TRMG2 Planners Guidebook

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TRIANGLE REGIONAL MODEL

Introduction

Basics

Who are you?

Technically focused transportation planners in the Triangle Region aiming to inform decisions affecting your communities over the next few decades.

What is this document for?

To make the Triangle Regional Travel Demand Model (TRM) more accessible and useful to planners.

How is this document structured?

Section #1 - Model steps, useful model outputs and possible use cases are summarized and explained.

Section #2 - Broad planning topics are presented along with analyses that can be performed by planners.

Glossary - Brief description of modeling vocabulary and terminology.

TRM Overview

What is the Triangle Regional Model?

The Triangle Regional Model (TRM) is a state of the practice regional travel demand model. It uses a series of mathematical equations or algorithms to represent the transportation system and the multi-modal travel choices that people make as they participate in activities.

The transportation system is represented by all major roads in the region and all transit services provided by local and regional providers. Travel choices are also influenced by demographic and land activity data grouped into transportation analysis zones (TAZ). TRM TAZs cover all of Wake, Durham and Orange counties, and portions of Alamance, Chatham, Franklin, Granville, Harnett, Johnston, Nash, and Person counties.

Resulting travel demand is developed using mathematical models that capture choices related to the number and types of trips people make, the mode they use to travel, the choice of destination, and the paths used to reach that destination. The TRM is the principal analytical tool used by transportation agencies in our region to develop and evaluate transportation strategies that support the mobility, accessibility, economic health and quality of life for the Triangle region.

Model Applications Guidelines

What should the TRM be used for?

- To develop and evaluate transportation strategies at the:
  - Regional level — whole metro
  - Subarea level — county, town, city or predefined district
  - Corridor level — collector, arterial, highway, interstate or transit-only facility
- To evaluate transportation system project additions (e.g. ridership on new transit service), modifications (e.g. new travel lanes on a roadway) or removal
- To help answer important transportation and land use related questions (e.g. toll, parking, or land use density studies)

What should the TRM **not** *be used for?*

- To evaluate operational level analysis such as on-street parking, auxiliary lanes, ramp metering, intersection traffic signal timing, intersection level delay
- To inform transit management and operations

Appropriate Expectations

The role of a travel demand model is not to provide the answer.

Well calibrated and validated models have a certain level of uncertainty in the validation year, and even more so in forecast years.

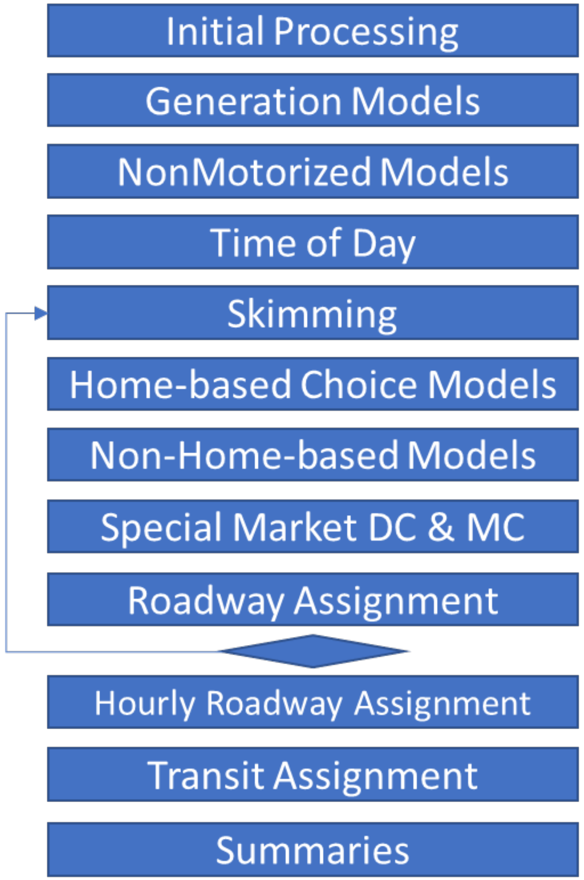
Travel demand models can and should be used to inform decision making, spark conversation and provide insight. One of the biggest strengths of travel models is for scenario planning/analysis and to support storytelling with data.

Model output is only as good as the model input. The model is sensitive to zonal input data, such as demographics (e.g. population, households and jobs) , but if that data is not modified to reflect future changes, then the sensitivity of the model will be limited.

Section #1

MODEL STEPS, USEFUL OUTPUTS, AND POSSIBLE USE CASES

TRM Process



This flowchart shows the process steps for the TRM. Each step is rich with data that could be useful in informing transportation planning analyses, processes and decisions. ***The individual model steps are detailed in the following pages.***

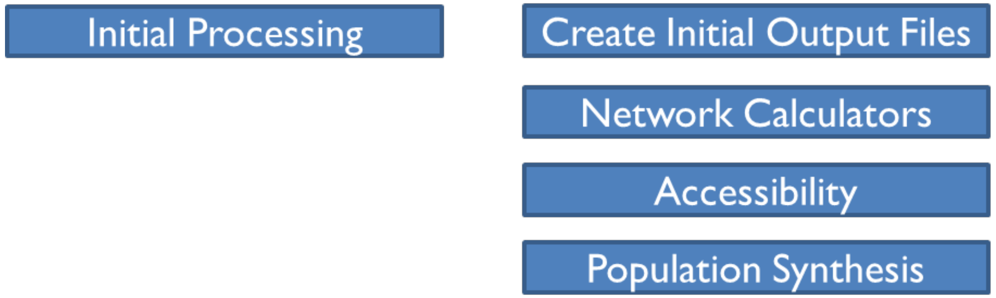
At a high level, the TRM takes input data - demographic and land use activity, and the transportation system - and processes that into the format needed by the travel choice submodels. Using this data, the submodels estimate regional residential travel including: the number and types of trips, the mode chosen, the destinations selected, and the transit routes or highway paths used.

This sequence is applied for four time periods: AM peak (7:00am-9:00am), midday (9:00am-3:30pm), PM peak (3:30pm-6:15pm) and nighttime (6:15pm-7:00am).

In addition to resident trips, the TRM also models trips for university students, freight (commercial vehicles and trucks), trips that begin and/or end outside of the Triangle region, and trips to and from the Raleigh-Durham International Airport.

The following pages include individual model steps, useful output data and possible applications. Geographic and data files can be used directly from the model. TransCAD geographic layers can be converted into .shp files for easy analysis in ArcMap and data tables are available as .csv files.

Initial Processing



This model step performs initial calculations to create important network variables. Using transportation network and land use data, several measures of accessibility are calculated for use in later steps of the model. This step also generates synthetic households and population for the region using TAZ inputs, Census ACS and PUMS data. It includes a wide variety of data that helps predict transportation choices.

Useful Outputs

- Fully attributed highway line layer
- Zonal accessibility measures including Gini-Simpson Diversity Index and walkability scores
- Individual synthetic households for the region (HH data: size, income, workers, seniors, kids, auto ownership)
- Individual synthetic persons for the region (person data: age, gender, employment status, worker, senior, child)

Possible Use Cases

- Evaluate changes in accessibility for various land use scenarios.
- Overlay with Communities of Concern data and evaluate accessibility for CoCs; intersect person level data with zonal data to evaluate accessibility for zero or insufficient car households.

Generation Models

Generation Models

Home-based Productions

Special Markets Generation

The number of trips produced by persons and households are estimated for several trip purposes including work, school, shopping, maintenance/dining out/other, and medical.

Trips to the airport are also estimated during this step, as are commercial vehicle/truck trips, university student trips, and trips that start and/or end outside of the Triangle region.   These are considered Special Markets.

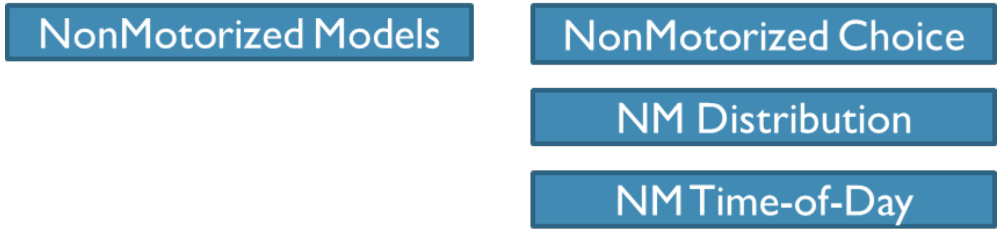
Useful Outputs

- Number of trips by trip purpose produced for each synthetic person and synthetic household in the region
- Number of trips by Special Market produced for each time period
- Spatial distribution of these trip productions

Possible Use Cases

- Develop person trip profiles by districts or counties.
- Evaluate changes in commercial vehicle trips resulting from various land use patterns.
- Evaluate changes in university student trips that result from on- or off-campus changes in land use/development patterns.

Non-Motorized Models



A non-motorized choice model is applied to split person level trip productions into motorized and non-motorized trips. The model is sensitive to person and household characteristics, zonal accessibility measures and land use mix. Person level trips are aggregated to TAZs and a gravity model is applied using walk- or bike-accessible attractions and walk/bike travel times. The non-motorized trip table is split by time of day (AM peak, midday, PM peak, nighttime).

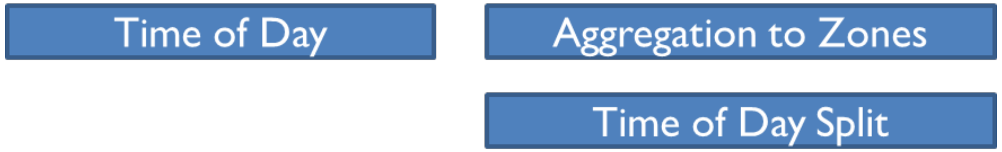
Useful Outputs

- Non-motorized trips by trip purpose for each synthetic person in the region
- Zone-to-zone non-motorized matrix for each trip type, trip length (long and short), and time period (AM, MD, PM, NT)
- Bike and walk skim matrices with zone-to-zone travel times and distances

Possible Use Cases

- Perform an equity analysis for non-motorized trips between different scenarios.
- Evaluate different development patterns and land use density adjustments on changes in non-motorized trip productions and destinations.
- Evaluate changes in non-motorized travel resulting from changes in multimodal accessibility.

Time of Day



Daily trip productions by trip purpose are disaggregated into four time periods:

- AM Peak (7:00am-9:00am)
- Midday (9:00am-3:30pm)
- PM Peak (3:30pm-6:15pm)
- Nighttime (6:15pm-7:00am)

The disaggregate person level trips are then aggregated to TAZs for use in the remaining aggregate level model steps.

Useful Outputs

- Trip productions by trip purpose by time of day

Possible Use Cases

- Investigate changes in the spatial and temporal allocation of trips by trip purpose between different scenarios.

Skimming

Skimming | Roadway Skims | Transit Skims

In this step, the minimum roadway and transit travel times between each TAZ are determined for each of the four time periods. For roadways, minimum travel time paths and the associated distances are included. And for transit, minimum paths include all time elements - walk, drive, wait, in-vehicle, and associated transfer times and penalties - and costs or transit fares. Costs for roadway skims - tolls and Transportation Network Company (TNC) fares - are also included.

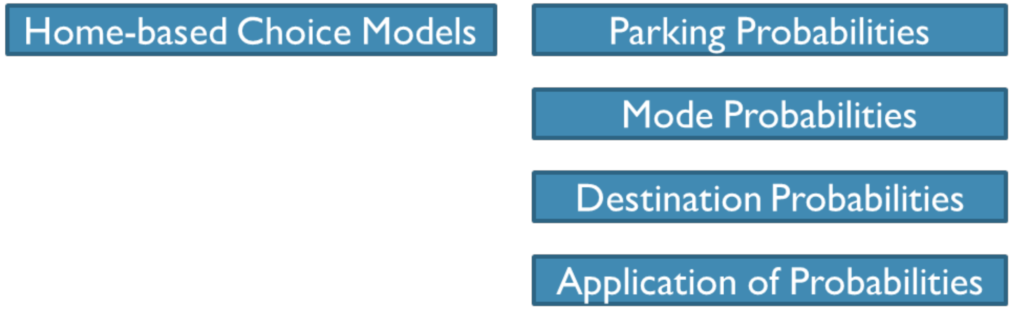
Useful Outputs

- Zone-to-zone highway (per time period):
  - travel times | distance | costs (tolls and TNC fares)
- Zone-to-zone transit (per time period):
  - times (walk access, drive access, wait, in-vehicle, access/egress walk, transfer wait/walk/penalty) | distance (drive access, in-vehicle) | costs (fares)

Possible Use Cases

- Perform a multimodal accessibility analysis by evaluating the number of jobs (or other measures) that can be reached within a certain time threshold by auto or transit.
- Compare accessibility to jobs (or other measures) between different scenarios.
- For a fixed zone pair, compare shortest paths by various modes under different circumstances, e.g. by time of day or congested verses uncongested times.

Home-Based Choice Models



This step determines how people will travel, where they will go, and any parking constraints. Choice models are applied that estimate the mode selected for different trip purposes, the spatial distribution of those trips, and the influence of parking constraints at predefined parking districts across the region. When a parking constraint is applied, the mode used to reach the final destination is also determined (walk or transit).

Useful Outputs

- Zone-to-zone trip tables by mode, trip purpose and time-of-day (e.g. trip “flows” between zones)
- The distribution of trips by time, e.g. the percent of trips within various time intervals

Possible Use Cases

- Investigate how the choice of mode and destination are influenced by various land use scenarios or transportation projects. Drill down to understand the data by corridor, subarea, district or county.
- Modify TAZ level demographics that influence auto ownership and investigate how mode choice and destination are influenced by these changes.

Non-Home-Based Models

Non-Home-based Models

NHB Generation by Mode

NHB Destination Choice

This step estimates trips that do not originate or end at a person's home. These trips are called non-home-based (NHB) trips. One example of a NHB trip is going out to lunch while at work. The NHB model uses characteristics of the original home-based (HB) trip and accessibility measures. It estimates the number of NHB trips by generation zone then distributes these trips to the destination zone. Because these trips are linked to the original HB trips, the mode of the initial HB trip is connected to the NHB trip so that mode choice is consistent.

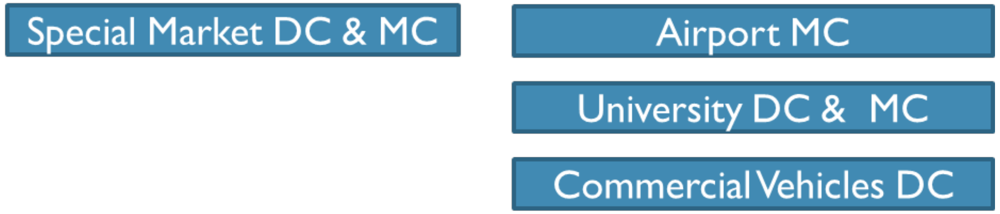
Useful Outputs

- NHB trips by zone
- Zone-to-zone trip tables by mode, trip purpose, and time of day

Possible Use Cases

- NHB trips in densely developed areas like downtowns and universities are often good candidates for mobility options like e-bikes and e-scooters. Outputs from this model under different scenarios could be used to identify areas that might be strong candidates for these types of programs.

Special Market Models



The airport model generates and distributes trips to RDU and assigns a mode for those trips.

The university model segments trips by on- and off-campus students and six trip purposes for NCSU, UNC, Duke and NCCU. The model estimates the number of student trips, how they will travel, and where they will go. Trips are segmented by AM, midday, PM and night.

The commercial vehicle model estimates the number of trips and where they will go for three vehicle classes (commercial vehicles, single-unit trucks, and multi-unit trucks). Trips are segmented by AM, midday, PM and night.

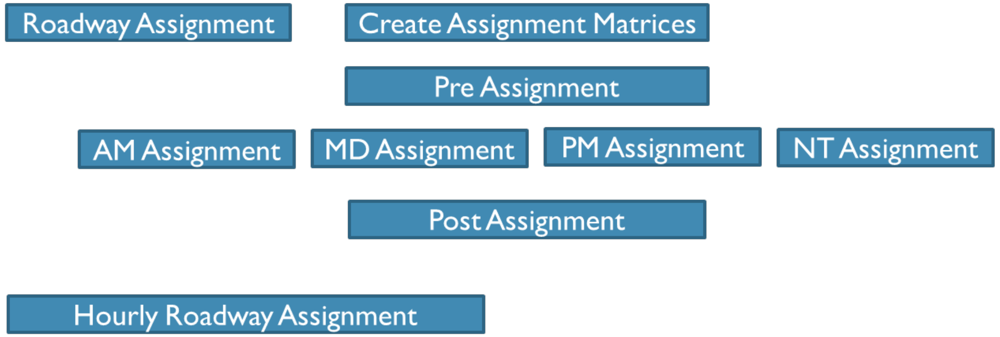
Useful Outputs

- Trips to and from the airport by zone, by time period and mode (single occupant vehicle, 2-person autos, 3+ person autos, and transit)
- Student trips to and from universities by time period and mode (auto, bike, walk, transit)
- Zone-to-zone commercial vehicle trip tables by time period and vehicle type (commercial vehicles, single-unit trucks, and multi-unit trucks)

Possible Use Cases

- Evaluate how expansions to RDU, either landside or airside, influence travel demand to and from the airport. Identify and evaluate improved transit service to the airport.
- Evaluate changes to university parking policies (cost and/or availability). Evaluate changes in student travel patterns resulting from land use changes or transit service improvements.
- Investigate changes in commercial vehicle travel patterns resulting from different land use scenarios.

Roadway Assignment



In this step, zone-to-zone forecasted trip flows are combined with the roadway network path attributes to estimate link level travel demand and congested travel times. Vehicle demand is segmented by six vehicle classes: sov, hov2, hov3, cv, sut, and mut. Roadway assignment is first performed by time period (AM, midday, PM and night) and then a peak hour assignment is performed. Values of time are used to evaluate traffic assignment for toll roads.

Useful Outputs

- Directional travel demand on each highway link by vehicle type, time period and peak hour
- Congested travel time and measures of delay

Possible Use Cases

- This step provides the key performance measures that are often used to evaluate projects either at a system-level, regional-level or corridor-level. The results of modifications to any previous steps can be evaluated against changes in travel demand and other metrics such as VMT, VHT and delay.

Transit Assignment

Initial Processing

Create Initial Output Files

Network Calculators

Accessibility

Population Synthesis

In this step, forecasted zone-to-zone transit trips are combined with the transit route system path attributes to estimate transit ridership by access mode (walk, park-n-ride, kiss-n-ride), mode (local bus, express bus, bus rapid transit, light rail transit and commuter rail), and time period (AM, midday, PM, night). Following transit assignment, results are processed into several summary outputs to improve access to the output data.

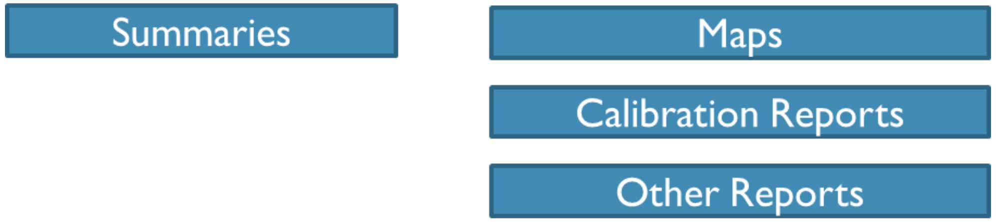
Useful Outputs

- Route level transit ridership by access mode, transit mode and time period

Possible Use Cases

- This step provides the key performance measures that are often used to evaluate transit projects either at a system-level, regional-level, or corridor-level. The results of modifications to any previous steps (including land use or route system characteristics) can be evaluated against changes in system ridership, route ridership, boarding and alighting data, and passenger miles and hours metrics.

Summaries



This final step was developed to automatically generate high level summaries of key model outputs. The easy-to-use and easy-to-understand tables, maps and matrices reflect the initial priorities expressed by model users. Additional summaries can be developed as needed.

Useful Outputs

- Validation maps with differences in traffic counts versus model-estimated traffic flows
- Comparison maps with differences in freeflow versus congested speeds per time period
- Volume to Capacity maps per time period
- Transit ridership, passenger miles/hours and link level transit flows
- Link-level and regional vehicle-miles (VMT) and vehicle-hours traveled (VHT)
- VMT by county and MPO
- Non-motorized trips by trip purpose

Possible Use Cases

- Use the tables and maps from this step to assess overall model performance measures.
- Use the output from this step to easily draw comparisons between different scenarios.

Section #2

PLANNER LED ANALYSES

QUESTIONS the model can help inform

Equity

- How can we improve transportation equity through different land use policies?
  - *Evaluate changes in accessibility and mobility that result from land use changes specifically designed to support underserved communities.*
- How can Communities of Concern benefit from transportation investments?
  - *Evaluate shifts in transit ridership that result from improved transit service to underserved communities.*

Community Health Metrics

- How does non-motorized travel change under different land use scenarios?
  - *Evaluate changes in non-motorized travel resulting from increasing the zonal mix of land uses and/or zonal density for specific clusters of zones.*
- Can changes in land use and school assignment policies increase walk to school trips?
  - *Evaluate changes in non-motorized trips for scenarios that intentionally cluster future schools around high concentrations of residential density.*

Quality of Life

- How do different land use patterns, investments in transit, or toll pricing influence travel choices, commute times, and time spent traveling in congestion?
  - *Conduct various scenario analyses that consider increased density, increased investments in transit, and various toll policies. Evaluate not just highway and transit assignment metrics, but also investigate changes in accessibility metrics, the spatial distribution of non-motorized trips, the spatial distribution of trips, changes in travel times, changes in mode shift for specific communities, etc.*

QUESTIONS the model can help inform

Economic Development

- What are the benefits of serving high employment areas with improved transit service?
  - *Identify TAZs with high employment (specifically low-wage jobs) and low existing transit ridership/service. Investigate the spatial distribution of trips to these high employment areas. Evaluate changes in ridership resulting from new investments connecting these areas.*
- What are the economic benefits of transportation investments?
  - *Use travel model output in conjunction with economic models to evaluate the diseconomies of congestion, the impacts of congestion on the workforce, and the benefits of modal investments.*

Safety

- Are there travel model performance metrics that can inform patterns of high crash locations?
  - *Use GIS to spatially investigate patterns between highway performance measures such as delay or congestion and high-frequency crash locations. Use this information as a surrogate for identifying possible future concerns in order to inform safety planning.*

Freight

- What is the effect of clustering freight efficient land uses on travel demand for commercial vehicle (CV) and trucks? How do these changes influence highway performance measures?
  - *Create a land use scenario that clusters freight efficient land uses and evaluate changes in the spatial patterns of CV and truck trips, changes in link level CV and truck demand, and changes in key highway performance measures.*

QUESTIONS the model can help inform

Land Use

- What is the sensitivity of travel choice to future year growth and land use policies forecast by local governments that show no change in demographics versus intentionally changing demographics to reflect expected changes?
  - *Evaluate various model performance measures, in particular changes in the spatial distribution of trip productions by trip purpose, non-motorized travel, and modal shifts that result in changing key demographic inputs such as income, percent workers, and percent seniors.*

Non-motorized Modes

- How does removing barriers to access improve non-motorized trips?
  - *Identify barriers between TAZs with complimentary land uses, e.g. lack of connectivity between retail and residential development, and provide off-road connectors to evaluate changes in non-motorized trips.*
  - *Use forecast link travel demand to identify roadways with low modeled volumes that can act as connectors for cyclists.*

Accessibility

- How can access to jobs be improved through multimodal transportation investments?
  - *Calculate the difference in number of people or jobs within different travel bands by different modes of travel.*

QUESTIONS the model can help inform

Mobility

- How do different land use policies and/or transportation investments support increased mobility? What does this look like for Communities of Concern?
    - *Perform analysis using different land use and transportation investment scenarios. Evaluate not just highway and transit assignment metrics, but also investigate changes in accessibility metrics, the spatial distribution of non-motorized trips, the spatial distribution of trips, changes in mode shift for specific communities, etc.*

Micro-Mobility

- Where should funding for micro-mobility be concentrated?
    - *Use output from the model to identify concentrations of short-distance trips. Evaluate existing or planned land use patterns to determine if they are more auto-supportive or multimodal-supportive. Focus investments on area that are multimodal-supportive and also demonstrate a high concentration of short-distance trips.*

Glossary

MODELING TERMS

Annual Average Daily Traffic (AADT): Traffic count data, collected by NCDOT, that represents the amount of vehicular traffic traveling on roads.

Attractions: The pull, or how attractive a traffic analysis zone (TAZ) is, measured by employment activity or number of jobs.

Auto Occupancy: The number of people in a vehicle, which is used to convert person trips to vehicle trips.

Auto Pay: A travel mode that represents transportation network companies like Uber and Lyft.

Area Type: A zonal variable that defines land use density within four categories: rural, suburban, urban and downtown. Note that if a TAZ is labeled "downtown", it doesn't necessarily mean the TAZ is located within the downtown area but rather that it meets the highest density threshold and contains a significant amount of households and/or employment.

Calibration: Model developers perform this process of defining and adjusting model parameters until the model replicates the travel patterns observed in the travel survey data for the study area.

Capacity: The number of vehicles the road was designed to carry, usually for a given hour; it can also be applied to transit (number of riders) or bicycle/pedestrian paths (number of people).

Carpool: Any vehicle where two or more people, including the driver, travel together between fixed points routinely.

Centroid: A point, or node, within a TAZ that represents the center of activity for the TAZ. All trips start from or end at the centroid within that particular TAZ. All trips originate at and end at centroids and the detailed transportation network is connected to the centroid with network links called a centroid connector (defined below).

Centroid Connector: A link that connects the TAZ's centroid to the network links. Centroid connector links are not actual roadways, but are placed in such a way that they best represent the underlying street system. Only vehicles or people who start or end their trip in that TAZ can use this link.

Cordon: An imaginary line enclosing the study area.

Destination Choice Model: Destination choice models help distribute trips across the study area. It is a spatial interaction model which is formulated with mathematical logit models.

External Station: A centroid point at the cordon that lies at the edge of model area boundary, and is used allow trips to enter and exit the study area.

External Trips: A trip with either the origin, destination or both, outside of the study area. An external-external (EE) trip has both origin and destination externally but the trip passes through the study area. An internal-external (IE) or external-internal (EI) trip has one end of the trip inside and one end outside of the study area.

Facility Type: Facility Type describes the operational characteristics of a roadway link and is used to determine capacity and free flow speed. For the TRMG2, the Highway Capacity Manual definition of facility type is used, including freeway, multi-lane highway, two-lane highway, superstreet, major arterial, arterial, major collector, collector, local, ramp, centroid connector and transit only links.

Free-flow Time: Non-congested travel time usually defined by link speed over length with the units of minutes.

Headway: The scheduled time interval between two transit vehicles operating in the same direction on the same route and units are in minutes.

High-Occupancy Vehicle (HOV): A motor vehicle carrying two or more persons, including the driver. The model differentiates between HOV2 where only two people are in the vehicle and HOV3 where three or more people are in the vehicle.

Home-based Trips: Trips where either the origin or the destination is the home TAZ location.

Intra-zonal Trips: Short-distance trips that start and end within the same TAZ.

Link: A geographic line in the transportation network that represents a roadway section between two nodes.

Logsum: This is the denominator of the mode choice model. It captures the combined impedance across all modes in the mode choice model, as such, it includes the measure of utility (e.g. travel time, travel cost, etc.) for a given zone pair and a given mode.

Median Type: A link-level variable that describes the median configuration of the link, which is one of the variables used to calculate link capacity. For the TRMG2, this includes none (no barrier or space between lanes traveling in opposite directions), nonrestrictive (continuous center turn lanes or one-way streets) or restrictive (a physical barrier or separation between lanes traveling in opposite directions).

Minimum Path: The travel route between two TAZs or two points which yields the minimum impedance, where impedance is often calculated as travel time, but can also capture logsums, distance or a combination of distance, travel cost and travel time.

Mode Choice Model: The model step that estimates which travelers will use each of the available transportation modes (for the TRMG2, this includes SOV, HOV, local bus and express bus, bus rapid transit, light rail and commuter rail) to reach their destination. Note that a separate choice model is applied at the individual person level earlier in the modeling process to estimate person trips that will be non-motorized trips (bike and walk) vs. non-motorized trips.

Network: A geographical representation of the transportation system composed of links and nodes and all associated attributes required to support the travel model, e.g. path building, assignment, etc.

Node: A point on a highway network where one link terminates or two or more links join or intersect. Nodes are also used to capture a change in network attributes, such as number of lanes or posted speed limited, for any given link.

Peak Hour: This represents the peak of the AM and PM peak periods or the single hour of traffic volumes that are the greatest in a given morning (7-8am) or afternoon (4:45-5:45pm).

Person Trips: A trip made by an individual person between two points. Multiple people can be in one vehicle, so vehicle trips will always be less than person trips. Person trips are segregated to single-occupant trips and HOV trips during the mode choice model, and HOV trips are converted to vehicle trips using auto occupancy factors prior to highway assignment.

Routes: Pathways through a roadway network that are composed of links and nodes. Transit routes are fixed pathways that represent the transit options available regionally.

Study Area: The geographic region encompassing all TAZs. The cordon encompasses the whole study area.

Single-Occupant Vehicle (SOV): A vehicle containing only the driver and no other passengers.

Time Period: TRMG2 breaks up a day into four time periods representing the AM peak (7-9am), midday (9am-3:30pm), PM peak (3:30-6:15pm) and nighttime (6:15pm-7am). All four periods summed together provide daily values.

Traffic Analysis Zones (TAZ): A geographic area used as a basis for grouping people, households, jobs, and other variables. TAZs are structured to contain mostly homogenous land uses and a moderate amount of people or employment. Higher density areas will have smaller TAZs and rural areas will have larger TAZs. A TAZ is similar to a Census Block, though often bigger than a Census Block and smaller than a Census Block Group.

Travel Time: The amount of time needed to travel between two points, TAZs or places.

Trip: A one-way journey, starting at the production (origin) point and ending at the attraction (destination) point.

Trip Assignment: This model process assigns vehicle trips to roadways and transit trips to transit routes in a transportation network. It estimates the routes for each mode and for each trip based on the assignment methodology selected, e.g. equilibrium. This results in the total number of vehicles on a roadway link or passengers on a transit route expected in a given day or specific time period. Time period results are combined to get daily results.

Trip Balancing: A procedure that takes regional trip productions and regional trip attractions and rectifies them by purpose so that productions match with attractions. This process ensures that all trips that are produced will have a determined end.

Trip Distribution: This process estimates the number of trips traveling between all TAZ pairs. The process determines the number of produced trips from a given zone that will be attracted by each remaining zone.

Trip Length Distribution (TLD): This is a statistical distribution that indicates the frequency or amount of trips at various trip lengths (commonly minutes of travel time), for different trip purposes.

Trip Purpose: The reason why people make a given trip, for example to go to work, shop, school, university or other destinations.

Trip Table: A zonal matrix listing the number of trips from each zone to every other zone in the study area. Trip tables can be broken down by why, how and/or when people travel (trip purposes, travel modes and/or time periods).

Utility Function: A mathematical function that expresses the advantages and disadvantages of using a particular transportation mode.

Validation: Model developers perform this process of running the calibrated model with current socioeconomic data and comparing modeled highway demand with traffic counts and modeled transit ridership with observed transit ridership.

Vehicle Trip: An auto made between two points, converted from a person-trip. Vehicle trips are fewer than person trips as multiple people can ride in the same vehicle. Truck and commercial vehicle trips are also classified as vehicle trips.

Volume Delay Function (VDF): A mathematical function that predicts the congested travel cost on a link as a function of the link’s capacity, and the volume carried by the link.

Vehicle Hours Traveled (VHT): The number of vehicles that traveled on a given link generally over the course of a day, multiplied by the length of the time traveled, in hours. The VHT for a study area is the sum of the VHTs for each link.

Vehicle Miles Traveled (VMT): The number of vehicles that traveled on a given link generally over the course of a day, multiplied by the length of the link, in miles. The VMT for a study area is the sum of the VMTs for each link.