# The Travel Demand Model for the Rome MPO

**Prepared for**

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**September 2011**

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# 1.0 Introduction

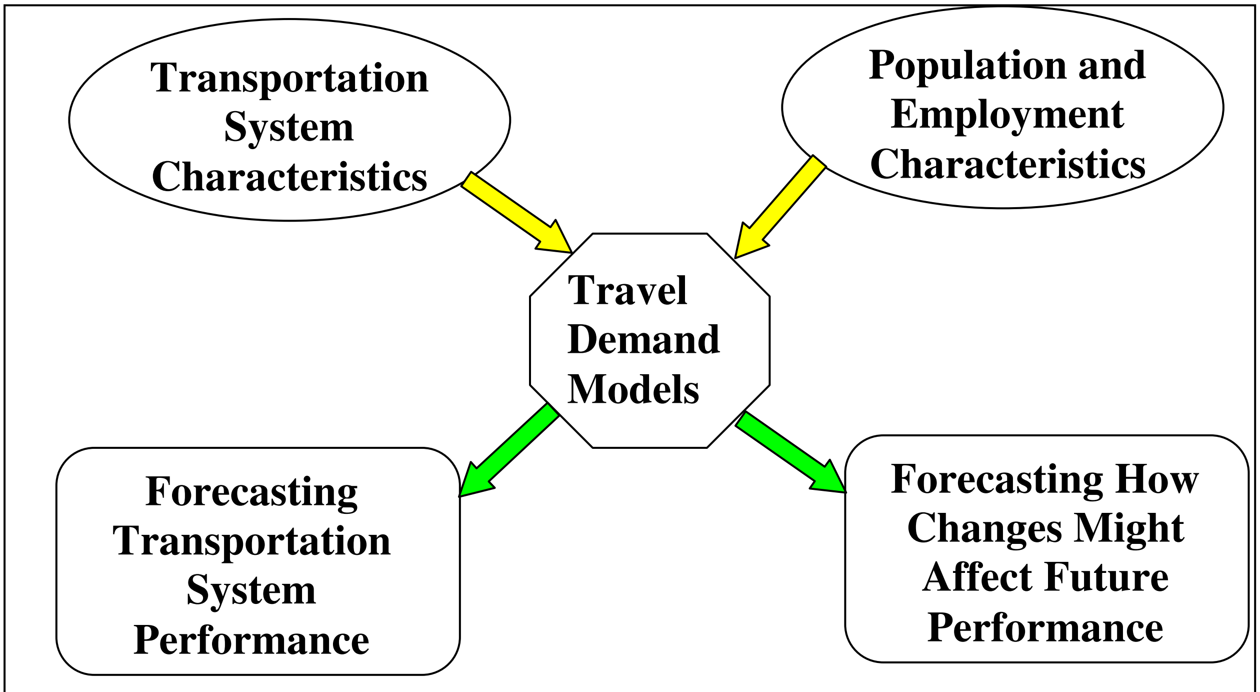
Transportation system studies are done periodically by the Georgia Department of Transportation, Floyd-Rome Urban Transportation Study (FRUTS) and Rome Transit to determine what types of transportation improvements or investments would best serve the public. Georgia DOT and FRUTS are primarily responsible for technical studies pertaining to the roadway system while the Rome Transit conducts studies of transit service.

The travel demand model is used to evaluate the performance of the roadway system in and around Rome by the Georgia Department of Transportation and FRUTS. The FRUTS model is a traditional urban area analysis tool that is used to identify where major improvements should be made to its principal thoroughfare system. Since there is usually more than one strategy proposed to address future congestion and safety concerns, the model is frequently used to study which combination of improvements provides the most end-user benefits. The output from the travel demand model is used to estimate mobile source emissions and perform the conformity analysis.

There are two key inputs to the travel demand modeling process, socio-economic data and the transportation system. Socio-economic data such as population, household and employment by type represents land use. Future year projections of socioeconomic data were based on a 2009 inventory of existing land uses including vacant land, as well as region wide forecasts of population, households and employment. Future year forecasts also considered planned major transportation improvements. Allocation of expected growth is then done using known development patterns and proposals as the basis, taking into consideration planned infrastructure improvements (new highways, sewer extensions, etc.). It is in this area of travel model development that land use and community planning are connected to the transportation planning process. Figure 1.1-1 shows the interaction between travel demand models and transportation system characteristics and population and employment characteristics

The other key element of the travel model is referred to as the highway network. The highway network is a computer file containing links and nodes that represent roadway segments and intersections. Each link record in the file contains information describing these items: free-flow travel speed, distance, number of lanes, area type (density of population and employment); facility type (similar to functional classification) and capacity. Node records simply contain positional, two dimensional x and y coordinates to enable the network file to be displayed pictorially.

**Figure 1.1-1**
**Travel Demand Models**




Source: Introduction to Travel Demand Forecasting

Georgia DOT is responsible for the development, maintenance and application of the FRUTS travel model. GDOT has updated various components of the FRUTS travel model to ensure that the model is state-of-the-practice and includes technical procedures that would be needed in developing the 2040 LRTP. A detailed description of the FRUTS' travel model is presented in Section 2. It includes explanations for how trips are estimated, how person trips are converted to vehicle trips, what attributes comprise the highway network and how trips are assigned onto the highway network. Each of the modeling steps involved in developing an urban travel model is described. These steps are as follows: Trip Generation; Trip Distribution; Mode Split; and Traffic Assignment.

## *2.0 Model Update*

Several significant changes were made to the Rome area travel model. These changes are based on the original 2006 model and listed below.

- Updated the model to reflect 2009 as the base year
- Updated the HPMS functional classification code to 2000 HPMS in the network
- Updated screenline locations
- Updated and validated the base year highway network

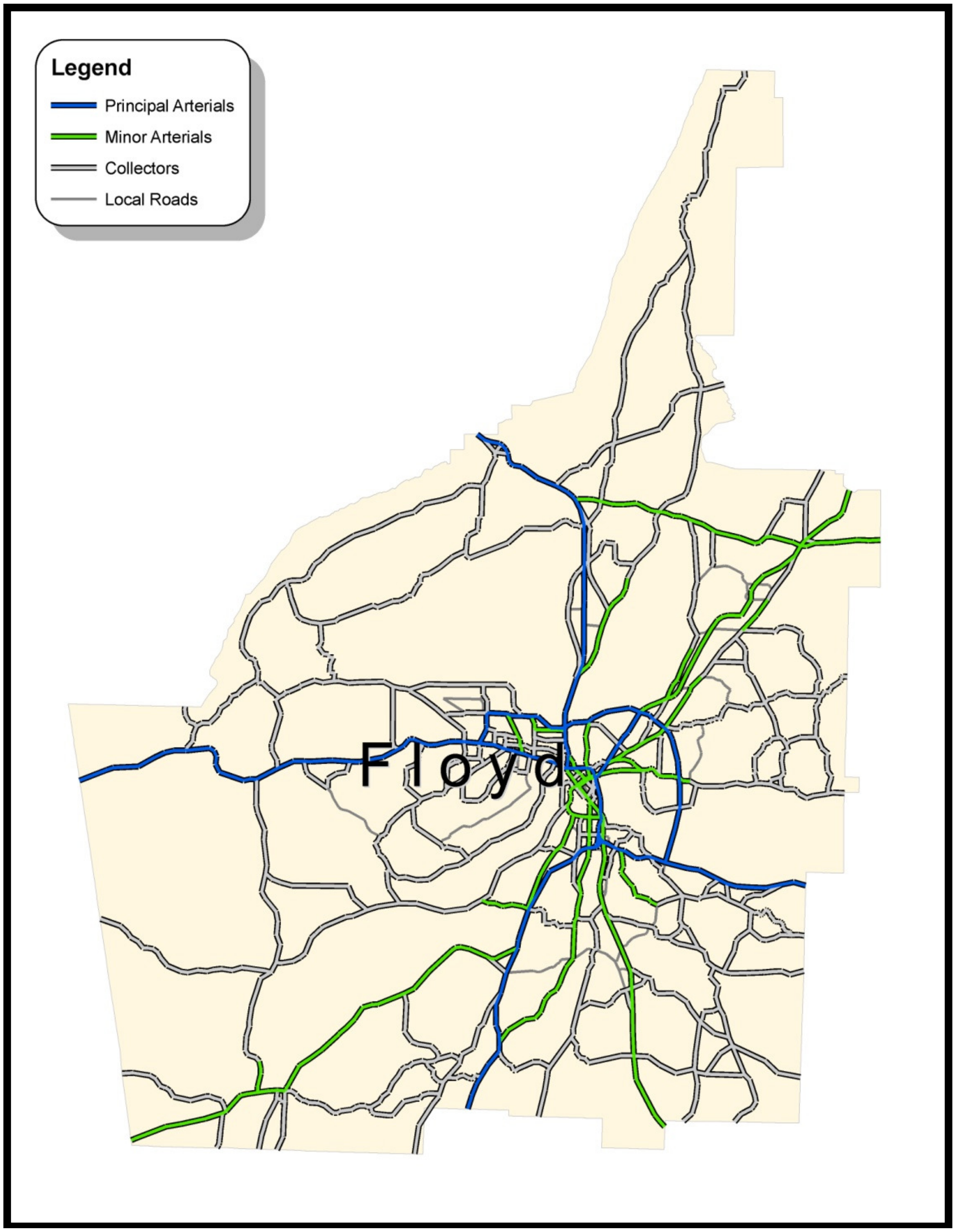
- Updated trip generation model
- Updated trip distribution model
- Updated the traffic assignment procedure (24-Hour daily)
- Updated external trip model
- Incorporated feedback loop assignment
- Added the delta matrix post-process procedure to refine the final traffic assignment

The general structure of the Rome model is standard, in comparison with other travel demand models used in urban areas that are similar in size to Rome. Descriptions of each principal model element are presented in the subsequent parts of this section.

### 2.1 Highway Network Coding

The base year model network was updated to reflect 2009 existing conditions. The 20069 highway network was closely examined and revised to reflect base year conditions for 2009. Projects that had been built in-between the current base year and previous one were included. The purpose of the highway network is to provide accurate routing paths based on the minimum time to travel from one traffic analysis zone to another. In effect, the highway network file is a simulation tool replicating the thoroughfare system in Rome MPO area. A graphical representation of the model highway network by facility type is presented in Figure 2.1-1.

**Figure 2.1-1**
**FRUTS 2009 Highway Network**



**Facility Type and Area Type.** Individually and in combination these two link attributes provide the framework for organizing the network into sub-groups so that free-flow speeds and capacities can be assigned. In combination with the distance and number of lanes, these attributes constitute the base layer of highway network data needed to update and apply the travel model. The facility type and area type definitions used in the FRUTS highway network and modeling process are shown in the table below.

**Table 2.1-1**
**Facility and Area Types**

| Code | Facility Type | | Code | Area Type |
|---|---|---|---|---|
| 1 | Interstate | | 1 | High Density Urban |
| 2 | Freeway | | 2 | High Density Urban Commercial |
| 3 | Expressway | | 3 | Urban Residential |
| 4 | Parkway | | 4 | Suburban Commercial |
| 6 | Freeway to Freeway Ramp | | 5 | Suburban Residential |
| 7 | Freeway Entrance Ramp | | 6 | Exurban |
| 8 | Freeway Exit Ramp | | 7 | Rural |
| 11 | Principal Arterial – Class I | | | |
| 12 | Principal Arterial – Class II | | | |
| 13 | Minor Arterial – Class I | | | |
| 14 | Minor Arterial – Class II | | | |
| 15 | One Way Arterial | | | |
| 21 | Major Collector | | | |
| 22 | Minor Collector | | | |
| 23 | One Way Collector | | | |
| 30 | Local Road | | | |
| 32 | Centroid Connector | | | |

**Capacity**. Link capacities for the model network are obtained from a lookup table of per-lane hourly capacities based on facility type and area type. The final link capacity is calculated by multiplying the hourly capacity per lane by the number of lanes. The following table displays the hourly capacities per lane:

**Table 2.1-2**
**Hourly Capacities**

| Facility Type | Area Type | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Interstate | 1900 | 1950 | 2000 | 2050 | 2100 | 2060 | 2020 |
| Freeway | 1600 | 1660 | 1730 | 1790 | 1850 | 1820 | 1780 |
| Expressway | 1300 | 1380 | 1450 | 1530 | 1600 | 1570 | 1540 |
| Parkway | 1170 | 1240 | 1310 | 1370 | 1440 | 1410 | 1380 |
| Freeway to Freeway Ramp | 1400 | 1530 | 1650 | 1780 | 1900 | 1860 | 1820 |
| Freeway Entrance Ramp | 900 | 1030 | 1150 | 1280 | 1400 | 1370 | 1340 |
| Freeway Exit Ramp | 800 | 810 | 810 | 820 | 820 | 810 | 790 |
| Principal Arterial – Class I | 1000 | 1030 | 1050 | 1080 | 1100 | 1080 | 1060 |
| Principal Arterial – Class II | 900 | 900 | 900 | 900 | 900 | 880 | 860 |

| Facility Type | Area Type | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Minor Arterial – Class I | 800 | 810 | 810 | 820 | 820 | 810 | 790 |
| Minor Arterial – Class II | 630 | 630 | 640 | 640 | 640 | 630 | 610 |
| One Way Arterial | 760 | 760 | 770 | 770 | 770 | 760 | 740 |
| Major Collector | 520 | 530 | 540 | 550 | 560 | 550 | 540 |
| Minor Collector | 380 | 390 | 390 | 400 | 400 | 390 | 380 |
| One Way Collector | 460 | 470 | 470 | 480 | 480 | 470 | 460 |
| Local Road | 340 | 350 | 360 | 370 | 380 | 370 | 360 |
| Centroid Connector | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Speeds**. Link speeds in the model network are derived from a speed lookup table based on facility type and area type. Assumed free-flow speed are approximately 5 mph faster than typical speed limits for the various roadway classes and area types, taking into consideration control for delay (i.e. traffic signals) if applicable. Peak and off-peak free-flow speeds were evaluated using observed speeds obtained from a travel time study conducted in the Rome area. Based on the initial study of the speeds, a revised speed table was developed. An analysis of the Rome data determined that Rome's characteristics and data results are appropriate for use in all GDOT MPO models since the travel dynamics for these urban areas are similar. Final free-flow calibrated speeds are shown in the matrix below.

**Table 2.1-3**
**Free Flow Speeds**

| Facility Type | Area Type | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Interstate | 55 | 60 | 60 | 60 | 60 | 70 | 70 |
| Freeway | 50 | 55 | 55 | 55 | 55 | 60 | 60 |
| Expressway | 50 | 50 | 50 | 50 | 55 | 55 | 55 |
| Parkway | 45 | 50 | 50 | 50 | 50 | 55 | 55 |
| Freeway to Freeway Ramp | 55 | 55 | 55 | 55 | 55 | 55 | 55 |
| Freeway Entrance Ramp | 45 | 50 | 50 | 50 | 50 | 55 | 55 |
| Freeway Exit Ramp | 22 | 23 | 30 | 31 | 34 | 40 | 48 |
| Principal Arterial – Class I | 25 | 28 | 33 | 34 | 37 | 47 | 52 |
| Principal Arterial – Class II | 23 | 26 | 31 | 32 | 35 | 45 | 49 |
| Minor Arterial – Class I | 22 | 23 | 30 | 31 | 34 | 40 | 47 |
| Minor Arterial – Class II | 21 | 22 | 27 | 30 | 32 | 38 | 45 |
| One Way Arterial | 23 | 26 | 30 | 32 | 35 | 42 | 48 |
| Major Collector | 17 | 18 | 21 | 27 | 29 | 34 | 42 |
| Minor Collector | 14 | 15 | 18 | 24 | 26 | 30 | 40 |
| One Way Collector | 17 | 18 | 21 | 27 | 29 | 34 | 42 |
| Local Road | 14 | 14 | 17 | 18 | 22 | 28 | 35 |
| Centroid Connector | 14 | 14 | 17 | 18 | 22 | 28 | 35 |

**Network Link Attributes.** All input network link attributes are included in the following table. While most of them are not directly involved in the model process, they provide assistance in link attributes summary for post model result processing and for model calibration and validation.

**Table 2.1-4**
**Input Network Link Attributes**

| Attribute Name | Description |
|---|---|
| Distance | Roadway Link Length in miles |
| Lanes | Number of Lanes |
| Ftype | Facility Type |
| *UAB | Urbanized Area Code, 1990 Census Geography |
| Screenline | Screenline ID |
| Roadname | Roadway Name |
| Cstation | Traffic Count Station Number |
| Fclass | HPMS Functional Classification Code, 2000 Census Geography |
| Lanesam | Number of Lanes in AM Peak Direction |
| Lanespm | Number of Lanes in PM Peak Direction |
| County | County FIPS Code |
| Twoway | Oneway/Twoway Identification Code |
| Count06 | 2006 AADT - Two Way (from GDOT QA/QC Database) |
| Aadt09 | 2009 AADT - Two Way |
| GDOT_PI | GDOT Project Identification Number |
| Local_PI | Local Project Identification Number |
| Open_date | Model Year Open to Traffic – Construction Completed |

* Optional attribute

**Network Nodes Attributes.** The network node contains four attributes designated to identify the accessibility of a node. Only the centroid nodes of the network are attached with these attributes which use non-zero to indicate the availability of transit. The level of the accessibility is shown in the following table.

**Table 2.1-5**
**Input Network Node Attributes**

| Attribute Name | Description |
|---|---|
| Transit | 1 - Centroid within 0.25 miles of transit access |
| | 2 - Centroid within 0.50 miles of transit access |
| | 3 - Centroid within 1.00 miles of transit access |

## 2.2 Trip Generation

Trip generation is the first step in the traditional four-step modeling process. It estimates the number of trips that will begin and end in each individual traffic analysis zone (TAZ). These are referred to as "trip ends". Trip ends generated by households are referred to as productions. Trip ends calculated from employment or school enrollment figures are referred to as attractions. This process is accomplished by establishing relationships between trips and socioeconomic variables. The process estimates the number of trip ends, or productions and attractions, for each traffic zone by various trip purposes. Trip generation does not determine the origin and destination of each trip, only the total trips generated by each TAZ's socioeconomic characteristics.

In 1997, GDOT contracted with a consulting firm to assist in developing a new standardized trip generation process for the state's urbanized areas outside of Atlanta. The Trip Generation Update Project included a household travel survey and external travel survey in the Augusta metropolitan area. Household travel behavior by household size and income group is homogeneous from one urban area to another if transportation choices and land-use patterns are similar. The Augusta survey information was used to formulate and recommend a trip generation process that is considered transferable to the State's other urbanized areas.

The new trip generation process includes trip production and trip attraction sub-models. For all trips that have origins and destinations inside the FRUTS region, excluding trucks, the trip production sub-model applies trip rates through a cross-classification of household size (1,2,3,4+) and automobiles available (0,1,2,3+). Aggregate household data for each traffic analysis zone is disaggregated into sixteen cross-classified cells using a household stratification model. The household stratification model is also a product of the Trip Generation Update Project. This model breaks out the total number of FRUTS households into cross-classification cells using zonal income, Rome area specific data from the Census Transportation Planning Package (CTPP), and data from the Augusta household survey. The trip production sub-model applies regression equations for other trip purposes. The trip attraction sub-model applies regression equations for all trip purposes.

Typically, there are three types of trips that travel demand models include: (1) Internal-Internal (I-I) trips whose origin and destination are inside the study area boundary; (2) Internal-External (I-E) trips that have exactly one trip end inside the study area; and (3) External-External (E-E) trips that have both trip ends outside of the study area. I-I trips follow the production and attraction logic of trip formulation. They are commonly grouped into trip purposes so their characteristics can be reproduced by the chain of sub-models in the four-step process. I-E and E-E trips are developed separately using a different methodology that is heavily dependent on traffic counts observed on the principal roads leading into and out of the region.

### 2.2.1 Trip Purposes

Seven trip purposes were included in the trip generation process. These purposes are summarized below:

1. **Home Based Work (HBW)**: All travel made for the purpose of work and which begins or ends at the traveler's home.
2. **Home Based Other (HBO):** Any trip made with one end at the home except those for the purpose of work or shopping.
3. **Home Based Shopping (HBS)**: Trips made for the purpose of shopping and which begins or ends at the traveler's home.
4. **Non Home Based (NHB)**: Any trip that neither begins nor ends at home.
5. **Internal-Internal Truck (IIT)**: Internal trips made by commercial vehicles.
6. **Internal-External Passenger Car (IEPC)**: Internal trips beginning or ending outside the modeled area, excluding trucks.
7. **Internal-External Truck (IET)**: Internal truck trips beginning or ending outside the modeled area.

### 2.2.2 Socioeconomic Data

The FRUTS provided 2009 Base Year socioeconomic data for the model. For each of the traffic analysis zones (TAZ's) in the model area, the following socioeconomic variables were collected for use in the trip generation model:

**Population**: The total number of individuals that are residing in each traffic zone.

**Retail Employment**: Number of employees working for retail businesses in a given traffic analysis zone where the business is located.

**Industrial Employment**: Number of employees working for industrial based businesses in a given traffic analysis zone where the business is located

**Service Employment**: Number of employees working for service based businesses in a given traffic analysis zone where the business is located.

**Wholesale and Warehouse Employment**: Number of employees working for Wholesale and whharehouse based businesses in a given traffic analysis zone where the business is located.

**Total Employment**: The total number of employed persons in those traffic zones with employment.

**Income**: Average household income in TAZ in 2000 dollars (per 2000 Census).

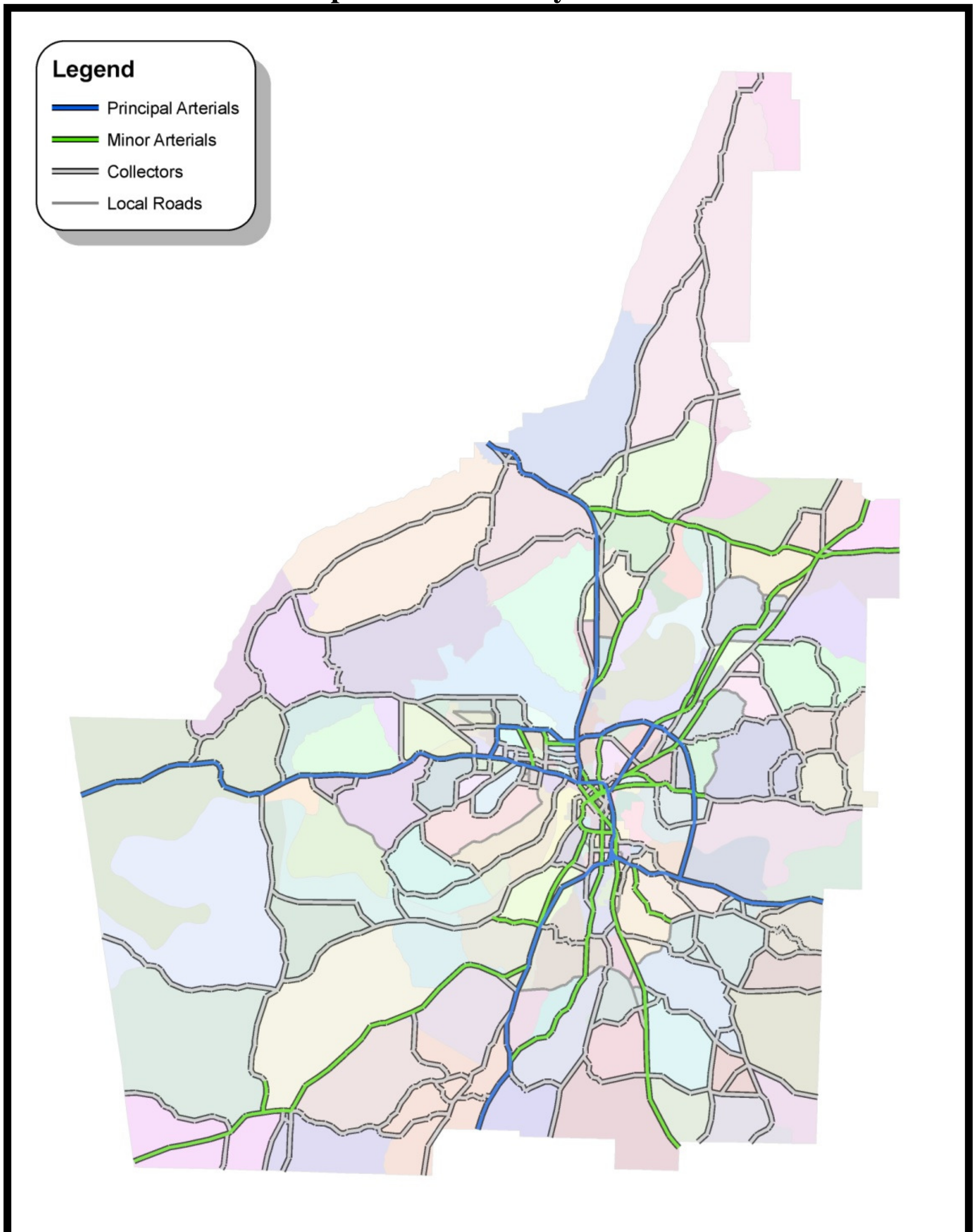
**Total Households**: Total number of occupied households in a given traffic analysis zone.

**School Enrollment**: The total number of enrolled students in zones with educational facilities.

**Acres**: Area of TAZ in acres.

An illustrative picture of the zone boundary map is presented in Figure 2.2.2-1. There are 233 internal zones in the FRUTS model with 26 additional zones called external stations. The external station zones represent the key facilities where travel in and out of the FRUTS region occurs such as US-27 and US-411.

**Figure 2.2.2-1**
**Map of Traffic Analysis Zones**




### 2.2.3 Household Stratification Model

The household stratification model subdivides the total number of households by TAZ into sixteen household strata defined by household size and the number of automobiles available. Stratification is done using zonal income, Rome area specific data from the Census Transportation Planning Package (CTPP), and data from the Augusta household survey. The model distributes the total households in a TAZ to each cross-classification cell by calculating a relative[1] probability that a household will be a particular size with a particular number of automobiles. The relative probability is calculated with the following equation:

P(i,j) = S * I * CF, where

P(i,j) = Relative probability that a household will be size i and own j autos
S = Household size factor from CTPP lookup table
I = Income factor from CTPP lookup table
CF = Composite household factor from Augusta household survey lookup table.

An estimate of the number of households in a particular cross-classification cell is then calculated by multiplying the total number of households in the TAZ by the corresponding relative probability. The final number of households in each cross-classification cell is calculated by applying an adjustment factor to each calculated value. The adjustment factor is applied to insure that the sum of the resulting disaggregated households equals the original aggregate number of households. This process is represented mathematically with the following equations:

HHij(est.) = HH * P(i,j), where

HHij(est.) = Estimated number of households of size i that own j autos
HH = Total number of households in the TAZ

HHij = HHij(est.) * F, where

HHij = Final number of households[2] of size i that own j autos
F = HH / ΣHHij(est.), control total adjustment factor.

The three lookup tables used in the household stratification model are shown on the following pages.

**Table 2.2.3-1**
**2000 Household Size CTPP Distribution**

| Computed Persons/HH | | | HOUSEHOLD SIZES | | | |
|---|---|---|---|---|---|---|
| Ranges | | | 1 | 2 | 3 | 4+ |
| 0.0 | to | 1.0 | 1.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1.0 | to | 1.2 | 0.7812 | 0.2056 | 0.0133 | 0.0000 |
| 1.2 | to | 1.4 | 0.6898 | 0.2568 | 0.0331 | 0.0203 |
| 1.4 | to | 1.6 | 0.5752 | 0.3128 | 0.0687 | 0.0433 |
| 1.6 | to | 1.8 | 0.4839 | 0.3511 | 0.1021 | 0.0630 |
| 1.8 | to | 2.0 | 0.4141 | 0.3537 | 0.1279 | 0.1043 |
| 2.0 | to | 2.2 | 0.3487 | 0.3563 | 0.1464 | 0.1486 |

1 The term relative probability is used because the value is not technically a statistical probability.
2 Not rounded to an integer value to eliminate problems with round off errors.

| Computed Persons/HH Ranges | | | HOUSEHOLD SIZES 1 | 2 | 3 | 4+ |
|---|---|---|---|---|---|---|
| 2.2 | to | 2.4 | 0.2872 | 0.3471 | 0.1689 | 0.1968 |
| 2.4 | to | 2.6 | 0.2389 | 0.3274 | 0.1879 | 0.2458 |
| 2.6 | to | 2.8 | 0.1939 | 0.3140 | 0.1985 | 0.2935 |
| 2.8 | to | 3.0 | 0.1553 | 0.2947 | 0.2076 | 0.3424 |
| 3.0 | to | 3.2 | 0.1253 | 0.2749 | 0.2074 | 0.3924 |
| 3.2 | to | 3.4 | 0.1152 | 0.2489 | 0.1996 | 0.4363 |
| 3.6 | to | 3.8 | 0.1119 | 0.2116 | 0.1932 | 0.4832 |
| 3.8 | to | 4.0 | 0.1038 | 0.2042 | 0.1688 | 0.5232 |
| 4.0 | to | 4.2 | 0.1028 | 0.2032 | 0.1608 | 0.5332 |

**Table 2.2.3-2**
**2000 CTPP Household Income Distributions**

| TAZ-Level Median HH Income | | Income Group 1 | Income Group 2 | Income Group 3 | Income Group 4 |
|---|---|---|---|---|---|
| | | < $20,000 | $20,000 - $39,999 | $40,000 - $59,999 | > $60,000 |
| $0 | $2,499 | 0.8835 | 0.1165 | 0.0000 | 0.0000 |
| $2,500 | $4,999 | 0.8549 | 0.1168 | 0.0232 | 0.0050 |
| $5,000 | $7,499 | 0.8300 | 0.1318 | 0.0300 | 0.0081 |
| $7,500 | $9,999 | 0.7585 | 0.1468 | 0.0427 | 0.0521 |
| $10,000 | $12,499 | 0.6933 | 0.1826 | 0.0718 | 0.0523 |
| $12,500 | $14,999 | 0.6311 | 0.2131 | 0.0802 | 0.0756 |
| $15,000 | $17,499 | 0.5771 | 0.2465 | 0.0894 | 0.0870 |
| $17,500 | $19,999 | 0.5031 | 0.2938 | 0.1046 | 0.0985 |
| $20,000 | $22,499 | 0.4326 | 0.3321 | 0.1257 | 0.1096 |
| $22,500 | $24,999 | 0.3927 | 0.3387 | 0.1449 | 0.1236 |
| $25,000 | $27,499 | 0.3316 | 0.3581 | 0.1702 | 0.1401 |
| $27,500 | $29,999 | 0.3071 | 0.3488 | 0.1824 | 0.1617 |
| $30,000 | $32,499 | 0.2734 | 0.3395 | 0.1945 | 0.1926 |
| $32,500 | $34,999 | 0.2399 | 0.3356 | 0.2152 | 0.2093 |
| $35,000 | $37,499 | 0.2108 | 0.3322 | 0.2254 | 0.2316 |
| $37,500 | $39,999 | 0.1825 | 0.3143 | 0.2418 | 0.2615 |
| $40,000 | $42,499 | 0.1655 | 0.2840 | 0.2612 | 0.2893 |
| $42,500 | $44,999 | 0.1501 | 0.2688 | 0.2676 | 0.3134 |
| $45,000 | $47,499 | 0.1391 | 0.2550 | 0.2663 | 0.3396 |
| $47,500 | $49,999 | 0.1207 | 0.2387 | 0.2649 | 0.3758 |
| $50,000 | $52,499 | 0.1188 | 0.2142 | 0.2569 | 0.4101 |
| $52,500 | $54,999 | 0.1016 | 0.2012 | 0.2566 | 0.4407 |
| $55,000 | $57,499 | 0.0945 | 0.1894 | 0.2480 | 0.4682 |
| $57,500 | $59,999 | 0.0901 | 0.1853 | 0.2256 | 0.4990 |
| $60,000 | $62,499 | 0.0844 | 0.1684 | 0.2102 | 0.5371 |

| TAZ-Level Median HH Income | | Income Group 1 | Income Group 2 | Income Group 3 | Income Group 4 |
|---|---|---|---|---|---|
| | | < $20,000 | $20,000 - $39,999 | $40,000 - $59,999 | > $60,000 |
| $62,500 | $64,999 | 0.0766 | 0.1598 | 0.2025 | 0.5612 |
| $65,000 | $67,499 | 0.0688 | 0.1510 | 0.1948 | 0.5854 |
| $67,500 | $69,999 | 0.0653 | 0.1416 | 0.1926 | 0.6004 |
| $70,000 | $72,499 | 0.0601 | 0.1271 | 0.1833 | 0.6295 |
| $72,500 | $74,999 | 0.0535 | 0.1218 | 0.1698 | 0.6549 |
| $75,000 | $77,499 | 0.0512 | 0.1087 | 0.1636 | 0.6765 |
| $77,500 | $79,999 | 0.0485 | 0.1042 | 0.1551 | 0.6922 |
| $80,000 | $82,499 | 0.0446 | 0.0991 | 0.1465 | 0.7099 |
| $82,500 | $84,999 | 0.0405 | 0.0939 | 0.1455 | 0.7202 |
| $85,000 | $87,499 | 0.0364 | 0.0889 | 0.1359 | 0.7387 |
| $87,500 | $89,999 | 0.0350 | 0.0839 | 0.1238 | 0.7573 |

**Table 2.2.3-3**
**Size/Income//Auto Ownership Distribution**

| Income Group | Persons Per Household | Autos Available | | | |
|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3+ |
| 1 | 1 | 0.3063 | 0.6689 | 0.0248 | 0.0000 |
| | 2 | 0.0978 | 0.6578 | 0.2222 | 0.0222 |
| | 3 | 0.0733 | 0.6909 | 0.1628 | 0.0730 |
| | 4 | 0.1000 | 0.5694 | 0.1765 | 0.1541 |
| 2 | 1 | 0.2548 | 0.4776 | 0.2259 | 0.0417 |
| | 2 | 0.0400 | 0.2140 | 0.6320 | 0.1140 |
| | 3 | 0.1111 | 0.1256 | 0.6033 | 0.1600 |
| | 4 | 0.0900 | 0.1080 | 0.5942 | 0.2078 |
| 3 | 1 | 0.1833 | 0.6056 | 0.1578 | 0.0533 |
| | 2 | 0.0274 | 0.1677 | 0.6343 | 0.1707 |
| | 3 | 0.0900 | 0.1050 | 0.5033 | 0.3017 |
| | 4 | 0.0600 | 0.0438 | 0.3862 | 0.5100 |
| 4 | 1 | 0.0577 | 0.6654 | 0.2000 | 0.0769 |
| | 2 | 0.0694 | 0.1044 | 0.5322 | 0.2939 |
| | 3 | 0.0200 | 0.0581 | 0.5098 | 0.4121 |
| | 4 | 0.0189 | 0.0405 | 0.5405 | 0.4000 |

### 2.2.4 Trip Production

The routine for computing trip productions uses cross-classified data from the household stratification model and applies trip rates to calculate Home Based Work, Home Based Other, Home Based Shopping, and Non Home Based Productions. Trip rates for each purpose are shown below.

**Table 2.2.4-1**

| Household Size | 0 Autos | 1 Auto | 2 Autos | 3+ Autos |
|---|---|---|---|---|
| **Home Based Work** | | | | |
| 1 | 0.520 | 0.800 | 0.800 | 0.800 |
| 2 | 1.056 | 1.474 | 1.782 | 1.848 |
| 3 | 1.406 | 1.748 | 2.014 | 2.261 |
| 4+ | 1.800 | 2.160 | 2.520 | 2.880 |
| **Home Based Other** | | | | |
| 1 | 0.918 | 1.605 | 1.872 | 1.600 |
| 2 | 1.834 | 2.444 | 3.401 | 3.612 |
| 3 | 3.947 | 4.521 | 5.295 | 5.537 |
| 4+ | 5.600 | 6.224 | 7.673 | 8.294 |
| **Home Based Shopping** | | | | |
| 1 | 0.486 | 0.555 | 0.288 | 0.560 |
| 2 | 0.758 | 1.174 | 0.973 | 0.924 |
| 3 | 0.197 | 0.631 | 0.641 | 1.127 |
| 4+ | 0.400 | 0.976 | 0.727 | 1.306 |
| **Non-Home Based** | | | | |
| 1 | 0.676 | 1.040 | 1.040 | 1.040 |
| 2 | 1.152 | 1.608 | 1.944 | 2.016 |
| 3 | 1.850 | 2.300 | 2.650 | 2.975 |
| 4+ | 2.200 | 2.640 | 3.080 | 3.520 |

Trip end productions for other purposes are calculated using the following regression equations:

**I-I Truck Productions** = 0.388*hh + 1.206*retail + 1.362*(manuf + whole) + 0.514*service
**I-E Passenger Car Productions** = 0.331*Households + 0.724*Total Employment
**I-E Truck Productions** = 0.078*Retail Employment + 2.149*Wholesale Employment + 0.228*Manufacturing Employment

### 2.2.5 Trip Attraction Sub-model

The trip attraction routine to compute the estimated number of trips attracted to each TAZ uses the following regression equations:

**Home Based Work Attractions** = 1.196*Total Employment
**Home Based Other Attractions** = 0.5077*Population + 0.967*Total Employment + 1.5258*School Enrollment
**Home Based Shopping Attractions** = 5.655*Retail Employment
**Non-Home Based Attractions** = 0.293(Population) + 2.82108*(Retail Employment + Wholesale Employment) + 0.6984*Service Employment
**Internal Truck Attractions** = Internal Truck Productions
**Internal-External Attractions** = Based on counts and EE% (internal zones=0)
**Internal-External Truck Attractions** = Based on counts, EE%, and Truck% (internal zones=0)

The trip rates were subsequently refined system-wide on case by case basis during the model calibration process to reflect local variations.

The total number of Internal-External (I-E) trips for each external station is calculated by subtracting the estimated number of External-External trips (based on an assumed percentage) from the station's daily traffic volumes. Then the total I-E trips are separated into I-E truck trips and other I-E trips based on an assumed truck percentage at each external station. The following table displays the percentages that are used to calculate I-E and E-E Attractions at each external station for truck and passenger cars.

**Table 2.2.5-1**
**Proportion of External-Internal Trips by External Station**

| | | | | Trucks | | PC's | |
|---|---|---|---|---|---|---|---|
| Model Station Number | 2009 Counts | Percent Trucks | Percent PC's | Percent E-E | Percent I-E | Percent E-E | Percent I-E |
| 234 | 190 | 5% | 95% | 1% | 4% | 10% | 85% |
| 235 | 1,980 | 20% | 80% | 2% | 18% | 9% | 71% |
| 236 | 1,310 | 5% | 95% | 1% | 4% | 10% | 85% |
| 237 | 9,080 | 10% | 90% | 2% | 8% | 14% | 76% |
| 238 | 8,790 | 20% | 80% | 3% | 17% | 13% | 67% |
| 239 | 410 | 5% | 95% | 0% | 5% | 4% | 91% |
| 240 | 1,630 | 5% | 95% | 1% | 4% | 10% | 85% |
| 241 | 16,790 | 10% | 90% | 1% | 9% | 10% | 80% |
| 242 | 1,430 | 0% | 100% | 0% | 0% | 11% | 89% |
| 243 | 524 | 0% | 100% | 0% | 0% | 4% | 96% |
| 244 | 262 | 5% | 95% | 0% | 5% | 4% | 91% |
| 245 | 520 | 5% | 95% | 1% | 4% | 10% | 85% |
| 246 | 315 | 0% | 100% | 0% | 0% | 4% | 96% |
| 247 | 6,360 | 10% | 90% | 2% | 8% | 14% | 76% |
| 248 | 419 | 0% | 100% | 0% | 0% | 11% | 89% |
| 249 | 10,940 | 10% | 90% | 1% | 9% | 10% | 80% |

| | | | | Trucks | | PC's | |
|---|---|---|---|---|---|---|---|
| Model Station Number | 2009 Counts | Percent Trucks | Percent PC's | Percent E-E | Percent I-E | Percent E-E | Percent I-E |
| 250 | 419 | 0% | 100% | 0% | 0% | 4% | 96% |
| 251 | 2,020 | 0% | 100% | 0% | 0% | 11% | 89% |
| 252 | 1,410 | 5% | 95% | 1% | 4% | 10% | 85% |
| 253 | 315 | 0% | 100% | 0% | 0% | 4% | 96% |
| 254 | 3,420 | 5% | 95% | 1% | 4% | 15% | 80% |
| 255 | 315 | 0% | 100% | 0% | 0% | 4% | 96% |
| 256 | 160 | 5% | 95% | 0% | 5% | 4% | 91% |
| 257 | 5460 | 10% | 90% | 1% | 9% | 10% | 80% |
| 258 | 1,200 | 5% | 95% | 1% | 4% | 10% | 85% |
| 259 | 8,110 | 25% | 75% | 3% | 22% | 8% | 67% |

### 2.2.6 External-External Trips

Two external-external (E-E) trip tables were estimated for the 2009 calibration; one for passenger cars and one for trucks. A matrix summarizing the distance in miles between all external stations was developed using the 2009 network with illogical movements eliminated. This distance matrix serves as a "seed" to develop the final E-E trip tables. The theory behind using distance between external stations to help predict external-external trips is that the greater the distance between external stations, the more likely there will be external-external trips between these external stations. For example, typically, the distance between two external stations on either end of an interstate facility would be longer and, likewise, the number of trips that will travel between the two external stations on either end of the interstate would be higher. The final 2009 external trip tables were estimated by applying the FRATAR procedure on the "seed" matrix to match the estimated E-E trips at each external station. Because E-E traffic volumes on collectors and local streets are relatively low, it is assumed these movements were negligible.

### 2.2.7 Special Trip Generators

Special trip purposes are used for zones or activity centers having trip rates that are not represented well by the standard trip generation process. Currently, there is no special trip generator that requires a special handling in the model for the Rome area.

### 2.2.8 Balancing Productions and Attractions

A TP+ script was developed for the trip generation process. Using 2009 socioeconomic data, the script calculates and balances the productions and attractions, writes the productions and attractions to a file, builds the E-E trip table, calculates Fratar factors, and applies the Fratar model to adjust the E-E table so that traffic volumes at external stations closely match traffic counts.

For trip purposes in the FRUTS model, production and attraction trip ends are computed separately. As ~~such~~a result, the sum of productions across all zones does not necessarily equal the sum of attractions. In reality~~ though~~, each trip has two trip ends; one is a production/origin and one is an attraction/destination. ~~In theory~~Therefore, it makes sense to equalize the sum of productions with the attractions across all zones which, in effect, "balances" the two types of trip ends. This balancing or reconciliation is performed in the trip generation script. The script uses the process listed below.

**Balancing Productions and Attractions**

1. Productions and Attractions are calculated for all internal TAZs by purpose.
2. Zonal attractions for each trip purpose are proportionally adjusted so the total attractions equal the total productions by purpose (i.e. attractions balanced to productions) for all internal zones.
3. Non-home based productions are set equal to non-home based attractions (NHB trip productions were generated in the "home" zone, but by definition, NHB trips do not begin or end at the home. Therefore, the assumption is that the attraction variables are a better indicator of total trips than home based characteristics).
4. Attractions are balanced to productions for all internal zones (except NHB).
5. Internal-External Attractions (including trucks) are calculated for external stations.
6. I-E productions (including trucks) are balanced to the calculated attractions (assumes that since I-E attractions are based on traffic counts or external station projections, they provide the best controls).
7. The I-E productions and attractions are appended to the I-I trip end file to produce the final productions and attractions.

## *2.3 Trip Distribution*

Trips are calculated for persons~~,~~ by trip purpose, from the production and attraction trip ends. The trip distribution step uses the gravity model process, which is commonly used for this purpose in urban models. The estimated number of trips between any two origin-destination zones will, in general, be proportional to the number of trip ends (mass) and inversely proportional to the travel time. The gravity model computes trips such that the resulting distribution matches an observed distribution of trips by travel time for each of the trip purposes.

Minimum time paths for the network were calculated using the TP+ Hwyload function. These times include all turn ~~prohibitory~~ prohibitors and turn penalties. The minimum times were then adjusted to include the intrazonal times and terminal times. Intrazonal times~~,~~, representing the average time it takes to make a trip inside a particular TAZ, were created by the TP+ Matrix function using half of the average travel time to the nearest four TAZ's. Terminal times were assigned based on the employment density of the origin and destination TAZ's. At the trip origin, terminal time generally ~~refers~~ represents~~to~~ the walk time from one's residence to their car. At the destination end, it generally represents the time it takes to go from one's car to their destination. The following table summarizes the terminal time criteria:

**Table 2.3-1**
**Terminal Time Criteria**

| | **Employment Density (Total Employees per Acre)** | | | | |
|---|---|---|---|---|---|
| **Zone** | **0-4.00** | **3.01-15.00** | **15.01-50.00** | **25.01-75.00** | **>75.00** |
| Origin | 1.0 minute | 1.0 minute | 2.0 minutes | 2.0 minutes | 2.0 minutes |
| Destination | 1.0 minute | 1.5 minutes | 2.0 minutes | 2.5 minutes | 3.0 minutes |

Average trip travel times are displayed in the following table. These are typical trip travel times, found in urban areas the size of Rome. Home Based Work trips have the longest trip travel time at 16.1 minutes while Non Home Based trips have the shortest travel time at 11.9 minutes. The comparison of the model results with the target values is shown in Appendix B.

**Table 2.3-2**
**Average Trip Travel Times**

| **Trip Purpose** | **Average Trip Travel Time (Time)** |
|---|---|
| Home Based Work | 16.1 |
| Home Based Other | 14.6 |
| Home Based Shopping | 13.8 |
| Non Home Based | 11.9 |
| Trucks | 12.2 |

Gravity model input consists of a set of travel time impedance factors (friction factors), in addition to the production trip ends, attraction trip ends and minimum time skim. These parameters force the gravity model to produce sets of trips by trip purpose, whose distributions approximate an observed travel time distribution.

### *2.4 Mode Split*

The mode split process determines what mode of travel will be used to make the trips between zones. A trip-end model split was used to determine the number of transit trips. Trip-end models are based on socio-economic characteristics within traffic zones (i.e., income, auto-ownership, etc.), rather than service characteristics between zones. Trip-end models can serve as a reasonable tool for estimating changes in regional transit ridership levels in response to changes in regional transit investments and policies.

Since trip-end models are based on zonal attributes, the implied assumption is that transit ridership consists primarily of "captive" riders who must use transit, and a fixed share of those who choose to use transit over other available modes. A trip-end modeling approach has been developed that can be used to test the effectiveness of system-wide transit improvements. The general approach is as follows:

1. Transit trip rates are calibrated to replicate base year transit ridership totals. Transit trip rates are stratified by auto ownership level (0 autos; 1 auto; 2 autos; 3+ autos)[3].
2. Each Traffic Analysis Zone (TAZ) is coded with attributes that designate whether a zone is within three transit service area buffers (0.25-mile, 0.5-mile and 1-mile).
3. Transit service area attributes are used to estimate the percentage of households in each zone that have access to transit.
4. Transit trips are estimated by applying transit trip rates to households that are within the transit service area.
5. Highway person trip tables are estimated by subtracting transit trips from the total person trip tables estimated in the trip generation model.

Future regional-level transit policies can be tested, including transit service area expansion, fare adjustments and headway[4] changes. Trip rates can also be factored to test the effects of attracting more choice riders. Base year operating costs and revenues are used to estimate the costs of the regional transit policies.

Rome has a transit system serving the area; the Rome Transit. After the transit trips are calculated and subtracted, the remaining person trips are converted to vehicle trips for the internal trip purposes (HBW, HBO, HBS, and NHB). Average auto occupancy rates by purpose from various sources such as the Census Journey-to-Work data and other national travel surveys were used to estimate the Rome average auto occupancy rate. The other trip tables, internal truck and I-E and E-E passenger car and truck trips were calculated in terms of vehicle trips at their inception. Conversion to vehicle trip table enables comparison to vehicle counts and capacity analyses.

The following trip table factors or vehicle occupancy rates were used in the FRUTS model:

**Table 2.4-1**
**FRUTS Vehicle Occupancy Rates**

| Trip Purpose | Occupancy Rate |
|---|---|
| Home Based Work | 1.104 |
| Home Based Other | 1.576 |

3 Initial trip rates were calculated from the 1997 Augusta Household Travel Survey, and are scaled proportionally to produce observed trip totals.
4 Using typical fare and headway elasticities.

| Trip Purpose | Occupancy Rate |
|---|---|
| Home Based Shopping | 1.394 |
| Non Home Based | 1.495 |
| Internal Trucks | No adjustment – already vehicle trips |
| Internal-External | No adjustment – already vehicle trips |
| Internal-External Trucks | No adjustment – already vehicle trips |

### 2.5 Traffic Assignment

The last step in the modeling sequence is the assignment or simulation of the trip tables to logical routes in the highway network. Trip assignment for the FRUTS model was accomplished using the equilibrium assignment technique. The traffic assignment algorithm is iterative, running through successive applications until equilibrium occurs. Equilibrium occurs when no trip can be made by an alternate path without increasing the total travel time of all trips in the network. The equilibrium assignment is an iterative process that reflects travel demand assigned to minimum time paths as well as the effects of congestion. In each assignment iteration, traffic volumes are loaded onto network links and travel times are adjusted in response to the volume to capacity relationships. Final assigned volumes are derived by summing a percentage of the loadings from each iteration. The percentages reflect congested conditions that usually influence motorists' path selection for a portion of the day, not the entire day.

During the model run, additional network link attributes are attached to the input network to store assignment results as well as values used in the traffic assignment. These additional attributes provide volumes, travel time, speed, and so on for each link, and can be used to summarize network-wide link statistics. A list of these attributes is shown in Table 2.5-1.

**Table 2.5-1**
**Output Network Attributes**

| Travel Demand Model – Output Network Attributes | |
|---|---|
| **Attribute Name** | **Description** |
| Taz | Nearest Taz ID |
| Taz | Closest Associated TAZ# |
| Atype | Area Type |
| Hcap | Hourly Capacity (Vehicles per Hour) |
| Hcapam | AM Peak Hourly Capacity (Vehicles per Hour) |
| Hcappm | PM Peak Hourly Capacity (Vehicles per Hour) |
| Capacity | Daily Capacity (Vehicles per Day) |
| Speed | Freeflow Speed in Mile per Hour (Miles per Hour) |
| Time_ff | Free Flow Travel Time (Minutes) |
| Time_cg | Initially Estimated Congested Time (Minutes) |
| Time_op | Off-peak Travel Time (Minutes) |
| Linkclass | Link Classification Used in Assignment |

| Travel Demand Model – Output Network Attributes | |
|---|---|
| **Attribute Name** | **Description** |
| V_1 | Daily Volume (One-way) |
| Time_1 | Congested Link Travel Time |
| Vc_1 | Daily Volume over Capacity Ratio |
| Cspd_1 | Congested Speed (Miles per Hour) |
| Vht_1 | Vehicle Hour of Travel |
| Vt_1 | Daily Volume (Two-way) |
| Count | Base Year Traffic Count (One-way) |
| V_hbw | Home Based Work Volumes |
| V_hbo | Home Based Other Volumes |
| V_hbs | Home Based Shopping Volumes |
| V_nhb | Non-home Based Volumes |
| V_trk | Truck Volumes |
| V_ie | Internal-External Volumes |
| V_ietrk | Internal-External Truck Volumes |
| V_eepc | External-External Volumes |
| V_eetrk | External-External Truck Volumes |
| V_totpc | Daily Volume (One-way passenger) |
| V_tottrk | Daily Volume (One-way truck) |
| Vmt_1 | Total Daily Vehicle Mile of Travel |
| Vhd_1 | Total Daily Vehicle Hours of Delay |
| Vcnt | Daily Volume over Base Year Count Ratio |

### 2.5.1 Model Calibration

Georgia DOT requires refinements to various model parameters until the base year (2009) model sufficiently replicates observed 2009-level travel patterns. The base year model was checked for accuracy by determining the percent error of assigned volumes compared to ground counts and by checking the reasonableness of the model's Vehicle-Miles Traveled (VMT) statistics. Also, the model was tested along screenlines to indicate if there were any broad areas and corridors where trips appeared to be consistently overestimated or underestimated. Results from each of these tests are presented in the following tables and figures.

Georgia DOT requires multiple validation checks to each of the major steps in the travel demand modeling process. Output modeled volumes are validated against traffic counts at several levels – regional, corridors (screenlines) and link-by-link. Regional evaluations include VMT, Root Mean Squared Error (RMSE) and R-Squared calculations for volume-count matching. Corridor evaluations are primarily screenline comparisons. Nationally recognized maximum desirable deviation standards are applied to analyze model performance at the link level. These include

FHWA's "*Calibration & Adjustment of System Planning Models*", 1990 and the NCHRP Report 365: "*Travel Estimation Techniques for Urban Planning*", 1998.

One of many steps in the validation process involves screenlines. Screenlines are defined by features such as railroads, creeks, and rivers. Since all roadways are not reflected in the travel demand model, these types of features serve to funnel traffic into corridors so that all trips can be analyzed where crossing of these features is possible. Figure 2.5.1-1 depicts the locations of screenlines used for the validation process. Where each screenline crosses a roadway can be identified by following the color coded links across the FRUTS area.

**Figure 2.5.1-1**
**Screenline Locations**

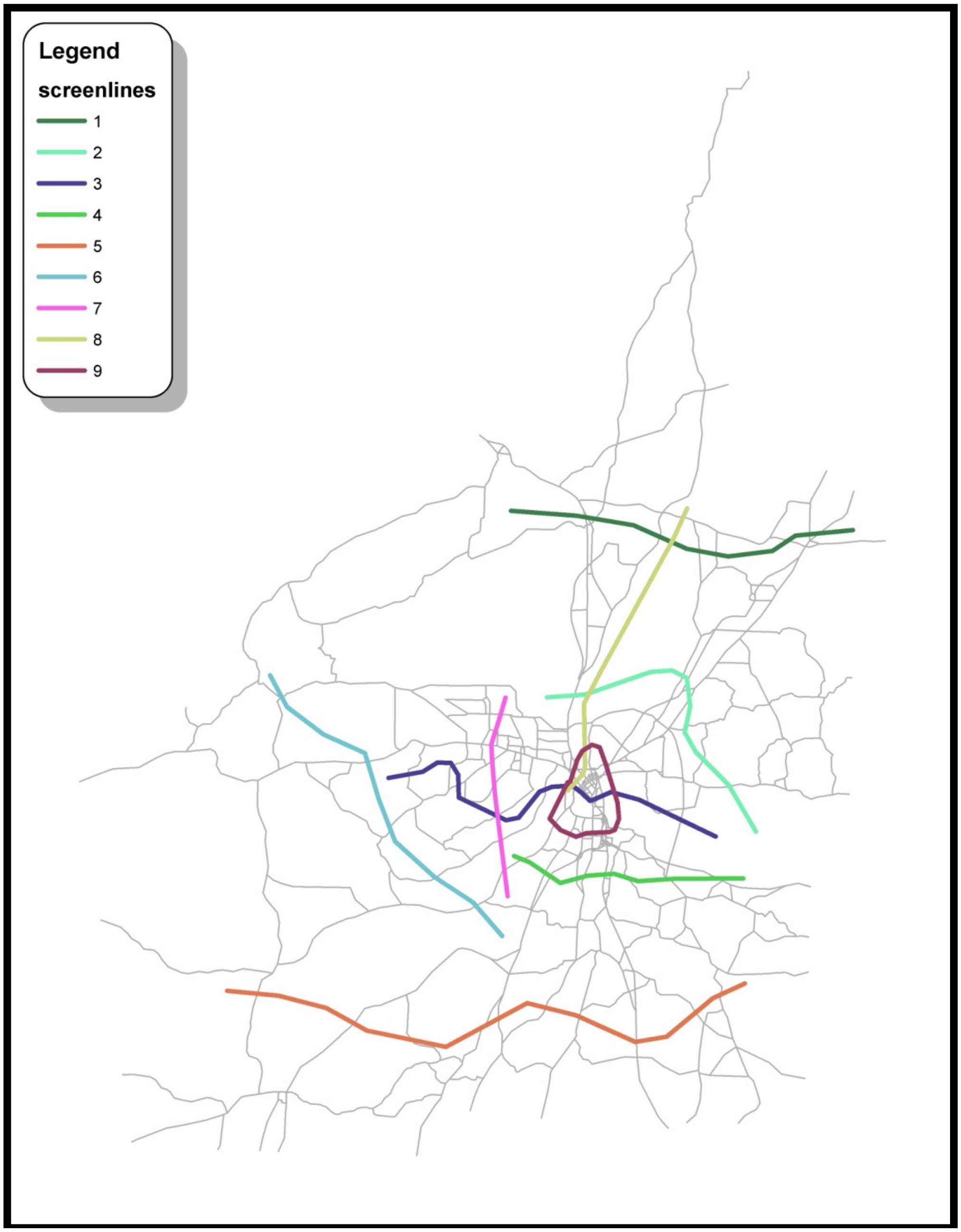


Table 2.5.1-1 lists the results of the screenline analysis. All of the model volumes for the screenlines are well within the acceptable range of error when compared to the observed traffic volumes.

**Table 2.5.1-1**
**Summary of the Screenlines**

| Screenlines | Target Range / Value | FRUTS 2009 Model |
|---|---|---|
| All Counts | +/- 12 % | 6% |
| 1 | +/- 36 % | -3% |
| 2 | +/- 29 % | 9% |
| 3 | +/- 25 % | -7% |
| 4 | +/- 29 % | 13% |
| 5 | +/- 29 % | 10% |
| 6 | +/- 28 % | 9% |
| 7 | +/- 29 % | 7% |
| 8 | +/- 26 % | 5% |
| 9 | +/- 27 % | 9% |

Table 2.5.1-2 lists the results of the comparison between the FRUTS model assigned volumes and the observed volumes for each link within each screenline. In most cases, the largest differences between the model and observed counts occur on the less traveled facilities.

**Table 2.5.1-2**
**Screenline Results**

| **Screenline 1:** | | | | | |
|---|---|---|---|---|---|
| | **2009** | **2009** | **Volume** | **Percent** | **Maximum** |
| | **Assign** | **Traffic** | **/Count** | **Deviation** | **Desirable** |
| **Road Name** | **Volume** | **Count** | **Ratio** | **From Base** | **Deviation** |
| SR 53 | 9,980 | 10,030 | 1.00 | -0.50% | 38.21% |
| SR 53 | 14,730 | 14,630 | 1.01 | 0.68% | 32.41% |
| Old Bells Ferry Road | 1,150 | 370 | 3.11 | 210.81% | 161.13% |
| SR 1 | 9,000 | 11,340 | 0.79 | -20.63% | 36.22% |
| Old Dalton Rd. | 2,360 | 1,970 | 1.20 | 19.80% | 77.71% |
| Total | 37,220 | 38,340 | 0.97 | -2.92% | 35.75% |

| Screenline 2: | | | | | |
|---|---|---|---|---|---|
| | **2009** | **2009** | **Volume** | **Percent** | **Maximum** |
| | **Assign** | **Traffic** | **/Count** | **Deviation** | **Desirable** |
| **Road Name** | **Volume** | **Count** | **Ratio** | **From Base** | **Deviation** |
| SR 1 (North) | 32,840 | 34,370 | 0.96 | -4.45% | 22.33% |
| Bells Ferry | 1,190 | 710 | 1.68 | 67.61% | 121.26% |
| SR 53 | 18,130 | 14,220 | 1.27 | 27.50% | 32.82% |
| Calhoun Road (North) | 6,590 | 6,270 | 1.05 | 5.10% | 46.90% |
| SR 293 | 8,530 | 7,710 | 1.11 | 10.64% | 42.86% |
| Wayside Rd. | 2,870 | 1,220 | 2.35 | 135.25% | 95.76% |
| Total | 70,150 | 64,500 | 1.09 | 8.76% | 29.32% |

| Screenline 3: | | | | | |
|---|---|---|---|---|---|
| | **2009** | **2009** | **Volume** | **Percent** | **Maximum** |
| | **Assign** | **Traffic** | **/Count** | **Deviation** | **Desirable** |
| **Road Name** | **Volume** | **Count** | **Ratio** | **From Base** | **Deviation** |
| Broad Street | 13,860 | 13,740 | 1.01 | 0.87% | 33.31% |
| SR 101(South) | 24,550 | 24,440 | 1.00 | 0.45% | 25.91% |
| Horseleg Creek Rd. | 4,120 | 3,760 | 1.10 | 9.57% | 58.62% |
| SR 1/SR 20 | 28,010 | 32,260 | 0.87 | -13.17% | 22.96% |
| Billy Pyle Rd | 1,270 | 1,020 | 1.25 | 24.51% | 103.54% |
| Mays Bridge Rd | 2,160 | 5,300 | 0.41 | -59.25% | 50.47% |
| Mt. Alto Rd | 160 | 1,440 | 0.11 | -88.89% | 89.09% |
| Burnett Ferry Rd. | 2,080 | 2,340 | 0.89 | -11.11% | 72.09% |
| Barker Rd | 730 | 480 | 1.52 | 52.08% | 143.84% |
| SR 1 Loop | 12,570 | 11,850 | 1.06 | 6.08% | 35.53% |
| Fosters Mill Road | 3,480 | 3,500 | 0.99 | -0.57% | 60.48% |
| Total | 92,990 | 100,130 | 0.93 | -7.13% | 24.80% |

| Screenline 4: | | | | | |
|---|---|---|---|---|---|
| | **2009** | **2009** | **Volume** | **Percent** | **Maximum** |
| | **Assign** | **Traffic** | **/Count** | **Deviation** | **Desirable** |
| **Road Name** | **Volume** | **Count** | **Ratio** | **From Base** | **Deviation** |
| Callier Springs Rd. | 4,520 | 1,980 | 2.28 | 128.28% | 77.53% |
| CR 639 | 430 | 3,440 | 0.13 | -87.50% | 60.94% |
| Lindale Rd | 7,390 | 7,550 | 0.98 | -2.12% | 43.25% |
| SR 1 (South) | 14,740 | 18,420 | 0.80 | -19.98% | 29.31% |
| Spring Rd. | 6,300 | 3,500 | 1.80 | 80.00% | 60.48% |

| Screenline 4: | | | | | |
|---|---|---|---|---|---|
| | **2009** | **2009** | **Volume** | **Percent** | **Maximum** |
| | **Assign** | **Traffic** | **/Count** | **Deviation** | **Desirable** |
| **Road Name** | **Volume** | **Count** | **Ratio** | **From Base** | **Deviation** |
| Chateau Dr | 820 | 610 | 1.34 | 34.43% | 129.56% |
| SR 101 | 10,580 | 11,180 | 0.95 | -5.37% | 36.45% |
| Old Lindale Rd | 6,910 | 3,740 | 1.85 | 84.76% | 58.75% |
| Total | 51,690 | 50,420 | 1.03 | 2.52% | 32.21% |

| Screenline 5: | | | | | |
|---|---|---|---|---|---|
| | **2009** | **2009** | **Volume** | **Percent** | **Maximum** |
| | **Assign** | **Traffic** | **/Count** | **Deviation** | **Desirable** |
| **Road Name** | **Volume** | **Count** | **Ratio** | **From Base** | **Deviation** |
| SR 101 | 7,830 | 8,520 | 0.92 | -8.10% | 41.03% |
| Reeceburg Rd | 1,090 | 1,030 | 1.06 | 5.83% | 103.10% |
| SR 1 (South) | 11,990 | 9,970 | 1.20 | 20.26% | 38.31% |
| Bowman Rd. | 2,100 | 2,980 | 0.70 | -29.53% | 64.87% |
| Wax Rd. | 1,720 | 1,830 | 0.94 | -6.01% | 80.24% |
| US 411/SR 53 | 5,090 | 3,390 | 1.50 | 50.15% | 61.33% |
| SR 100 | 3,990 | 2,510 | 1.59 | 58.96% | 69.91% |
| Abrams Rd. | 1,660 | 630 | 2.63 | 163.49% | 127.75% |
| Total | 35,470 | 30,860 | 1.15 | 14.94% | 38.83% |

| Screenline 6: | | | | | |
|---|---|---|---|---|---|
| | **2009** | **2009** | **Volume** | **Percent** | **Maximum** |
| | **Assign** | **Traffic** | **/Count** | **Deviation** | **Desirable** |
| **Road Name** | **Volume** | **Count** | **Ratio** | **From Base** | **Deviation** |
| Blacks Bluff Rd. | 4820 | 3590 | 1.34 | 0.3426 | 0.5981 |
| Horseleg Creek Rd. | 880 | 630 | 1.40 | 0.3968 | 1.2775 |
| Mays Bridge Road | 1,860 | 930 | 2.00 | 1 | 1.078 |
| Huffaker Rd | 780 | 940 | 0.83 | -17.02% | 107.30% |
| SR 20 (West) | 13,170 | 11,720 | 1.12 | 12.37% | 35.70% |
| Total | 21,510 | 17,810 | 1.21 | 20.77% | 47.88% |

| Screenline 7: | | | | | |
|---|---|---|---|---|---|
| | **2009** | **2009** | **Volume** | **Percent** | **Maximum** |
| | **Assign** | **Traffic** | **/Count** | **Deviation** | **Desirable** |
| **Road Name** | **Volume** | **Count** | **Ratio** | **From Base** | **Deviation** |
| SR 20 (West) | 22,690 | 25,390 | 0.89 | -10.63% | 25.49% |

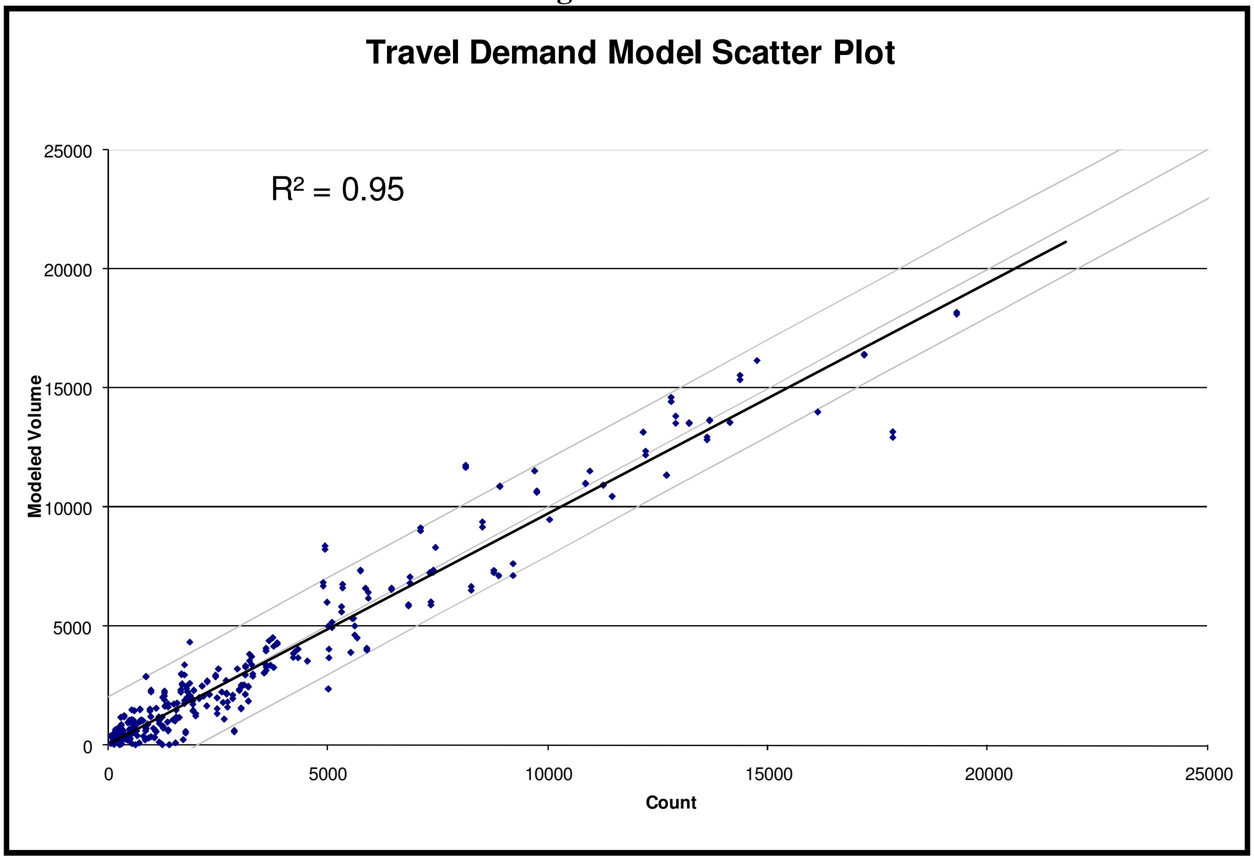
| Screenline 7: | | | | | |
|---|---|---|---|---|---|
| | **2009** | **2009** | **Volume** | **Percent** | **Maximum** |
| | **Assign** | **Traffic** | **/Count** | **Deviation** | **Desirable** |
| **Road Name** | **Volume** | **Count** | **Ratio** | **From Base** | **Deviation** |
| Burnett Ferry Road | 3,670 | 6,397 | 0.57 | -42.63% | 46.49% |
| Technology Parkway | 21,850 | 22,520 | 0.97 | -2.98% | 26.85% |
| Horseleg Creek Rd. | 1,920 | 2,730 | 0.70 | -29.67% | 67.40% |
| Total | 50,130 | 57,037 | 0.88 | -12.11% | 30.73% |

| Screenline 8: | | | | | |
|---|---|---|---|---|---|
| | **2009** | **2009** | **Volume** | **Percent** | **Maximum** |
| | **Assign** | **Traffic** | **/Count** | **Deviation** | **Desirable** |
| **Road Name** | **Volume** | **Count** | **Ratio** | **From Base** | **Deviation** |
| SR 1 | 26,100 | 35,670 | 0.73 | -26.83% | 21.97% |
| 5th Avenue | 8,010 | 7,200 | 1.11 | 11.25% | 44.16% |
| 2nd Avenue | 30,910 | 28,730 | 1.08 | 7.59% | 24.15% |
| SR 1 Loop | 27,130 | 28,270 | 0.96 | -4.03% | 24.32% |
| Total | 92,150 | 99,870 | 0.92 | -7.73% | 24.82% |

| Screenline 9: | | | | | |
|---|---|---|---|---|---|
| | **2009** | **2009** | **Volume** | **Percent** | **Maximum** |
| | **Assign** | **Traffic** | **/Count** | **Deviation** | **Desirable** |
| **Road Name** | **Volume** | **Count** | **Ratio** | **From Base** | **Deviation** |
| US 27 | 27,360 | 25,810 | 1.06 | 6.01% | 25.30% |
| SR 1 | 21,300 | 19,500 | 1.09 | 9.23% | 28.59% |
| 5th Avenue | 13,160 | 16,520 | 0.80 | -20.34% | 30.74% |
| Riverside Parkway | 5,860 | 6,600 | 0.89 | -11.21% | 45.86% |
| SR 53 | 14,610 | 14,800 | 0.99 | -1.28% | 32.25% |
| SR 293 | 13,510 | 9,800 | 1.38 | 37.86% | 38.60% |
| Callier Springs Road | 1,180 | 2,180 | 0.54 | -45.87% | 74.35% |
| Dean Avenue | 11,890 | 14,690 | 0.81 | -19.06% | 32.35% |
| Maple Ave. | 6,790 | 7,170 | 0.95 | -5.30% | 44.24% |
| Blacks Bluff Rd. | 770 | 1,350 | 0.57 | -42.96% | 91.63% |
| Cave Springs Road | 7,340 | 6,450 | 1.14 | 13.80% | 46.33% |
| SR 1 (North Bound) | 16,170 | 14,750 | 1.10 | 9.63% | 32.30% |
| Total | 139,940 | 139,620 | 1.00 | 0.23% | 21.84% |

Another way of viewing link validation is through the use of a scatter plot that depicts the relationship between traffic counts and modeled volumes. The following graphic depicts this relationship for the FRUTS 2009 network. The graphic indicates that the majority of modeled volumes are consistent with the traffic counts. It should be noted that it is normal to have outliers, both high and low. The $R^2$ value of 0.95 indicates the model sufficiently replicates base year travel characteristics.

**Figure 2.5.1-2**




The modeled traffic volumes summarized by facility type are shown in Table 2.5.1-3. The HPMS VMT is based on the Georgia Department of Transportation's Office of Transportation Data "445 Report". ~~as well as on the data from South Carolina Department of Transportation. The HPMS VMT numbers represent the average annual daily VMT for the year 2009 for all of Columbia, Richmond, and Aiken County and parts of Edgefield County. The HPMS VMTs for Edgefield County were prorated based on its roadway mileage by functional classifications.~~

The highway network and trip table are considered to provide a good representation of travel conditions on the existing system if the total percent error region-wide for the VMT is less than +/-5 percent. For the FRUTS model, the total percent error region-wide is less than about 3% excluding the local streets. Calculating the percent error by facility type indicates whether the model is loading trips in a reasonable manner. The FRUTS model is performing very well estimating traffic volumes for all of the facility types except for local roads. This is not surprising or alarming since most of the local roads in an urban area are usually not included in a regional travel demand model. These volumes are provided below just for informational purposes only.

**Table 2.5.1-3**
**Travel Demand Model Maximum Desired Deviation Chart**

| | VMT | | | |
|---|---|---|---|---|
| **Facility Type** | **Model** | **HPMS** | **Difference** | **Percent** |
| Principal Arterial | 1,032,000 | 1,098,000 | -66,000 | -6.0% |
| Minor Arterials | 630,000 | 591,000 | 40,000 | 6.7% |
| Collectors | 398,000 | 366,000 | 32,000 | 8.9% |
| Local | 365,000 | 138,000 | 227,000 | 164.1% |
| Total | 2,426,000 | 2,193,000 | 233,000 | 10.6% |

Comparing the deviation of assigned link volumes with the maximum desirable deviation is also a method for checking the model validation and calibration~~ check~~. The higher the link traffic count, the smaller the maximum desired deviation allowed on that link. Generally, models should ~~be able to ~~replicate traffic volumes on higher designed facilities more accurately than those on lower designed facilities. Since ~~H~~higher designed facilities have higher usage, they are frequently the ~~ and often are~~ focus~~es~~ of various transportation studies and strategies~~ policy making~~. Therefore, how well the model assigns trips on these facilities is another indicator for how well the model is validated and calibrated~~ and how useful the model would be~~. Figure 2.5.1-3 shows the comparison of the maximum desired deviation curve and the model assigned volumes. Figure 2.5.1-4 illustrates the trip-loaded network. The model performed very well system-wide with almost all major facilities within the maximum desired deviation allowed.

**Figure 2.5.1-3**

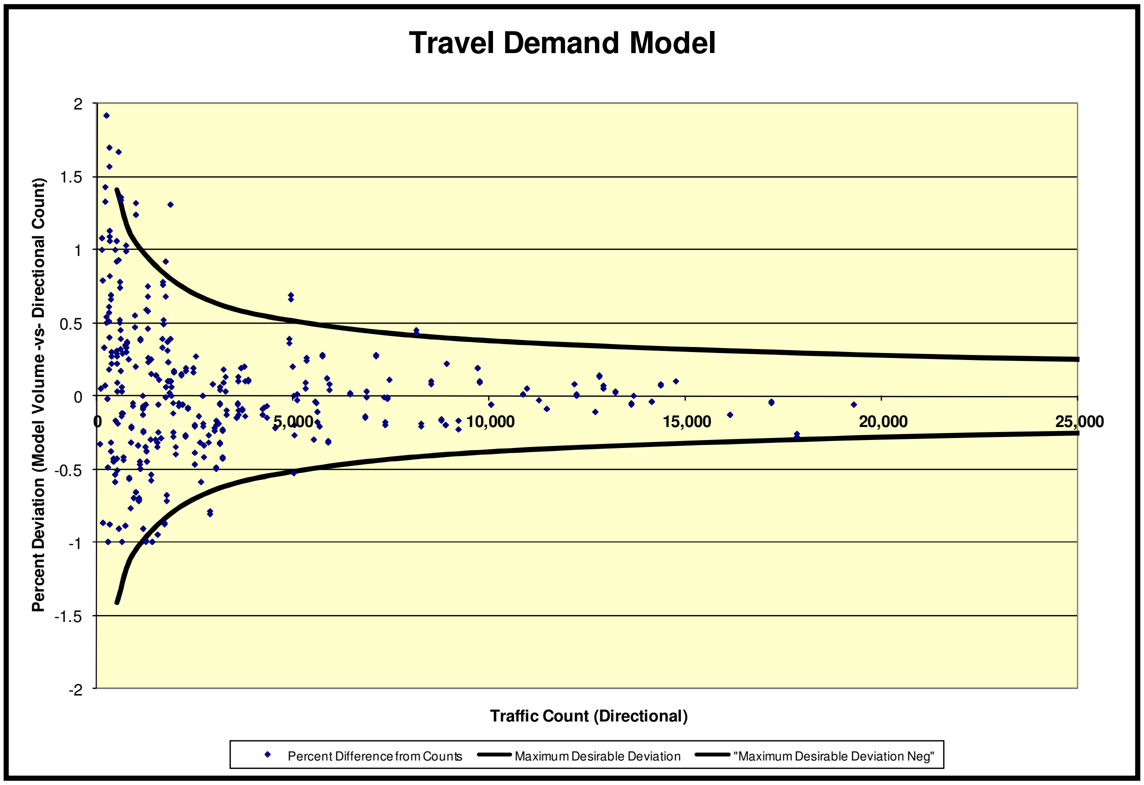
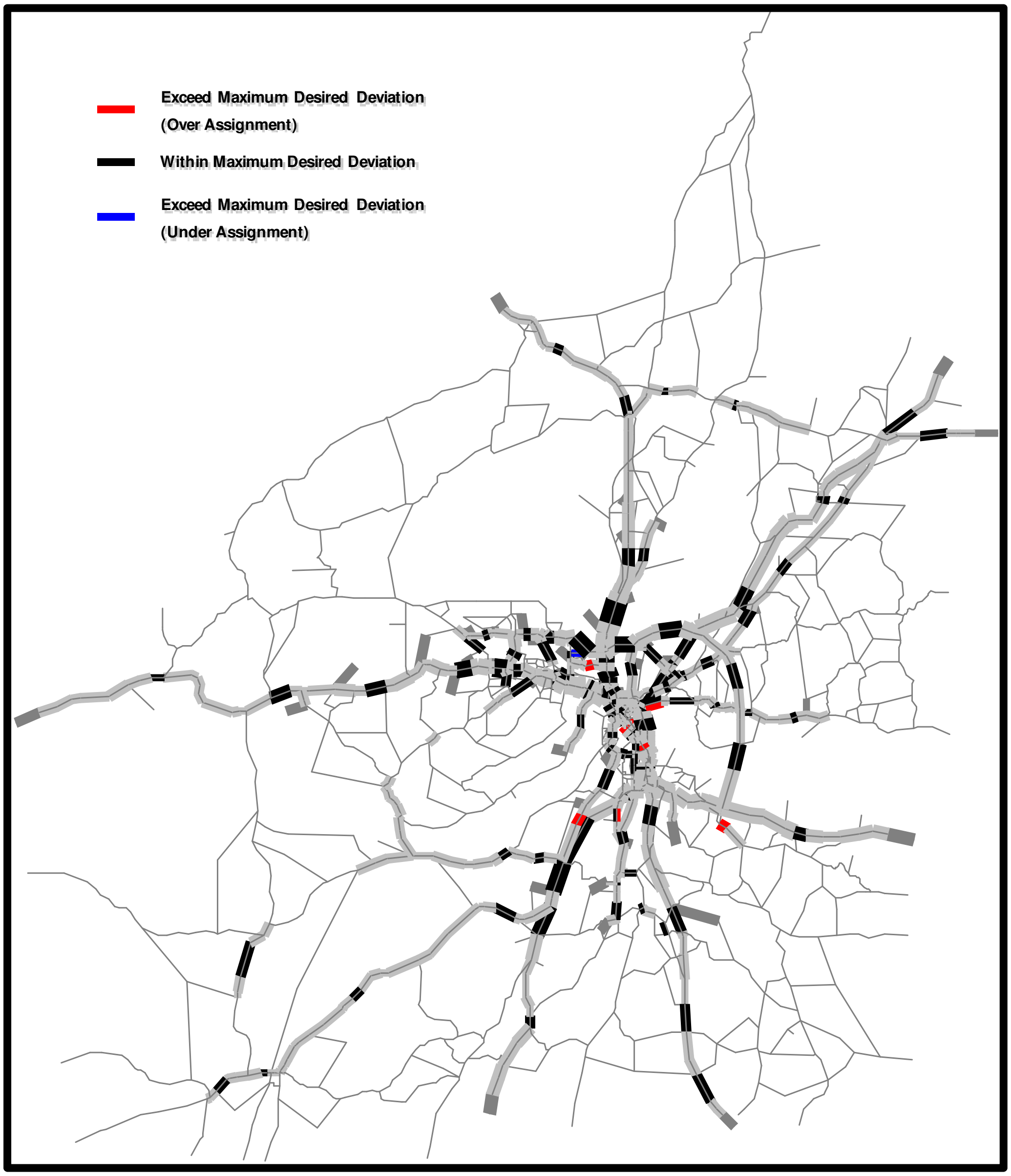

Travel Demand Model
Percent Deviation (Model Volume -vs- Directional Count)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0
5,000
10,000
15,000
20,000
25,000
Traffic Count (Directional)
Percent Difference from Counts
Maximum Desirable Deviation
"Maximum Desirable Deviation Neg"

**Figure 2.5.1-4**



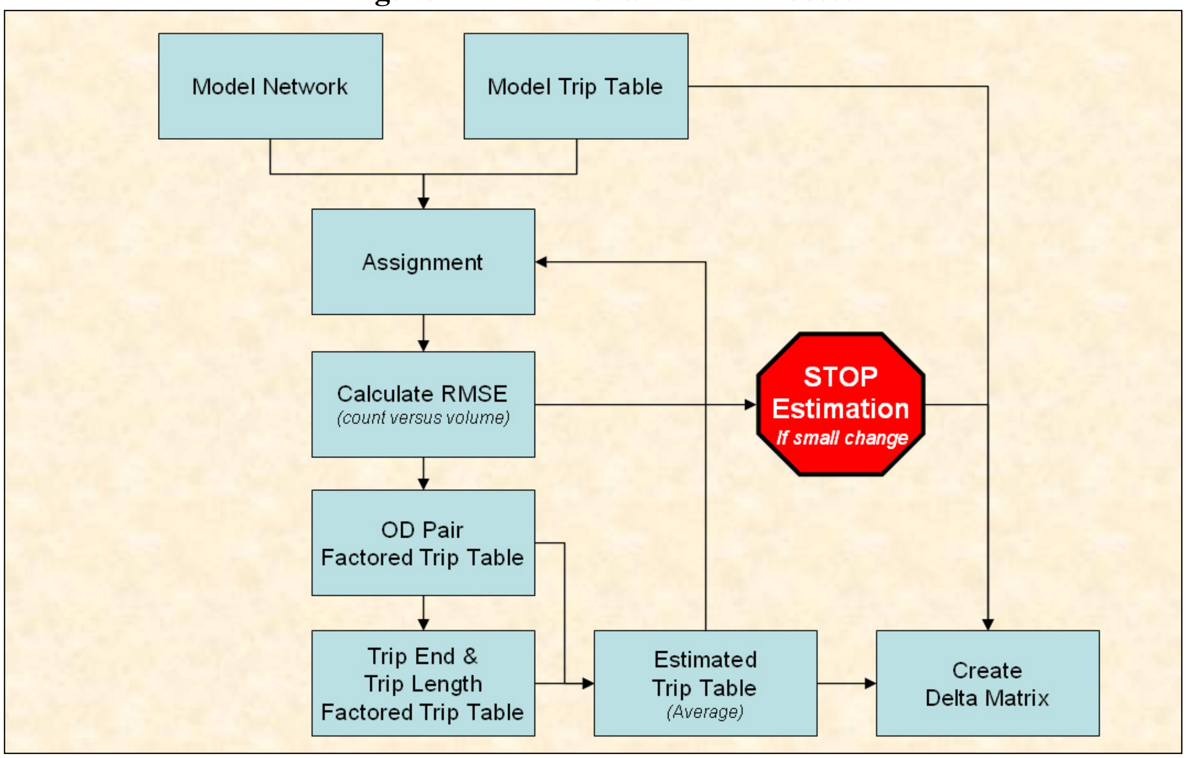

### 2.5.2 Delta Matrix Process

Due to the many variables involved, estimated traffic volumes from travel demand models will inevitably differ from observed traffic counts. As a result, it is usually necessary to post-process modeled volumes for use in traffic studies. National Cooperative Highway Research Program (NCHRP) Report 255 outlines a widely used methodology for post-processing model results, but like many approaches to refining travel demand models, the procedures are intended for specific projects or corridors and are not easily applied to an entire region.

Matrix estimation techniques to post-process travel demand model volumes for an entire region have been developed for the GDOT MPO areas. This region level post-processing is done by developing a delta matrix, which is a trip table that is combined with the normal travel demand model trip table to produce traffic assignments that closely replicate observed traffic counts.

Figure 2.5.2-1 outlines how a delta matrix is developed. The delta matrix process uses the travel demand model trip table as a seed for a matrix estimation process. The matrix estimation process attempts to closely replicate observed traffic counts, while also controlling the trip ends and trip lengths possessed by the seed matrix. This is accomplished by iteratively assigning a trip table, adjusting the trip table to match traffic counts, then applying a tri-proportional fitting process to match trip ends and trip lengths. Once a trip table is produced that sufficiently matches the traffic counts, a delta matrix is produced by subtracting the initial seed trip table from the estimated trip table.

**Figure 2.5.2-1 – Delta Matrix Process**




Conceptually the resulting delta matrix represents the localized factors that the regional travel demand modeling process does not reproduce well. Future travel demands are post-processed by applying the same local corrections that are represented in the delta matrix without adjustment since similar localized issues cannot be identified for future conditions. Therefore, the delta matrix is simply added to future trip tables before assigning the trips.

# Appendix A: Travel Demand Model Validation Sample Report

| Travel Demand Model Validation Report | | |
|---|---|---|
| | | |
| | | |
| **Calibration Measure** | **Target Range / Value** | **Model** |
| | | |
| **Socio-Economic Data** | | |
| Persons / Household | 2 - 4 | 2.7 |
| Workers / Household | 1 - 3 | 1.2 |
| | | |
| **Trip Generation** | | |
| Person Trips Per Household | 8.5 - 9.2 | 8.1 |
| Person Trips Per Person | 3 - 4 | 3.0 |
| HBW Trips / Employee | < 2 | 1.4 |
| Shopping Trips / Retail Employment | - | 5.7 |
| P/A Ratio Before Balancing (HBW) | 0.9 - 1.1 | 1.2 |
| P/A Ratio Before Balancing (HBO) | 0.9 - 1.1 | 1.1 |
| P/A Ratio Before Balancing (HBShop) | 0.9 - 1.1 | 1.0 |
| P/A Ratio Before Balancing (NHB) | 0.9 - 1.1 | 1.0 |
| | | |
| | | |
| **Trip Distribution** | | |
| Average Trip Length (HBW) | 16.0 - 17.7 | 16.1 |
| Average Trip Length (HBO) | 14.4 - 15.9 | 14.6 |
| Average Trip Length (HBShop) | 13.9 - 15.4 | 13.8 |
| Average Trip Length (NHB) | 11.8 – 13.0 | 11.9 |
| Average Trip Length (Truck) | N/A | 12.2 |
| % Intrazonal Trips | < 10% | 4.0% |
| | | |
| **Trip Assignment** | | |
| VMT-Freeway | 0 | 0 |
| VMT-Arterials | 1,689,000 | 1,663,000 |
| VMT-Collectors | 366,000 | 398,000 |
| VMT-Total | 2,055,000 | 2,061,000 |
| VMT / Household | 58.4 | 58.5 |
| VMT / Person | 21.4 | 21.4 |
| | | |
| Screenlines | | |
| All Counts | +/- 12 % | 6% |
| 1 | +/- 36 % | -3% |
| 2 | +/- 29 % | 9% |
| 3 | +/- 25 % | -7% |
| 4 | +/- 29 % | 13% |

| Travel Demand Model Validation Report | | |
|---|---|---|
| | | |
| | | |
| **Calibration Measure** | **Target Range / Value** | **Model** |
| 5 | +/- 29 % | 10% |
| 6 | +/- 28 % | 9% |
| 7 | +/- 29 % | 7% |
| 8 | +/- 26 % | 5% |
| 9 | +/- 27 % | 9% |
| | | |
| | | |
| RMSE = Root Mean Squared Error (Vol) | < 94% | 28% |
| % RMSE (0-5K) | < 86% | 45% |
| % RMSE (5K-10K) | < 45% | 21% |
| % RMSE (10K-15K) | < 35% | 7% |
| % RMSE (15K-20K) | < 30% | 16% |