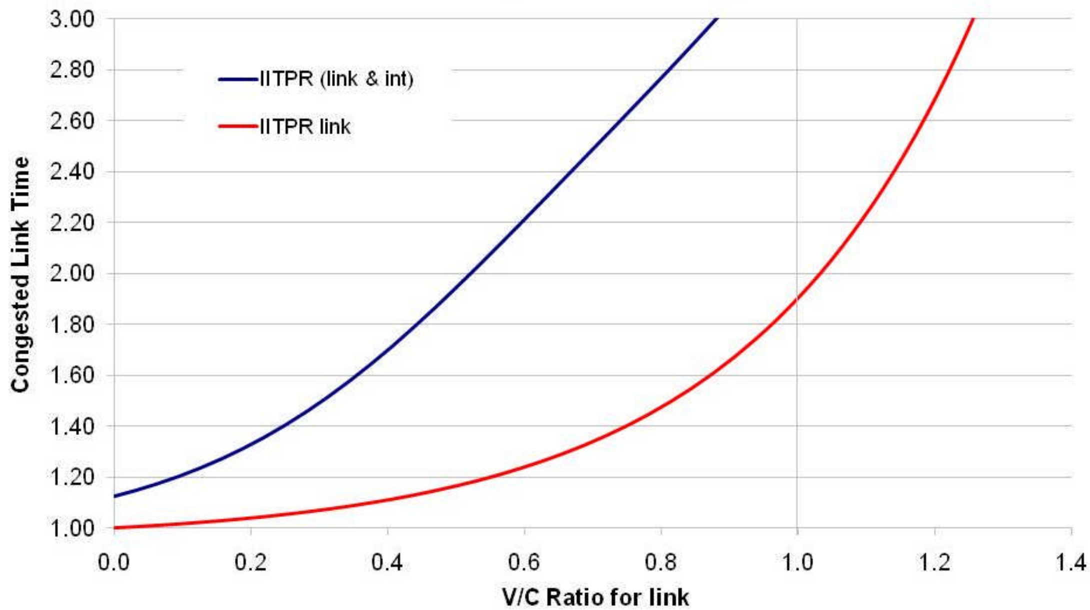


Figure 33: Node Delay for non-Freeway Facilities

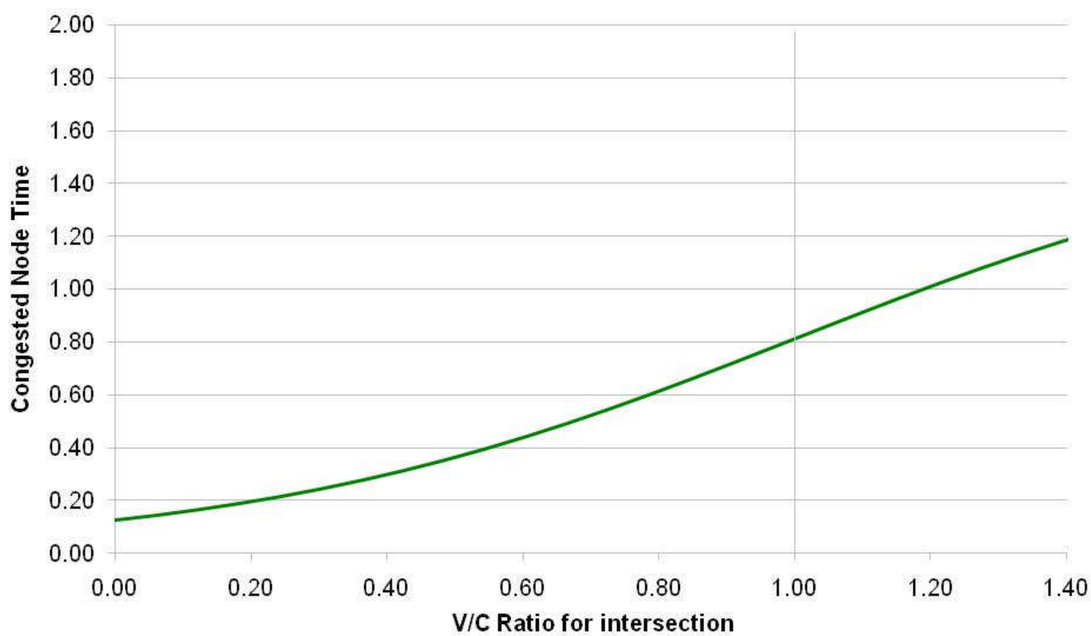


Figure 34: Link Delay and Total Delay for Interstates

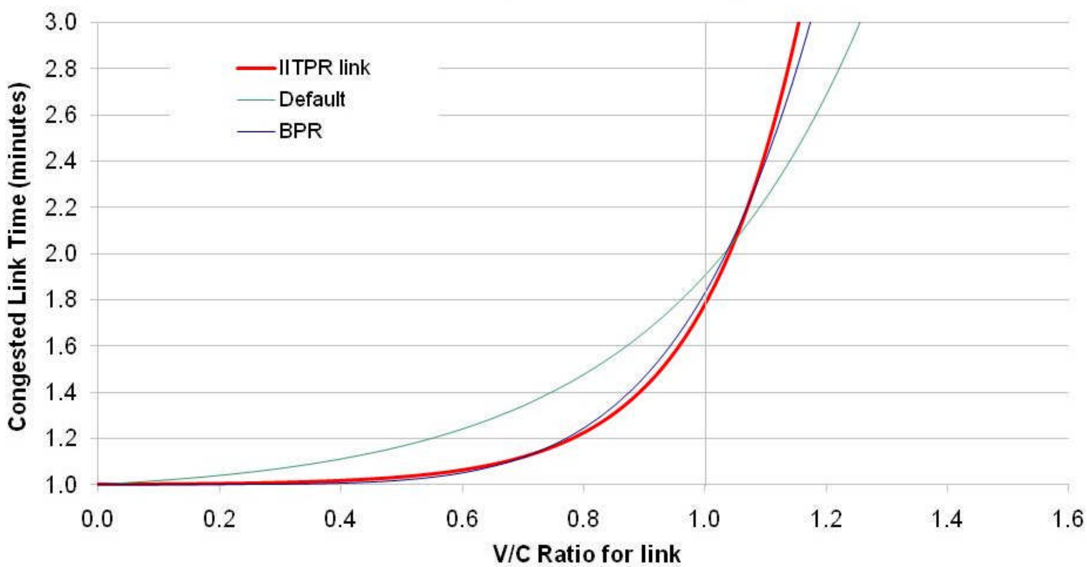
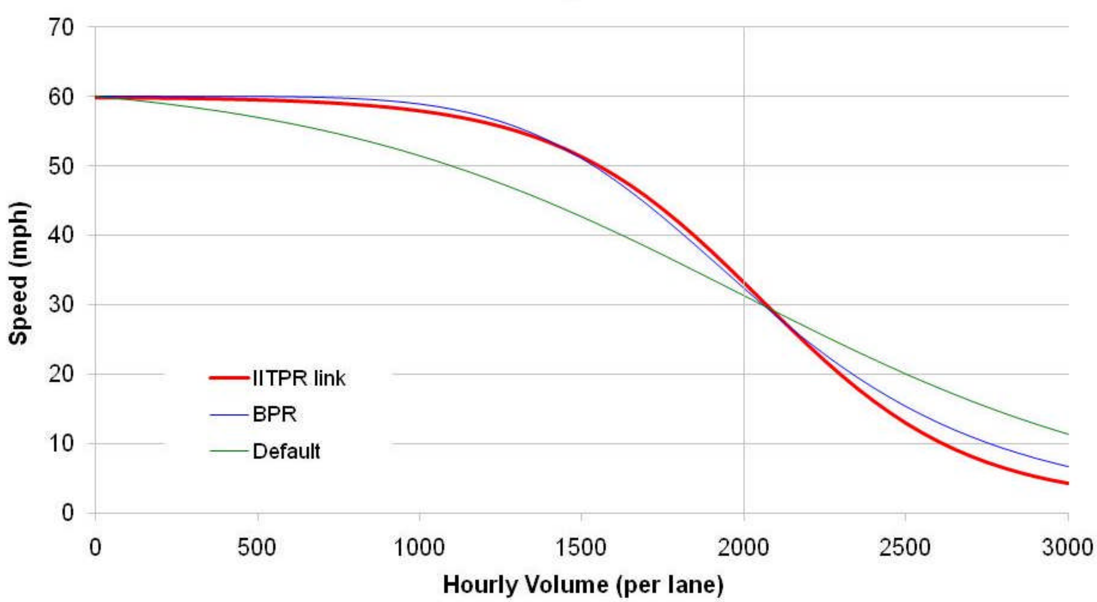


Figure 35: Link Speed for Interstates



12.0 TRANSIT ASSIGNMENT

The transit assignment model tabulates the number of riders using each stop and route. Unlike highway assignment, transit assignment is not formally constrained by a capacity, and therefore, the transit routing computed between each TAZ pair during the transit skimming procedure (see section 7.2) is imitated in assignment. The SMTC transit assignment model relies on Caliper's "pathfinder" algorithm, the compatible assignment algorithm to that used in skimming, and for cases where pathfinder built a composite path between TAZ pairs in skimming (see section 7.2.3), the trips are apportioned among the alternative routes based on the ratio of headway times.

13.0 Feedback and Model Convergence

The model is converged if and only if the outputs are consistent with the inputs. This means that the congested travel times coming out of assignment must be consistent with the travel times that were used in trip distribution. Because the SMTC model starts “cold” and uses free flow times in the first pass of trip distribution, it is expected that assignment travel times will look slower than those used in trip distribution. To account for this discrepancy, the assignment travel times are used to create new congested skims for trip distribution (see Figure 2). However, this is not the end of the process. Because the first pass of trip distribution used free flow times, each destination appeared unrealistically accessible, leading to too much VMT and slow travel times on the highway. Therefore, the assignment travel times sent to the second pass of distribution are expected to make destinations appear too inaccessible. In turn, this leads to lower VMT on the highway and faster travel times in the second round of assignment. Continuing this feedback process indefinitely leads to oscillating VMT and travel times, but with each subsequent loop, the absolute change decreases. Eventually, the absolute change is judged to be small enough where the model has reached equilibrium.

13.1 MSA Feedback

The SMTC model follows the method of successive averages (MSA) process of feedback where new travel times are calculated by applying the volume delay function to an unweighted average of volumes from each assignment iteration (see Figure 36). Because the weight of the next assignment run is inversely proportional to the number of iterations, the new travel times change less and less, and convergence will be reached in a finite amount of time.

Figure 36: MSA Feedback

$$\mathbf{MSAFlow_n = MSAFlow_{n-1} + (1/n)*(Flow_n - MSAFlown\text{-}1)}$$

where:

n = current MSA iteration number

$MSAFlow_n$ = calculated MSA flow at iteration n

$Flow_n$ = resulting flow directly from trip assignment

13.2 Feedback Criteria

Some of the symptoms of an unconverged model include: fluctuations in travel times and in VHT, fluctuations in assignment volumes and in VMT, and fluctuations in trip tables between subsequent iteration. The SMTC model runs three tests, performed on each of the four period assignments or each of the four trip purposes to check for some of these symptoms:

- At least 95% of link volumes must change by less than 5%. This test is run for each of the four assignment periods.
- The change in total VHT must be less than .1%. This test is run for each of the four assignment periods.
- For 95% of TAZ pairs, the change in trips is must either be less than 1% or less than .01 trips. This test is run for each of the four trip purposes.

If any of the twelve tests fail, then another feedback loop is run, but if all of the twelve tests pass, then the model is deemed converged and terminates.

14.0 FUTURE YEAR MODELS

The future year models use the same structure and parameters as the base year model, but several of the inputs are updated. The adjusted inputs include the highway network, socioeconomic data for TAZs, demand for special generator TAZs, external demand to/from internal TAZs, and external demand to/from other external TAZs.

The focus of the future modeling work was on creating reasonable inputs for a 2035 horizon year. Once the 2035 inputs were created, weighted interpolations/extrapolations of the 2007 to 2035 data trends were developed to build assumptions for four other future years: 2013, 2020, 2030, and 2040.

14.1 Highway Networks

The future year highway network includes projects that are suggested (i.e. included in the SMTC LRTP, or otherwise programmed by NYSDOT, Onondaga County, or other municipalities) to be built before 2035. The significant projects that are coded in the future year networks are presented in Table 36. The table indicates which future year scenario the project first appears in. Most of the projects did not require much interpretation to model, as they involved obvious changes to network, such as physical changes to links, changes to network attributes, such as a change in the number of lanes, and edits to the node types to reflect intersection improvements. However, there were projects that required judgment to model. In particular, the traffic signal improvement projects were modeled by assuming a 5 mph increase in the freeflow speeds and a 5% increase in link capacity near the intersection.

Table 36: Future Year Network Projects

Project	First Modeled
Onondaga Lake Parkway speed reduction	2013
University Ave between Waverly Ave E. Genesse St. conversion to two-way	2013
Northern Blvd/E Molloy Safety Project	2013
Old Liverpool Rd/Electronics Pkwy Safety Project	2013
Bridge St at I690 WB ramp improvements	2013
James, Salina, Seneca Turnpike, E. Genesee and South Ave, traffic signal improvements	2013
Geddes, W. Genesee, Lodi, and North Salina Street Traffic Signal Improvements	2013
Third lane of Frontage Road	2020
NY 31 Additional travel lane	2020
Routes 31/81 interchange improvements	2020
Seventh North/Buckley intersection upgrade	2020
Soule Road & Route 31/Route 481 interchange improvement	2020
Comstock Ave Lane Reduction	2020
Waverly Ave Lane Reduction	2020
Route 11/Route 20 intersection Improvements	2020
Electronics Pkwy/Henry Clay Blvd Signal Improvements	2020
Buckley Rd/Bear Rd intersection expansion	2027
Bear Street Extension	2030
Genant Street upgrade	2030

14.2 Socioeconomic data

The development of 2035 socioeconomic data was discussed in sections 3.2.3 (households and population) and 3.2.5 (employment). Due to local knowledge of the current (2007-2010), adverse, economic conditions, the SMTC decided to weight the 2007 to 2035 socioeconomic growth so that a disproportionately large amount of the growth occurred after 2013, when growth is projected to display a more typical trend. The one exception to this rule was for the Carousel Mall special generator, where 25% of the growth is expected to occur by 2013, and all of the remaining growth is assumed to occur by 2020. The annual socioeconomic growth rate from 2035 to 2040 was assumed to be 25% of the average annual growth rate from 2007 to 2035. Table 37 presents the cumulative percent of the 2007 to 2035 growth by future year.

Table 37: Cumulative Percent of 2007 to 2035 Growth

Year	Carousel Mall	Other TAZs
2013	25.0%	5.4%
2020	100.0%	40.2%
2030	100.0%	82.1%
2035	100.0%	100.0%
2040	104.5%	104.5%

14.3 Special Generators

For special generators that relied on a hand-selected ITE formula in base year estimation (see Table 26), the 2035 attractions were estimated by growing the key variable by the same percentage that total employees grew between 2007 and 2035 and reapplying the ITE formula. The attractions for other special generators, as well as trip productions for every special generator, were estimated by the standard application of socioeconomic data presented in sections 6.2 (productions) and 6.3 (attractions). Table 38 presents the 2035 motorized productions and attractions.

Table 38: 2035 Special Generator Motorized Productions and Attractions

TAZ	Special Generator	Productions	Attractions
8001	NY State Fairgrounds	(SE)	(SE)
8002	Carousel Center	13,013	40,033
8003	Onondaga Community College	3,952	7,437
8004	Van Duyn Home & Hospital	362	3,480
8005	Loretto	604	1,814
8006	SU South Campus	5,251	3,058
8007	OnCenter	972	1,963
8008	OnCenter	2,108	12,999
8009	OnCenter	726	2,132
8010	Lemoyne College	5,662	5,223
8011	University Hill Hospitals	16,306	43,940
8012	Syracuse University	7,910	23,055
8013	Carrier Dome	(SE)	(SE)
8014	St. Joe's Hospital	233	5,459
8015	Alliance Bank Stadium	(SE)	(SE)
8016	Hancock Airport	5,719	20,328

(SE): Special Event locations that are not included in a model run that represents a typical day

The special generators demand for the other future years was estimated by interpolating/extrapolating the 2007 to 2035 growth as indicated in Table 37.

14.4 External Trips

External demand was assumed to grow at 1% per year from 2007 to 2035. The external demand for 2013, 2020, and 2030 was estimated as a straight line interpolation of the 2007 to 2035 growth, and the external demand for 2040 was estimated as 25% of a straight line extrapolation out from 2035. Table 39 and Figure 37 present the 2035 external-to-external trips.

Table 39: 2035 External-to-external Trips

External Origin TAZ	Origin Highway	External Destination TAZ	Destination Highway	AM Trips	PM Trips	Daily Trips
10001	I-81 (N)	10007	I-90 (E)	46	57	795
10001	I-81 (N)	10022	I-81 (S)	99	122	1,701
10001	I-81 (N)	10036	I-90 (W)	68	84	1,171
10007	I-90 (E)	10001	I-81 (N)	46	57	795
10007	I-90 (E)	10022	I-81 (S)	102	125	1,752
10007	I-90 (E)	10036	I-90 (W)	695	851	11,892
10007	I-90 (E)	10047	Route 481	47	57	802
10022	I-81 (S)	10001	I-81 (N)	69	84	1,181
10022	I-81 (S)	10007	I-90 (E)	102	125	1,752
10022	I-81 (S)	10036	I-90 (W)	68	83	1,165
10022	I-81 (S)	10047	Route 481	19	24	330
10036	I-90 (W)	10001	I-81 (N)	68	84	1,171
10036	I-90 (W)	10007	I-90 (E)	695	851	11,892
10036	I-90 (W)	10022	I-81 (S)	76	93	1,296
10047	Route 481	10007	I-90 (E)	47	57	802
10047	Route 481	10022	I-81 (S)	19	24	330
			TOTAL	2,269	2,777	38,827

14.5 Future Year Traffic Volumes

Figure 38 shows predicted future increases in daily traffic volumes for the model extent (2035 Volumes – 2007 Volumes). Figure 39 shows the same predicted future daily traffic volume increases, but with a focus on Syracuse proper.

Figure 37: Future Year External to External Trips

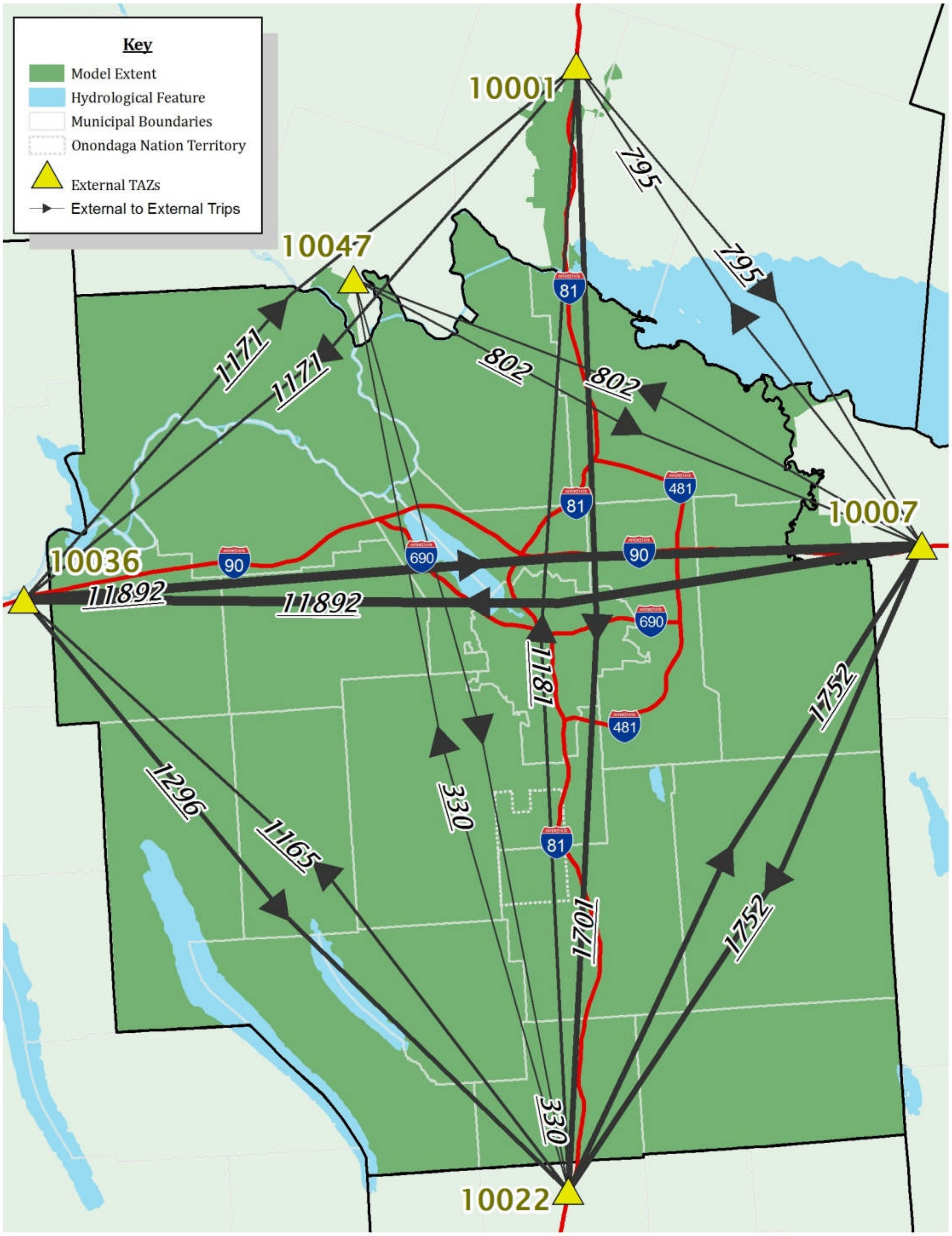


Figure 38: Future Increases in Daily Traffic Volumes (Model Region)

Figure 39: Future Increases in Daily Traffic Volumes (City of Syracuse and Vicinity)

15.0 Model Calibration, Validation and Reasonableness Checks

Model calibration is the process of reviewing and adjusting parameter values in the various model steps to ensure that it reasonably replicates the existing conditions. Model validation and reasonableness checking is performed for each step in the model. Generally speaking, the model is calibrated when the model-generated roadway volumes and speeds reasonably reflect reality, and other key indicators and parameters are reasonable from a behavioral standpoint and consistent with other models and survey data.

Examples of parameters that can be modified as part of the calibration process include:

- Trip generation rates;
- Friction factors in the gravity model (trip distribution);
- Coefficients in the mode split equations (e.g. the relative weight of time vs. money);
- Time-of-day parameters;
- Network and TAZ structures;
- Free-flow speeds and capacities on the roadway network; and
- Coefficients in the assignment model relating V/C ratio to delay.

Calibration is as much an art as a science, and it requires the model developer to exercise considerable judgment as to "reasonableness." There is an inherent balance in the process, between the extremes of an uncalibrated model that does not accurately replicate measurable field conditions and a model that is "overcalibrated" through the use of unjustifiable correction factors such that a model's ability to predict future travel conditions is compromised.

Three publications used to guide the calibration effort were:

- Calibrating and Adjustment of System Planning Models, FHWA, December 1990. Publication No. FHWA-ED-90-015
- Model Validation and Reasonableness Checking Manual; FHWA, February 1997
- NCHRP Report 365 – Travel Estimation Techniques for Urban Planning, TRB, 1998

The calibration process used in the SMTC model development included evaluating the following metrics:

- Trip generation
- Trips/person per day
- Trips/household per day
- Trip distribution
- Average trip duration by trip purpose
- Trip length frequencies by trip purpose
- Mode choice
- Regional transit ridership
- Auto occupancy
- Traffic assignment
- Regional 24-hour ground counts v. model volumes
- 24-hour ground counts v. model volumes by functional class
- Highway Performance Monitoring System (HPMS) data

15.1 Trip generation

To validate the overall output from the trip generation model, the total regional trip productions were compared to trip rates extracted from the 2001 NHTS. The average number of trips per household in the model is 9.1, close to the 9.66 trips per household in the NHTS.

15.2 Trip distribution

To validate the trip distribution model, the trip length frequency distributions were extracted from the survey and the model to determine if the model was replicating the overall shape of the observed frequency distributions. The model and the survey frequency distributions are examined at 2-mile distance bins (0-2 miles, 2-4 miles, etc) and 3-minute time bins (0-3 minutes, 3-6 minutes, etc). The average trip distance and average trip time can then be determined from the modeled and observed frequency distributions. Table 40 and Table 41 compare the modeled and observed average trip distance and time respectively. In both cases, the model matches closely with the observed trip lengths.

Table 40: Average Trip Distance (miles)

Trip Type	Observed	Model
HBW	9.0	9.3
HBS	5.2	6.2
HBO	6.0	6.0
NHB	6.1	5.1

Table 41: Average Trip Time (minutes)

Trip Type	Observed	Model
HBW	19.4	17.0
HBS	10.3	10.8
HBO	11.9	10.7
NHB	12.3	9.1

Figure 40 to Figure 43 present comparisons of the observed and modeled trip distance frequency distribution. Figure 44 to Figure 47 present comparisons of the observed and modeled trip time frequency distribution. In all cases, the model replicates the observed trip length frequency distributions closely.

Figure 40: Home-Based Work Trip Distance Distributions

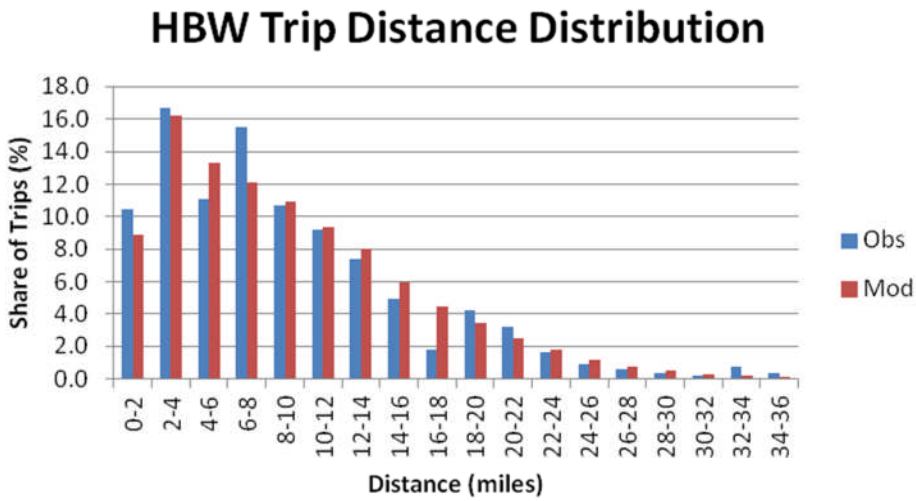


Figure 41: Home-Based Shopping Trip Distance Distributions

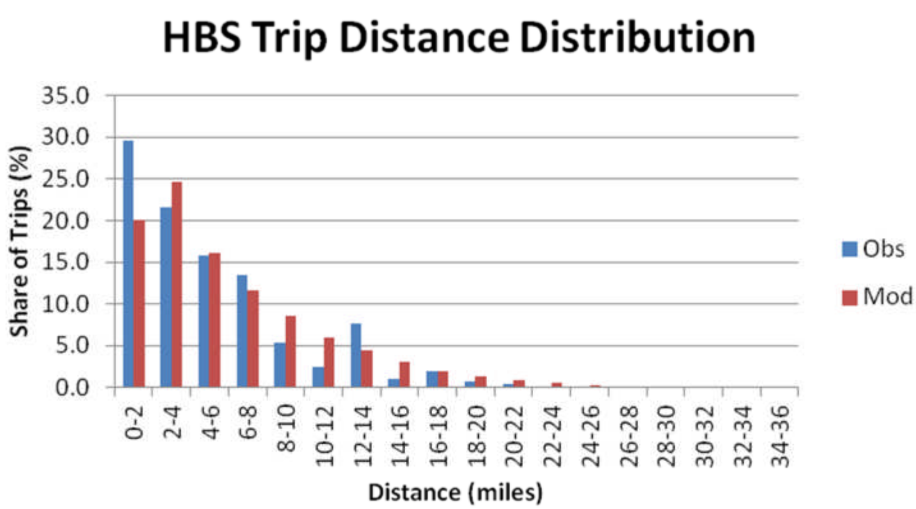


Figure 42: Home-Based Other Trip Distance Distributions

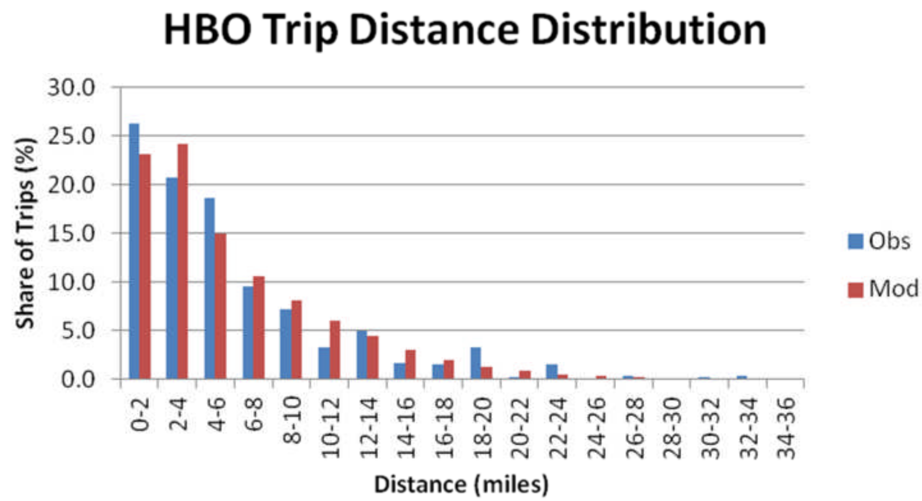


Figure 43: Non Home-Based Trip Distance Distributions

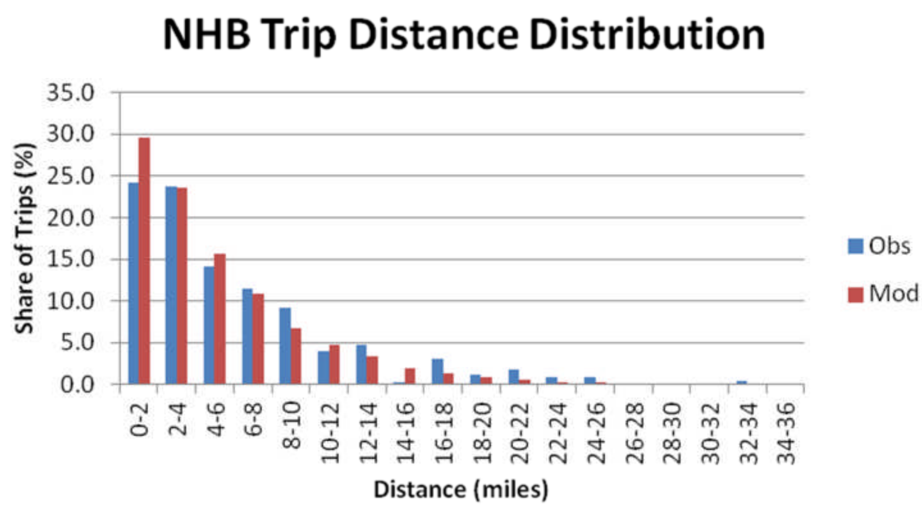


Figure 44: Home-Based Work Trip Time Distributions

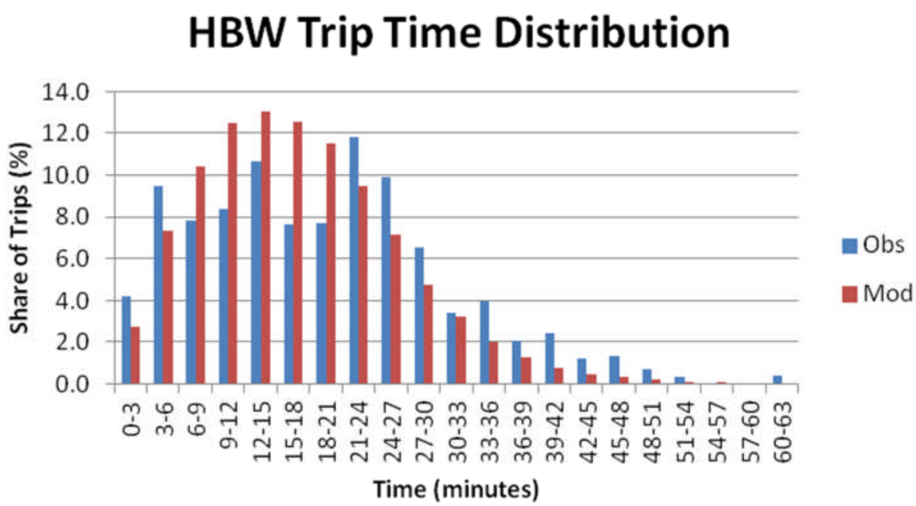


Figure 45: Home-Based Shopping Trip Time Distributions

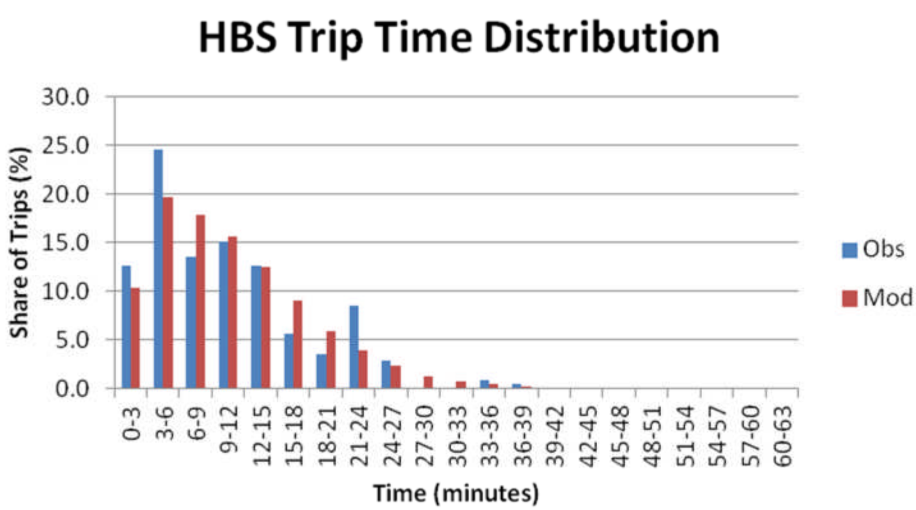


Figure 46: Home-Based Other Trip Time Distributions

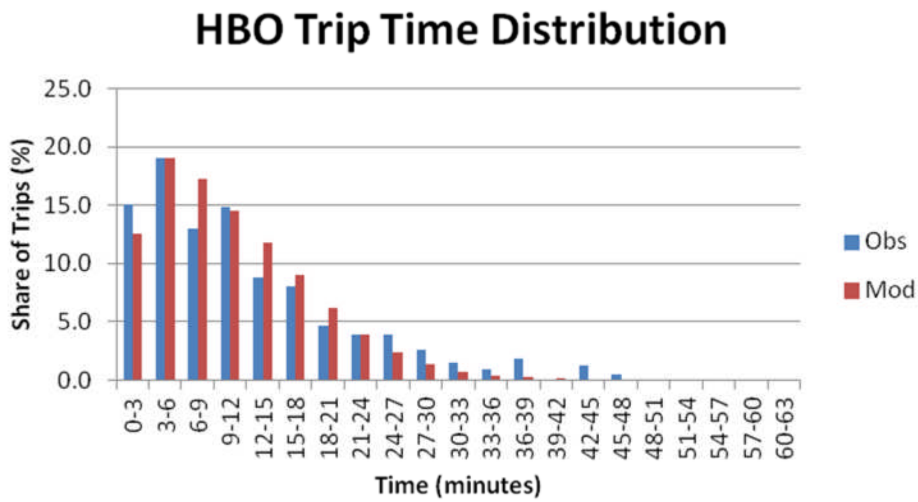
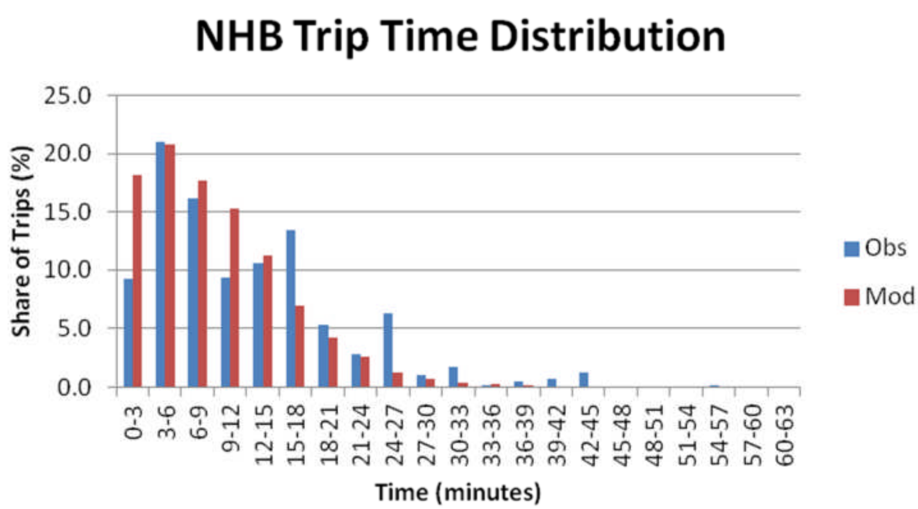


Figure 47: Non Home-Based Trip Time Distributions



15.3 Mode choice

Transit demand was compared with observed data – ridership counts by time of day – to confirm that the mode choice model was producing reasonable results. While the model choice model parameters are not estimated statistically using survey data, the comparison shown in Table 42 confirms that the asserted model produces results that match closely to both peak and off peak transit boardings.

Table 42: Comparison of Model and Observed Transit Boardings

	Model	SMTC Counts
Peak Boardings	13,420	11,378
Off Peak Boardings	9,592	10,695
Total Boardings	23,012	22,074

15.4 Assignment

The Federal Highway Administration (FHWA) has developed guidelines for calibration standards. The following sections detail the calculation of the various statistics used to measure calibration. Individual link errors were calculated by subtracting the simulation volume from the ground count for that link.

15.4.1 Coefficient of Correlation

The coefficient of correlation, "r", is commonly used to measure the strength and direction between two sets of variables. An r value of 1.0 would indicate a perfect one to one correlation between the two variables, an r value of 0 would indicate a completely random correlation, and an r value of -1 would indicate a perfect inverse correlation. The value of r can be estimated using the following formula.

$$\mathrm{r} = \frac{\sum(x \cdot y) - n \cdot \bar{x} \cdot \bar{y}}{\sqrt{\left(\sum(x^2) - n \cdot \bar{x}^2\right)\left(\sum(y^2) - n \cdot \bar{y}^2\right)}}$$

where:

x = Ground count

y = Calibration volume

n = Number of observations

FHWA recommends a minimum r value of 0.88; **the daily model has a correlation coefficient of 0.97.**

15.4.2 Root Mean Squared Error

The root mean squared error (RMSE) is an average link error that weights the larger volume errors in a network. It should be noted that the RMSE is always higher than the actual average network error because of the weighting scheme. RMSE is calculated as:

$$\mathrm{RMSE} = \frac{\sqrt{\frac{\sum\left[(x-y)^2\right]}{n}}}{\frac{\sum x}{n}}$$

where:

x = Ground count

y = Calibration volume

n = Number of observations

The RMSE should generally be less than 40%; **the daily model has an RMSE of 35.9%.**

15.4.3 Sum of Differences

The sum of differences is the average error of the network. It is similar to FHWA's "percent error region-wide standard".

$$\text{SumDif} = \sum (y - x) \quad \text{or} \quad \frac{\sum (\text{y - x})}{n} \times 100\%$$

where:

x = Ground count

y = Calibration volume

n = Number of observations

The region-wide percent sum of differences for the daily model is 0.2%.

15.4.4 Comparison to Calibration Guidelines

A comparison between the FHWA guidelines and the calibrated daily model is shown in Table 43. All measures of performance exceed guidelines published by the FHWA. The previous version of the model did meet all of the guidelines except for sum of differences for freeways; compared to the previous version of the model, the overall correlation with counts has been improved from 0.93 to 0.97.

Table 43: FHWA Assignment Calibration Guideline

	FHWA Guideline	Model
Correlation Coefficient	0.88	0.97
Percent Error Region-Wide	+ / - 5%	0.2%
Sum of Differences by Facility		
Freeways	+ / - 7%	5.1%
Principal Arterials	+ / - 10%	1.3%
Minor Arterials	+ / - 15%	-3.6%
Collectors	+ / - 25%	-4.9%

Table 44 presents the assignment validation reports generated by the model for the all day (Daily), the AM Peak Hour and the PM Peak Hour. The tables show the RMSE, correlation, percent error, average error and number of observations by facility type. The tables also summarize the validation measures when the 'Collectors' and 'Locals' are omitted from the calculation. A very large share of the count data is on collectors and locals. The extent to which the travel model can replicate volumes on these low class facilities is heavily influenced by the traffic analysis loading points also known as centroid connectors. The loading points can be somewhat arbitrary; therefore the model should not be expected to do a great job replicating roadway volumes at these locations.

Table 44: Assignment Validation

DAILY

Facility Type	RMSE	Correlation	Percent Error	Average Error	Count Locations
Interstate/Freeway	15.7%	0.964	5.1%	1,132	208
Principal Arterial	37.6%	0.780	1.3%	88	310
Minor Arterial	38.5%	0.760	-3.6%	-179	623
Collector	55.8%	0.720	-4.9%	-87	722
Local	79.7%	0.752	-18.5%	-189	271
External Connector	8.6%	1.000	3.6%	91	64
Ramp	37.5%	0.884	-2.0%	-99	201
ALL	***= 0.359***	***0.966***	***0.2%***	***9***	***2399***
ALL -- Excluding Collectors & Locals	***= 0.294***	***0.963***	***1.2%***	***97***	***1406***

AM Peak Hour

Facility Type	RMSE	Correlation	Percent Error	Average Error	Count Locations
Interstate/Freeway	24.4%	0.919	5.6%	116	176
Principal Arterial	34.1%	0.847	-2.1%	-11	234
Minor Arterial	40.4%	0.780	-9.1%	-36	356
Collector	65.3%	0.671	-7.1%	-11	397
Local	90.4%	0.759	-13.4%	-11	138
External Connector	38.2%	1.000	28.2%	217	2
Ramp	40.8%	0.886	-4.1%	-18	168
ALL	***= 0.417***	***0.959***	***-0.5%***	***-2***	***1471***

PM Peak Hour

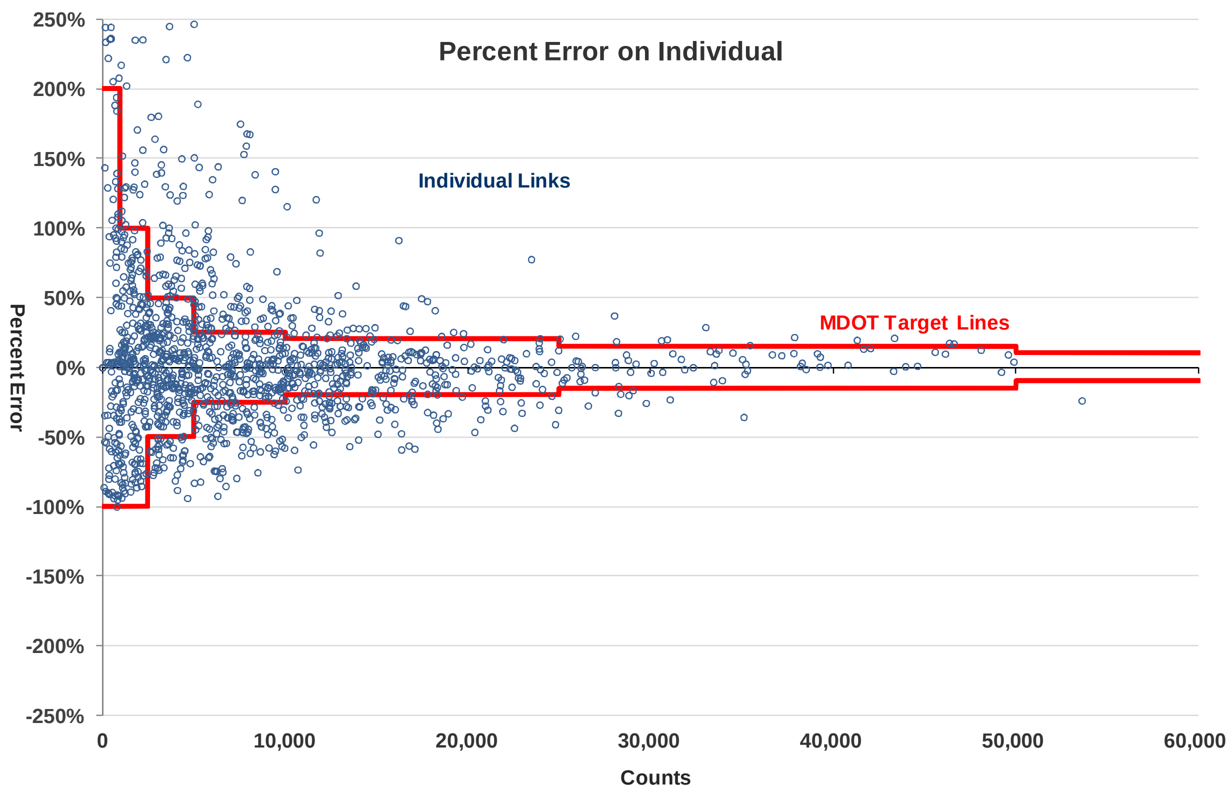
Facility Type	RMSE	Correlation	Percent Error	Average Error	Count Locations
Interstate/Freeway	25.2%	0.915	11.0%	238	178
Principal Arterial	34.4%	0.840	-3.8%	-26	234
Minor Arterial	39.6%	0.763	-11.5%	-55	356
Collector	54.3%	0.713	-8.8%	-16	397
Local	79.8%	0.712	-13.6%	-12	138
External Connector	31.8%	1.000	29.7%	261	2
Ramp	37.4%	0.890	-0.9%	-4	168
ALL	***= 0.408***	***0.956***	***0.9%***	***5***	***1473***

The Michigan Department of Transportation (MDOT) has developed error targets for comparing daily model and observed volumes for individual links. The MDOT error targets are presented in Table 45 and are displayed as the red lines in Figure 48. Outliers are expected and typically having a majority of the data points within the error boundary is deemed acceptable with more stringent criteria applied to the high volume links.

Table 45: Michigan DOT Volume-based Calibration Standards

(Upper Bound) Link Volume	MDOT error
0	200%
1,000	100%
2,500	50%
5,000	25%
10,000	20%
25,000	15%
50,000	10%

Figure 48: Comparison of Individual Link Level Errors using MDOT Criteria



Scattergrams which plot the observed count on the x-axis versus the model volume on the y-axis are used to visually inspect the model fit to observed data. A 'perfect fit' is illustrated by the y=x line where the model volume is equal to the count volume on the link. Data points distant from the y=x line are cases where the model is not well-aligned with the observed count data. Again, as the link volumes increase, the model should do a better job matching existing counts on the high class facilities such as interstates and freeways. Figure 49, Figure 50, and Figure 51 show daily, AM and PM scattergrams respectively.

Figure 49: Scattergram showing daily counts vs. model volumes

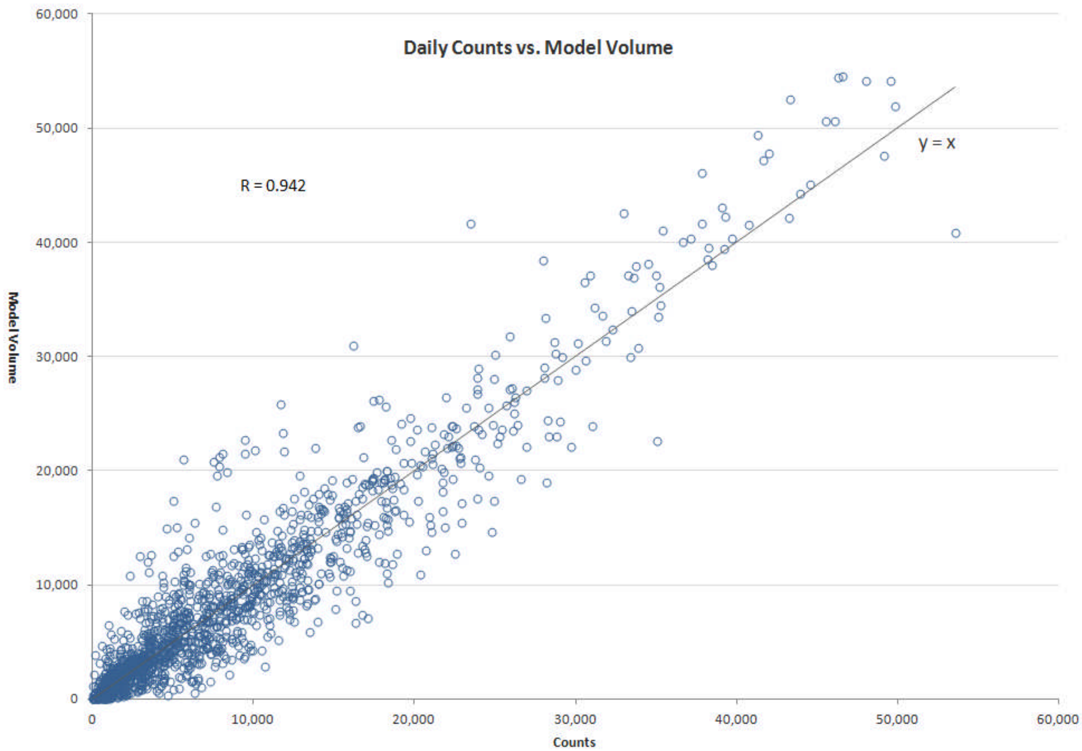


Figure 50: Scattergram showing AM counts vs. model volumes

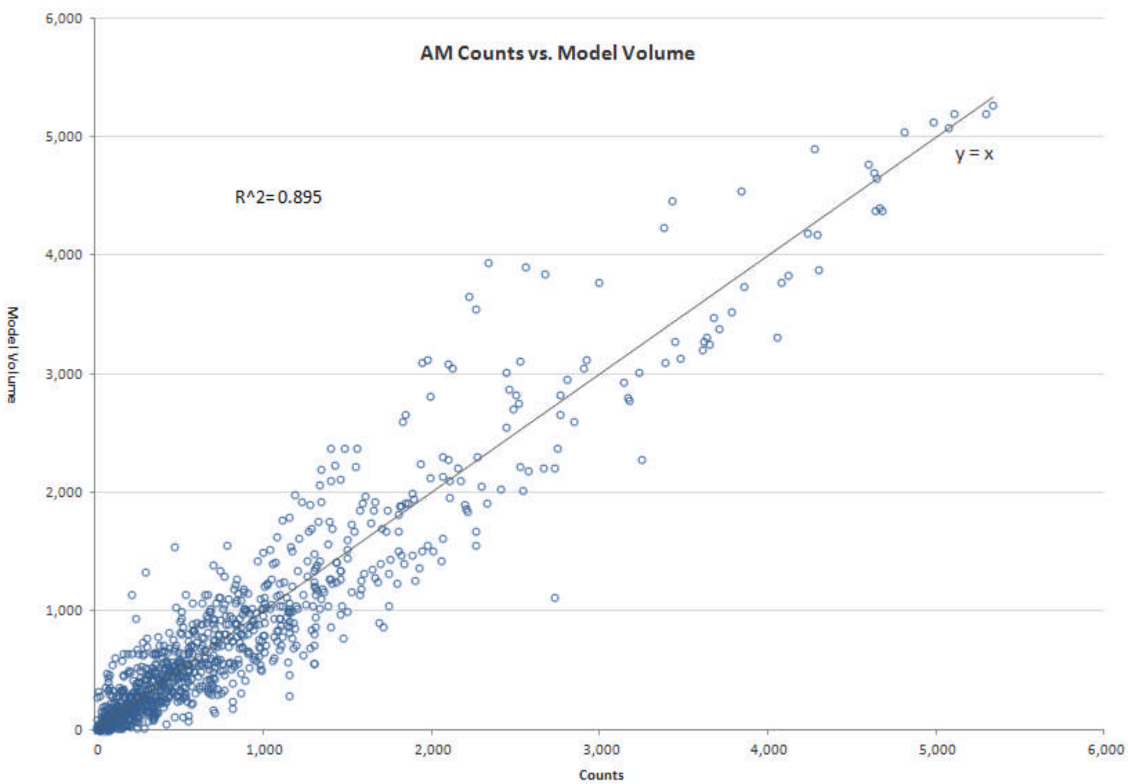


Figure 51: Scattergram showing PM counts vs. model volumes

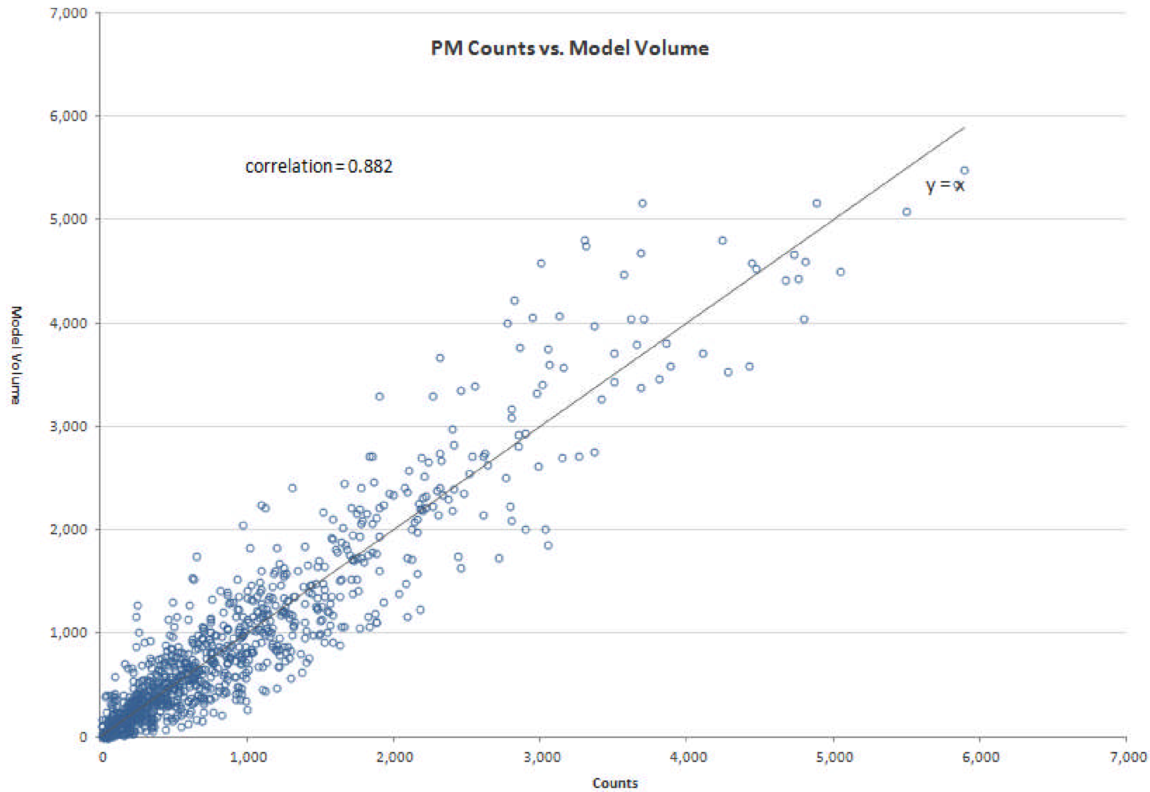


Figure 52 shows volume error (Model Volume – Observed Counts) and Figure 53 shows the same volume area with a focus on Syracuse proper.

Figure 52: Volume Error Model Region

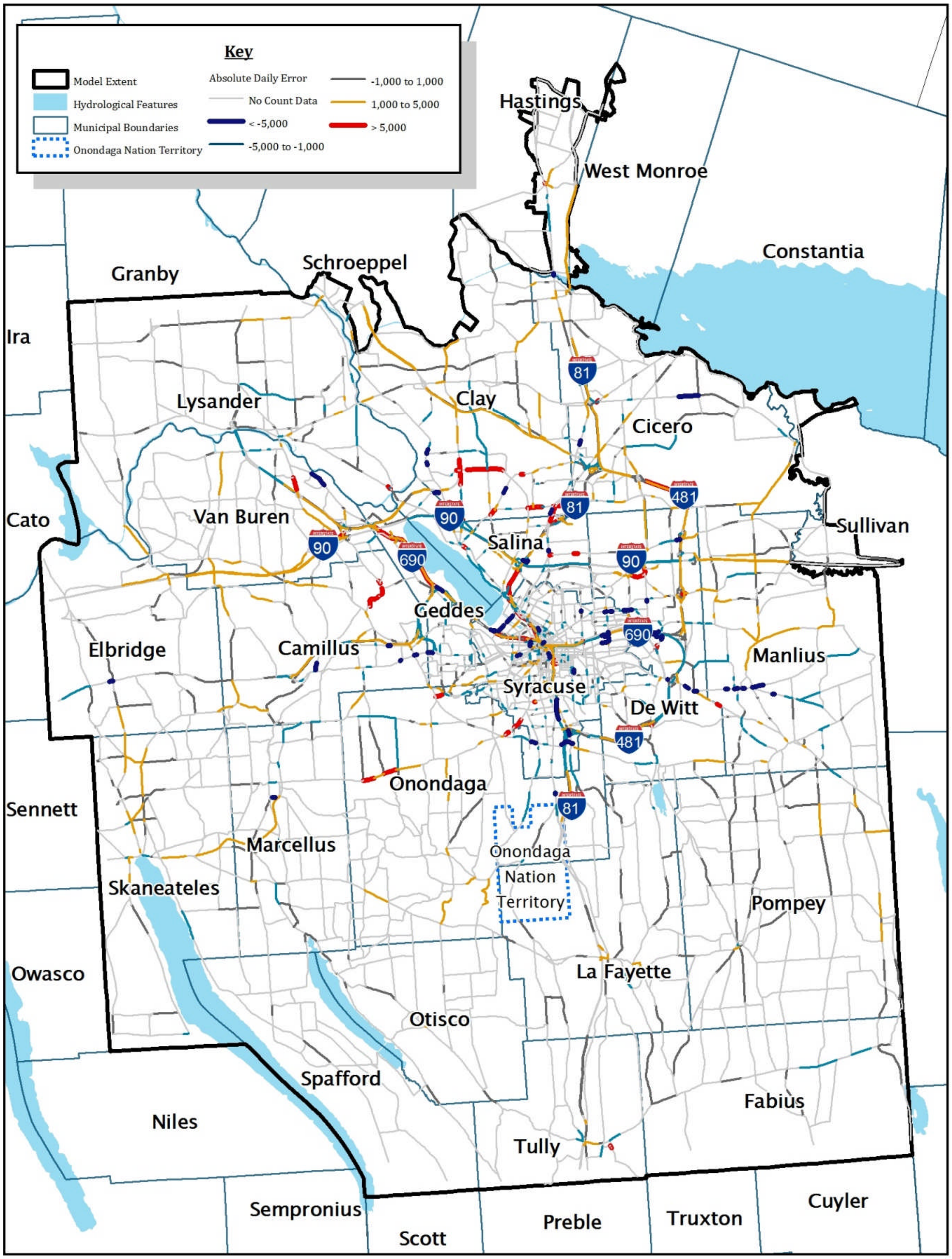
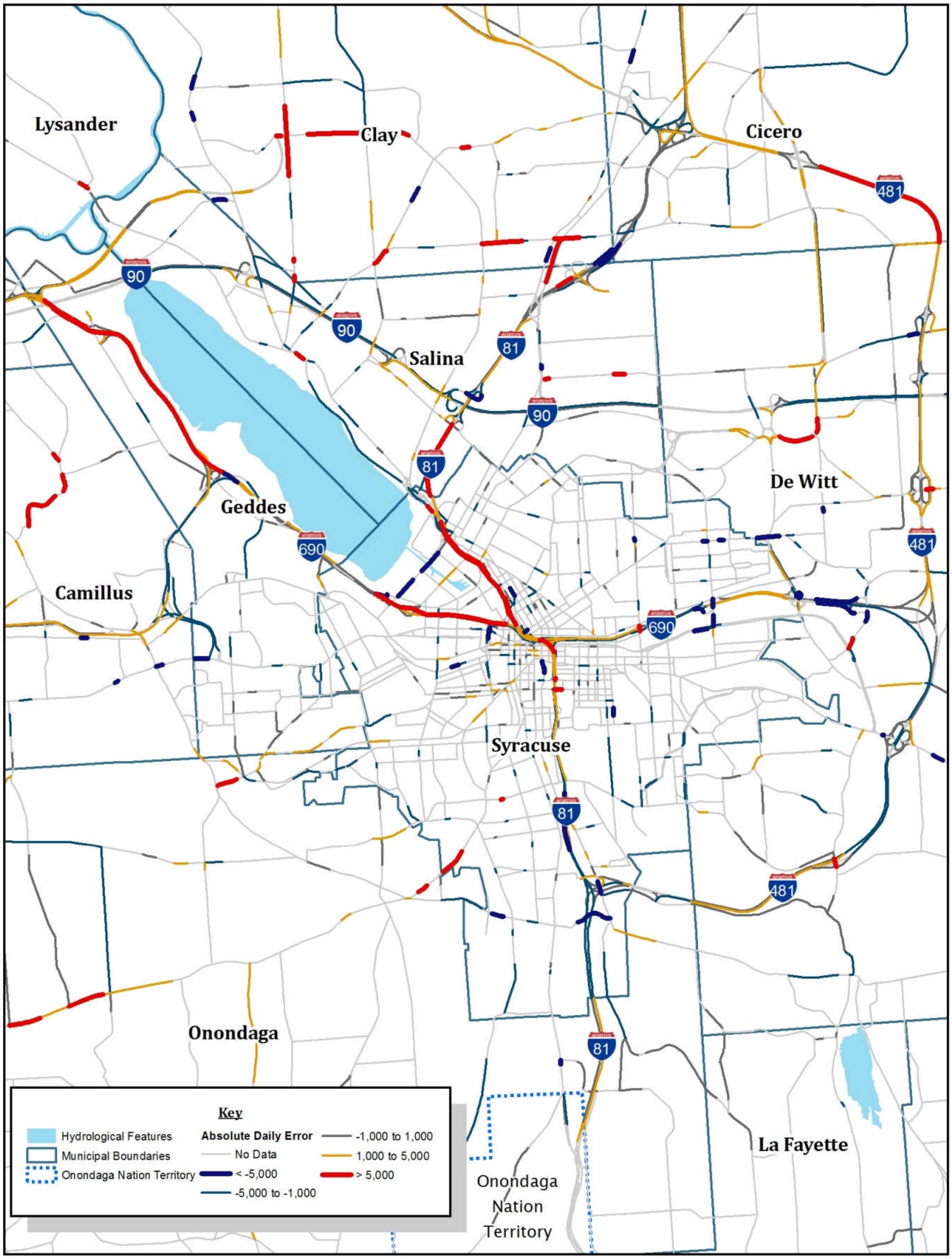


Figure 53: Volume Error Syracuse Proper



15.4.5 Comparison of modeled and observed speeds

It was determined that collecting average speeds for major commuter facilities was necessary to fill in the gaps where speed data was not collected at NYSDOT traffic count locations, validate existing speed data collected at certain NYSDOT traffic count locations and for validation of model outputs. The SMTC collected speed data in the field over a 3 month period in the late summer/fall of 2009. Data was collected for approximately 25 segments of major commuter routes in the MPA and on major facilities in the Downtown and University Hill areas of the City of Syracuse.

Prior to this effort a data collection plan was created. All data collection occurred during the middle of the work week (Tuesday – Thursday) during 3 time periods including the AM peak period (7am-9am), the midday off peak period (10am-12pm and/or 1pm-3pm) and the PM peak period (4pm-6pm). Each segment was driven a minimum of 4 times in each direction to determine average speeds during a peak period as well as an off peak period. Facilities with existing speed data may have been driven fewer times. Any event impacting normal travel patterns (significant rain, accident, construction, etc.) was noted and data collected during that event was reviewed and removed if average speeds were impacted.

Speed data was collected using several methods. The basic method of using a stop watch to collect drive times between pre-determined locations was utilized for some locations while a more technologically advanced technique, by means of a GPS unit, was used for others. Drive times between pre-determined intersections were then converted into average speeds and recorded into a database. Both methods were successful and yielded acceptable results.

The data were used in two ways: to develop more accurate free flow speeds by area type by varying values slightly from posted speeds, and secondly as a validation dataset for testing whether modeled speeds during congested conditions were accurate. Table 46, Table 47, and Table 48 show comparisons of off peak, AM peak, and PM peak modeled and observed average speeds respectively, by functional class and facility type. Note that missing cells indicate a lack of observed data to support a comparison. The comparison shows that the model estimates travel speeds adequately during a range of uncongested and congested conditions.

Table 46: Comparison of Off Peak Modeled and Observed Average Speeds

Model Off Peak Speeds - VMT Weighted				
Functional Class	Syracuse	CDP*	Urban	Rural
Highway	53	67	67	
Principal Arterial	23	22	31	49
Minor Arterial	17	29	31	53
Major Collector		23	34	
Local	17			

Observed Off Peak Speeds - VMT Weighted				
	Syracuse	CDP*	Urban	Rural
Highway	58	65	65	
Principal Arterial	23	26	36	48
Minor Arterial	18	21	27	53
Major Collector		26	41	
Local	15			

*CDP = Census Designated Place

Table 47: Comparison of AM Peak Modeled and Observed Average Speeds

Model AM Peak Speeds - VMT Weighted				
Functional Class	Syracuse	CDP*	Urban	Rural
Highway		67	66	
Principal Arterial	25	17	29	53
Minor Arterial	15	28	28	52
Major Collector		22	31	
Local	18			

Observed AM Peak Speeds - VMT Weighted				
	Syracuse	CDP*	Urban	Rural
Highway		67	68	
Principal Arterial	29	27	34	47
Minor Arterial	16	22	36	56
Major Collector		24	33	
Local	18			

*CDP = Census Designated Place

Table 48: Comparison of PM Peak Modeled and Observed Average Speeds

Model PM Peak Speeds - VMT Weighted				
Functional Class	Syracuse	CDP*	Urban	Rural
Highway	52	66	67	
Principal Arterial	20	24	32	48
Minor Arterial	15		32	
Major Collector				
Local	17			

Observed PM Peak Speeds - VMT Weighted				
	Syracuse	CDP*	Urban	Rural
Highway	52	66	67	
Principal Arterial	20	24	32	48
Minor Arterial	15		32	
Major Collector				
Local	17			

*CDP = Census Designated Place

16.0 NYSDOT MINIMUM REQUIREMENTS AND SUGGESTED BEST PRACTICES

16.1 Minimum Requirements Noted by NYSDOT ESB

This section describes how the Model meets the "minimum requirements" listed in the January 7, 2005 letter from NYSDOT ESB.

16.1.1 VMT Estimation

The model estimates base year (2007) VMT and future year (2035) VMT. To estimate VMT, the model incorporates population and employment projections and includes projects programmed in the TIP and LRTP.

The model estimates traffic volumes for four one hour periods, with one hour falling in each of four time periods that together cover the whole day:

- In the AM peak (6AM to 9AM) the traffic in the 7AM-8AM hour is assigned
- In the midday off peak (9AM to 3PM) the traffic in the 12PM-1PM hour is assigned
- In the PM peak (3PM – 6PM), the traffic in the 5PM-6PM hour is assigned
- In the evening off peak (6PM – 6 AM), the traffic in the 8PM-9PM hour is assigned

The portions of total vehicle trips that are to be assigned in each hour are calculated using a diurnal trip profile (see discussion in Section 10.0) which divides daily trips by trip purpose into the number that occur in each hour of the day. Following assignment, the process is reversed to estimate daily traffic volumes on each link in the highway network. The diurnal trip profile is used to scale the hourly results into totals for each link in each time period. Finally, the four time period totals are added together to calculate daily traffic volumes on each link, the basis of the VMT estimate.

Total 2007 estimated daily VMT for the model region is slightly less than the Highway Performance Monitoring System (HPMS) daily VMT estimate for 2007 for both highways and arterials. For other (lower functional class) roads, the model network is significantly abstracted and so only models a portion of the VMT recorded by the HPMS (Table 49). The model estimates of VMT for highways and arterials are significantly closer than the previous version of the model. The previous version of the model also only represented some of the VMT on other roads. In order to ensure that differences between modeled and observed VMT are not ignored in forecasts of future VMT, the proportional difference between base year modeled and HPMS VMT are carried forward to forecast years when producing forecasts of future VMT. This adjustment is made to modeled VMT during post processing after the model run is complete.

Table 49: Comparison of HPMS and Model VMT, SMTC Region

Facility Type	HPMS	Model	Model Error	Previous Model Error
Highway	5,167,000	5,115,682	-0.99%	25%
Arterial	4,238,000	3,791,547	-10.53%	-14%
Other	3,545,000	1,847,347	-47.89%	-33%

Table 50 looks more closely at the Syracuse Urban Area. It can be seen that much of the difference between HPMS VMT and model VMT is due to the relatively small proportion of the local road network that is represented in the model network. For facility types with functional classes higher than local, total modeled urban area VMT is 7% lower than HPMS VMT.

Table 50: Comparison of HPMS and Model VMT, Syracuse Urban Area

Facility Type	HPMS	Model	Model Error
Interstate/ Freeway	4,542,000	4,495,355	-1.0%
Principal Arterial	1,319,000	1,332,396	1.0%
Minor Arterial	2,338,000	2,042,619	-12.6%
Urban Collector	908,000	695,789	-23.4%
Local Roads	1,407,000	299,914	-78.7%
Total	10,514,000	8,866,073	-15.7%
Total (excluding local roads)	9,107,000	8,566,159	-5.9%

16.1.2Travel Speed Estimation

Section 15.4.5 discusses the collection of observed data in the model region and a comparison with estimated model speeds, which are sensitive to traffic volumes and vary by time of day and by road functional class. The comparison demonstrates that the model adequately replicates observed speeds.

16.2 Suggested Good Practice

This section describes how the Model responds to the suggested good practices/network demand model criteria listed by the NYSDOT ESB.

16.2.1 Validation against Observed Counts

As noted in section 15.4, the 2007 Model was calibrated to 2,399 ground counts. As shown in Table 43, the correlation coefficient, percent error system-wide, and sums of differences by roadway class all exceed the guidelines published by FHWA. The table includes a comparison with the previous version of the model, which also met all of the FHWA guidelines except for freeways falling slightly outside an acceptable range for the sum of differences between model volumes and observed counts. Overall, the model matches more closely with observed counts that the previous version of the model.

16.2.2 Latest Planning Assumptions

As described in section 3.2, the land use (household and employment) data used in the base year model was updated to reflect 2007 conditions and projected to the future model horizon of 2035. The 2007 data are based on

- Information received by SMTC from municipalities and local planning agencies during a series of meetings held in 2010.
- 2000 U.S. Census data on households at the block level (U.S. Census Bureau)
- 2010 U.S. Census data on households at the block level (U.S. Census Bureau)
- 2007 U.S. Census American Community Survey (ACS) 3-year data on households (U.S. Census Bureau)
- 2009 parcel data for Onondaga County (Syracuse-Onondaga Planning Agency)
- 2009 Business Location Analysis Tool (BLAT) data on employment (New York State Department of Transportation)
- 2007 Onondaga County employment totals by sector (New York State Department of Labor)
- 2006 aerial photography for household and employment location confirmation (New York State Department of Transportation).

Section 4.0 describes the models highway network. As part of this model update, SMTC refined the highway network. A combination of field verification and review of orthogonal and oblique aerial images were used to verify network attributes such as number of lanes, posted speeds, turn penalties and intersection types.

Section 5.0 describes the model's transit network. The transit network was updated using information from CENTRO on current bus routes, fares, and headways.

16.2.3 Land Use Development Scenarios

Household and employment growth in the model area is occurring at low rates, while population decreases slightly by the future year in 2035. Section 3.2 describes the development of future land use (households and employment by TAZ) for the model. SMTC met with local officials and professionals with experience in demographic analysis and/or knowledge of local demographic conditions. The socioeconomic data update outreach was completed over a several week period in the spring of 2010 and included representatives from various geographic levels. Additional updates to the future households forecasts were made following review of the 2010 Census data. The future year transportation networks include projects programmed in the region's TIP and LRTP.

16.2.4 Assignment Methodology

As noted in section 11.0, the model employs a capacity-sensitive assignment methodology (user equilibrium) which uses an iterative process to achieve a convergent solution in which no travelers can improve their travel times by switching to another route. The model carries out four, one hour time period assignments, AM peak, midday off peak, PM peak, and evening off peak, and so differentiates between peak and off peak link volumes and speeds.

16.2.5 Travel Impedances

As noted in section 7.0, the model includes an impedance matrix (reflecting travel times, travel costs, and travel distance between zones). A friction factor matrix is derived from the impedance matrix. The friction factors are used in the gravity model. Congested travel times from trip assignment are iterated back to trip distribution and mode choice in a feedback loop.

16.2.6 Model Sensitivity

As noted above, the model includes a mode choice step in which trips are split among auto and transit trips. The mode choice model is sensitive to transit attributes such as travel time, headway, and fare, and to auto attributes such as travel time, travel distance, and travel cost (e.g. tolls).

The assignment step in the model selects shortest paths across the highway network based on the minimum generalized cost. This step uses travel time, trip distance, and toll cost as impedance variables. The model has proven to be reasonably sensitive to changes in travel times. Changes to link and node characteristics (speeds, capacities, number of lanes, etc.) have a direct impact on the selection of shortest paths and the volumes assigned to links.

17.0 MODEL CHANGES BY VERSION

This section of the report lists the changes that were made in this revision to the model. This section is a cumulative record of changes that have been made since SMTC Travel Demand Model, Version 3.00, which was documented in the SMTC Travel Demand Model Validation Report (December 2010)[8].

17.1 SMTC Travel Demand Model, Version 3.02 (November 2011)

The changes made in this revision to the model are:

- As part of the I-81 Corridor Study, calibration adjustments were made to the model to better match traffic count data in the area around the I-81 viaduct in central Syracuse. Adjustments were made to some turn penalties and ramp penalties, through trip numbers on I-90, and parameters in the highway network skimming process. While the changes made insignificant differences on a regional level, they did improve the match with observed traffic patterns in the I-81 study area, and resolved a small number of anomalous locations close to I-81 that had been identified during model output reviews by the I-81 Corridor Study team.

17.2 SMTC Travel Demand Model, Version 3.023 (April 2012)

The changes made in this revision to the model are:

- Changes to the land use data describing the number of households, the household population and the group quarters population in the City of Syracuse for both the base year (2007) and the future year (2035) to better reflect observed growth rates seen in the 2010 Census data for Syracuse, which was not available when the land use inputs to model version 3.02 were developed. These changes are described in Section 3.2.6 of SMTC Travel Demand Model Version 3.023 Documentation.

[8] Note that the model version number used in this report was SMTC Travel Demand Model, Version 2.2; this was later revised to be SMTC Travel Demand Model, Version 3.00

18.0 MODEL INPUT FILES

This section lists the input files to the SMTC model.

18.1 Highway Network Inputs

- Model Network ("SMTC_Network_20**.dbd") – A geographic file that contains the structural detail and lists (most of) the link and node attributes of the highway network.
- Link Attributes ("Link_Attributes.bin") – A binary table that contains some link data organized by facility and area type.
- Node Attributes ("Node_Attributes.bin") – A binary table that contains some intersection data organized by node type.
- Link Turn Penalties ("Link_Turn_Penalites_20**.bin") – A binary table that lists all the link-to-link turn prohibitions and penalties.
- Inter-Facility Turn Penalties ("xFacility_Turn_Penalties.bin") – A binary table that lists all the inter facility turn penalties.

18.2 Transit Network Inputs

- Transit Stops Layer ("Stops.bin") – A binary table that lists the key stops and via points in transit network.
- Transit Route Stops ("RouteStops.bin") – A binary table that lists each stop or via point visited by each route.
- Transit Routes ("Routes.bin") – A binary table that lists each route in the transit network.
- Transit Mode Table ("transitModeTable.bin") – A binary table that lists the argument to various network parameters by transit sub-mode.

18.3 Trip Generation Inputs

- TAZ Layer ("SMTC_TAZs_20**.dbd") – A geographic file that contains the structural detail of the TAZ layer and lists the TAZ attributes.
- Special Gen ("SpecialGen_PA.csv") – A text file that lists the productions and attractions by special generator.
- IXXI Trips ("IXXI.csv") – A text file that lists the productions and attractions by external TAZ.
- Production Rates ("Production_Rates.bin") – A binary table that lists trip production rates by the joint distribution of trip purpose, household size, and number of vehicles.

18.4 Trip Distribution Inputs

- Trip Distribution ("EE_Veh_Distribution_20**.mtx") – A matrix that lists the number of daily external-to-external trips.
- Fixed Distribution ("SpecialGen_Fixed_Distributions.csv") – A text file that lists the number of attractions by TAZ to a selected set of special generators.

18.5 Diurnal Distribution Inputs

- Diurnal Distribution ("SMTC Peak Hour Factors.bin") – A binary table that lists the distribution of trips by time of day.

18.6 Assignment Inputs

- Volume Delay Function Parameters ("VDF_Param.bin") – A binary table that lists the volume delay parameters by functional class.
- Query File ("****.qry") – An optional query file that may be used in assignment.

18.7 Reporting Inputs

- TAZ Aggregation ("Zones.bin") – A binary table that lists the TAZ aggregation scheme to be used in reporting.

19.0 MODEL SCRIPTS

This section lists the scripts used to run the SMTC model. There are a total of fourteen scripts. One script is responsible for declaring the other thirteen scripts, which are used to execute different phases of the model.

- SMTCMacros.lst – Declares each of the scripts used in the model by specifying their paths.
- InterfaceMacros.rsc – Controls the graphical user interface
- SharedVariables.rsc – Declares which variables are shared between scripts, defines the output file paths
- InitializeNetwork.rsc – Initializes the highway network for a new model run.
- TripGeneration.rsc – Executes the trip generation model
- CreateHighwayNetwork.rsc – Executes the highway skimming procedure
- CreateTransitNetwork.rsc – Executes the transit route building and skimming procedures
- TripDistribution.rsc – Executes the trip distribution model
- ModeSplit.rsc – Executes the mode choice model and converts auto person trips to vehicle trips
- Diurnal.rsc – Tabulates hourly, auto demand
- HighwayAssignment.rsc – Executes the highway assignment model
- TransitAssignment.rsc – Executes the transit assignment model
- Feedback.rsc – Test for model convergence
- Report.rsc – Generates a number of model reports

20.0 Model Outputs and Reporting

This section lists the outputs of the SMTC model.

20.1 Highway Network Outputs

- Highway Network File ("20**_SMTC_TransCAD_Network_File.net") – A network file that contains all the compiled data for the highway network.
- Auto Skim Matrices ("20**_SMTC_**_Auto_Travel_Times_and_Costs.mtx") – A series of matrices (AM,MD,PM,OP, work, non-Work, peak,off-peak) that list the skimmed highway attributes between each TAZ pair.
- Model Network ("SMTC_Network_20**.dbd") – The data within the highway network (see section 18.1) is updated during model application.

20.2 Transit Network Outputs

- Valid Transit Nodes ("PotentialTransitStops.dbd") – A geographic file that contains the set of valid highway nodes for which the transit stops are snapped to.
- Route Stops ("LocalBus_RouteStops_Adj.bin") – A binary table that lists all stops visited by all routes, including those that were automatically added in the route building process.
- Transit Route System ("LocalBus_RouteSystem.rts") – A geographic file that contains the structural detail and lists stop and route attributions of the transit network.
- Transit Network File ("Centro 20** Local Bus ***Peak Network File.tnw") – A network file that contains all the compiled data for the transit network.
- Transit Skim Matrices ("20** SMTC ***Peak Transit Travel Times and Costs.mtx") – A series of matrices (peak, off-peak) that list the skimmed transit attributes between valid TAZ pairs.

20.3 Trip Generation Outputs

- Trip Productions Table ("20** Productions.bin") – A binary table that lists the number of productions by TAZ by trip purpose.
- Terminal Times Table ("20** Terminal.bin") – A binary table that lists the terminal time (out-of-vehicle) for each TAZ.
- Terminal Times Matrix ("20** Terminal.mtx") – A matrix that lists the total out-of-vehicle time for each TAZ pair.
- TAZ Layer ("SMTC_TAZs_20**.dbd") – The data within the TAZ layer (see section 18.3) is updated during model application.

20.4 Trip Distribution Outputs

- Distribution Matrix ("20** SMTC PA Person Trip Matrix.mtx") – A matrix that lists the productions and attractions by trip purpose for TAZ pair.

20.5 Mode Choice Outputs

- Mode Choice Probability Matrices ("20** SMTC *** ***Peak Probabilities.mtx") – A series of matrices (HBW Peak, HBW Off-Peak, HBS Peak, HBS Off-Peak, HBO Peak, HBO Off-Peak, NHB Peak, NHB Off-Peak) that list mode choice probabilities.
- Mode Choice Trip Matrices ("20** SMTC *** ***Peak PA Person Trips by Mode.mtx") – A series of matrices (HBW Peak, HBW Off-Peak, HBS Peak, HBS Off-Peak, HBO Peak, HBO Off-Peak, NHB Peak, NHB Off-Peak) that list person trips by mode.
- Mode Choice Person Trip Matrix ("20** SMTC PA Person Trip Matrix By Mode.mtx") – A single matrix that lists the number of production-to-attraction person trips by mode, trip purpose, and period (peak/off-peak) for each TAZ pair.
- Mode Choice Auto Vehicle Trip Matrix ("20** SMTC PA Vehicle Trip Matrix By Mode.mtx") – A matrix that lists the number of production-to-attraction auto trips by trip purpose for each TAZ pair.

20.6 Diurnal Distribution Outputs

- Hourly, Auto Origin-to-Destination Matrix ("20** SMTC OD Vehicle Trip Matrix By Purpose.mtx") – A matrix that lists the number of origin-to-destination auto trips by trip purpose and hour.
- Period, Auto Origin-to-Destination Matrix ("20** SMTC OD Vehicle Trip Matrix.mtx) – A matrix that lists the number of origin-to-destination auto trips by trip purpose and period.

20.7 Highway Assignment Outputs

- Highway Assignment Table ("20**_**_ASSN.bin") – A series of binary tables (AM, MD, PM, OP) that list the assignment results by network link.
- Highway Turning Movement Table ("20**_**_Turn.bin") –A series of binary tables (AM, MD, PM, OP) that lists the link-to-link turning movements from assignment.
- Highway Congested Travel Times ("20**_SMTC_Assn_TT_Bin.bin") – A binary table that lists the congested travel to be used in feedback.

20.8 Transit Assignment Outputs

- Walk Flow Table ("20**_LocalBus_***Peak_WalkFLow_Assignment") – A series of binary tables (peak, off-peak) that list the walk volumes along all access, egress, and transfer links.
- Transit Flow Table ("20**_LocalBus_***Peak_Flow_Assignment) – A series of binary tables (peak, off-peak) that list the transit volume along each route segment.
- Transit Boardings Table ("20**_LocalBus_***Peak_Boardings") – A series of binary tables (peak, off-peak) that list the transit boardings and alightings at each stop for each route.
- Transit Aggregate Flow Table ("20**_LocalBus_***Peak_AggregateFlow_Assignment") – A series of binary tables (peak, off-peak) that list the total transit flow along each link.

20.9 Reports

- Conformity Report ("20**_SMTC_Conformity Report.txt") – A text file that lists VMT and average speed by facility and area type.
- General Model Report ("20**_SMTC_General Report.txt") – A text file that contains a series of reports

and metrics that document the model results at a high-level.

- Trip Length Distribution ("20**_SMTC_TLD_BIN.bin" – A binary table that lists the trip length (distance and time) distributions by trip purpose.
- Town to town Flows ("20**_SMTC_Town2TownFlow.mtx") – A matrix that that list the town-to-town flow by trip purpose.

21.0 GLOSSARY

Accessibility: measure describing the ease with which travelers can reach activities and/or destinations.

Accuracy: degree of conformity of a measure to a standard, known or true value

Aggregate: a collection of units into a single body or mass (in this case TAZs)

Attractions: the non-home end of any home-based trip or the destination of any non-home based trips

Calibration: procedure used to estimate the various parameters and coefficients of a travel demand model so the results produced replicate known travel behavior for a base year

Computed Data: data that the model will automatically calculate at during a model run. No maintenance is needed by the analyst)

Delay: the difference between congested travel time and freeflow travel time

Freeflow travel time: travel time under freeflow conditions typically calculated as the distance divided by the posted speed limit

Friction Factors: represent the reluctance of persons to make trips of various duration or distances. The general friction factor indicates that as travel times increase, travelers are increasingly less likely to make trips of such lengths. Calibration of the gravity model involves adjusting the friction factor

Gravity Model: a mathematical model of trip destination based on the premise that trips produced in any given area will distribute themselves in accordance with the accessibility of other areas and the attractions those areas offer

HOV2: 2-person high occupant vehicle

HOV3+: 3+person high occupant vehicle

Immutable Data: data that should never be edited by the analyst. The immutable status is typically reserved for identification fields in tables .

Logit Choice Model: statistical procedure that describes choices made by people among a finite set of alternatives

Lookup Table Data: data that is automatically imported from another source, such as a text file. Although the model executes this import during a model run, the analyst typically needs to manage the lookup source (e.g. a binary file with link speeds and capacities)

Pivoting: process used to adjust raw model volumes by applying the difference between two scenarios to observed ground counts

Precision: strictly conforming to a pattern, standard or convention

Productions: the home end of a home-based trip and the origin end of non-home based trip

Shortest path: the shortest path between two locations measured in terms of either distance, time or both distance and time

Skimming: the process of collecting all the shortest-path information for all zones in the travel model network. An automated process that typically uses commercially available transportation planning software such as TransCAD

Smart Growth: building urban, suburban and rural communities with housing and transportation choices near jobs, shops and schools. This approach supports local economies and protects the environment.

SOV: single occupant vehicle

Traffic analysis zone (TAZ): geographical unit the region is broken down into for the purpose of collecting and analyzing land use data. Model calculations are performed at this level of spatial disaggregation

Transit Oriented Development (TOD) - is a mixed-use residential or commercial area designed to maximize access to public transport

Trip length frequency: a graphical distribution which shows the number of trips plotted by trip time

Value of time (VOT) - is the opportunity cost of the time that a traveler spends on his/her journey. In essence, this makes it the amount that a traveler would be willing to pay in order to save time, or the amount they would accept as compensation for lost time

Volume-delay function: a set of functions that calculate congested travel time base on the relationship between a road's volume and capacity

User-Maintained Data: data that the analyst is responsible for entering and maintaining

VMT: vehicle miles of travel (link volume multiplied by link distance summed for all links in the network)

VHT: vehicle hours of travel (link time multiplied by link volume summed for all links in the network)