

Dynamic Traffic Assignment Model Development for the Regional Transportation Commission of Southern Nevada

Prepared for



Prepared by



Caliper Corporation
1172 Beacon Street
Suite 300
Newton, MA 02461
Phone: 617-527-4700

The preparation of this report has been financed in part through grant[s] from the Federal Highway Administration and Federal Transit Administration, U.S. Department of Transportation, under the Metropolitan Planning Program, Section 104(f) of Title 23, U.S. Code. The contents of this report do not necessarily reflect the official views or policy of the U.S. Department of Transportation.

Table of Contents

1.0 Executive Summary and Introduction	1
2.0 Model Development	2
2.1 Data Sources	2
2.2 Model Design	2
2.3 Street Network Development	3
2.3.1 Geometric Detail.....	3
2.3.2 Roadway Functional Classification.....	5
2.4 Traffic Control Input Development	6
2.5 Traffic Count Data.....	8
2.6 Speed Data	12
2.7 Travel Time Data	12
2.8 GTFS Data	15
2.9 TransDNA Model Development.....	16
3.0 Calibration	17
3.1 Driver Behavior Adjustments.....	17
3.1.1 Vehicle Class Distribution.....	17
3.1.2 Freeway Transfer Penalties.....	17
3.1.3 Centroid Connector Travel Time Error.....	17
3.1.4 User A at I-15 Express Lanes.....	18
3.2 Simulation-Based Dynamic Traffic Assignment.....	18
3.3 Dynamic Origin Destination Matrix Estimation (DODME).....	19
3.4 Calibration Results.....	20
3.5 TransDNA Model Calibration.....	24
4.0 Validation	29
5.0 Model Application Guidance	36
5.1 Choosing the Right DTA for Your Analysis	36
5.2 Microsimulation of Smaller Subareas in TransModeler	36
5.3 Creating OD Matrices for Future-Year Scenarios.....	37
6.0 TransModeler DTA User's Guide.....	38
6.1 Introduction to Projects and Scenarios.....	38
6.1.1 The RTC Simulation Project	38
6.1.2 Scenarios.....	38
6.1.3 Map Layers	40
6.2 How to Perform a DTA in TransModeler	41
6.3 How to Maintain and Update the Model.....	42
6.3.1 Road Editing.....	42
6.3.2 Road Classification	44

6.3.3	Traffic Count and Speed Data	46
7.0	TransDNA DTA User's Guide	48
7.1	TransDNA File Organization	48
7.1.1	The Line Layer.....	48
7.1.2	The Network File	50
7.1.3	The Workspace File.....	50
7.1.4	The Demand Files	50
7.1.5	The TransDNA Project Files.....	50
7.2	Road Link Classification and Speed-Density Functions	51
7.3	How to Perform a DTA in TransDNA.....	52
7.4	The TransDNA toolbar	54
7.5	Working with TransDNA Outputs	55
7.5.1	Visualizing Network Performance Dynamically in TransDNA	55
7.5.2	Charting Individual Link Performance in TransDNA.....	60
7.5.3	Reviewing DTA Output Files in TransDNA	61
7.6	Scenario Analysis with TransDNA	62

List of Figures

- Figure 2-1. Interchange at I-15 and W. Flamingo Road.....4
- Figure 2-2. A pair of roundabouts along N. Town Center Drive4
- Figure 2-3. Map of street network color-coded by functional class.....6
- Figure 2-4. Map of ramp meter locations in the DTA model7
- Figure 2-5. Map of signalized intersection locations in the DTA model.....8
- Figure 2-6. Example of count location weighted zero9
- Figure 2-7. Count locations..... 10
- Figure 2-8. Count locations near the Strip and Airport..... 11
- Figure 2-9. Locations of TAZ Centroids in Sample for Google Travel Times..... 13
- Figure 2-10. Scatterplots Comparing Google Travel Times when Travel Distances are the Same..... 14
- Figure 2-11. Scatterplots Comparing Google Travel Times when Travel Distances are Different..... 15
- Figure 2-12. Imported transit routes..... 16
- Figure 3-1. Illustration of the Dynamic Origin-Destination Matrix Estimation (DODME) Process..... 20
- Figure 3-2. A scatter plot comparing AM DTA model volumes and AM traffic counts on all roads 22
- Figure 3-3. A scatter plot comparing PM DTA model volumes and PM traffic counts on all roads 22
- Figure 3-4. A scatter plot comparing AM DTA model volumes and AM traffic counts on major arterials only 23
- Figure 3-5. A scatter plot comparing PM DTA model volumes and PM traffic counts on major arterials only 23
- Figure 3-6. A scatter plot comparing AM DTA model volumes and AM traffic counts on freeways only 24
- Figure 3-7. A scatter plot comparing PM DTA model volumes and PM traffic counts on freeways only 24
- Figure 4-1. A scatter plot comparing AM DTA model and Google travel times: 7:00 AM 30
- Figure 4-2. A scatter plot comparing AM DTA model and Google travel times: 7:30 AM 30
- Figure 4-3. A scatter plot comparing AM DTA model and Google travel times: 8:00 AM 31
- Figure 4-4. A scatter plot comparing AM DTA model and Google travel times: 8:30 AM 31
- Figure 4-5. A scatter plot comparing PM DTA model and Google travel times: 2:00 PM 32
- Figure 4-6. A scatter plot comparing PM DTA model and Google travel times: 2:30 PM 32
- Figure 4-7. A scatter plot comparing PM DTA model and Google travel times: 3:00 PM 33
- Figure 4-8. A scatter plot comparing PM DTA model and Google travel times: 3:30 PM 33
- Figure 4-9. A scatter plot comparing PM DTA model and Google travel times: 4:00 PM 34
- Figure 4-10. A scatter plot comparing PM DTA model and Google travel times: 4:30 PM 34
- Figure 4-11. A scatter plot comparing PM DTA model and Google travel times: 5:00 PM 35
- Figure 4-12. A scatter plot comparing PM DTA model and Google travel times: 5:30 PM 35
- Figure 7-1. The Las Vegas line layer for TransDNA..... 49
- Figure 7-2. A zoomed-in view of the Las Vegas line layer in TransDNA 49
- Figure 7-3. The Road Classification Dialog Box in TransDNA 51
- Figure 7-4. Speed-Density Model Parameters in TransDNA 52

Figure 7-5. The Scenario Manager Dialog Box in TransDNA.....	53
Figure 7-6. The TransDNA Toolbar	54
Figure 7-7. A Dynamic Color Theme in TransDNA	56
Figure 7-8. Dynamic Theme Settings in the TransDNA Scenario Manager	57
Figure 7-9. Dynamic Theme Settings During Assignment.....	58
Figure 7-10. DTA Progress by Iteration in TransDNA.....	59
Figure 7-11. Chart of DTA Convergence by Interval and Iteration.....	60
Figure 7-12. A Chart Depicting Link Performance in TransDNA.....	61

List of Tables

Table 3-1. %RMSE and percent error threshold summary	21
Table 5-1. Input files defining a model scenario	39
Table 5-2. Road Editing Tools in TransModeler	43
Table 5-3. Road Classification Parameters.....	45
Table 5-4. Description of Count Fields in Segments Layer	46

1.0 Executive Summary and Introduction

This report describes the efforts and outcomes of a project begun in April 2017 and concluded in July 2019 to develop dynamic traffic assignment (DTA) tools for the Regional Transportation Commission (RTC) of Southern Nevada. The DTA models cover the RTC Regional Travel Demand (TDM) model's entire modeling domain area, which includes the City of Las Vegas, the City of North Las Vegas, the City of Henderson, the unincorporated Clark County areas within the Las Vegas Valley, and the core of Boulder City. Caliper Corporation, the developers of the software platforms TransCAD and TransModeler on which the models are built, created two DTA models for the RTC:

One DTA model is implemented in TransDNA, a mesoscopic DTA built on the TransCAD platform and leveraging much of the same data and geography that drive the RTC's TransCAD travel demand model. This mesoscopic DTA provides a rapid DTA for region-wide applications for which operational fidelity and accuracy can be sacrificed for quicker responses to longer-range or more planning-oriented decision-making.

The second DTA model is implemented in TransModeler and uses high-fidelity microscopic traffic simulation to model traffic flow throughout the region. This microscopic DTA more reliably and accurately addresses operational concerns, predicting operating capacity and its influence on congestion patterns and, consequently, route choices.

Both DTA models include every street that is included in the RTC planning model, but many additional streets are added to the microscopic DTA in TransModeler in order to capture the effects of all signalized intersections in the region, without which traffic models of all kinds risk underestimating travel times and delays on arterials. DTA scenarios were developed for the AM peak (6:00 AM – 9:00 AM) and PM peak (1:00 PM – 6:00 PM) periods.

The DTA model was calibrated to verify that the model's trip patterns (e.g., temporal distribution of departure times) reflected historical traffic count data and validated to verify that the model's simulated travel times matched closely with measured travel times and speeds. This report details the steps taken and assumptions made in the development of the DTA models, briefly describes the calibration methods, reports the validation results, and illustrates how to use the models.

2.0 Model Development

The Dynamic Traffic Assignment (DTA) model in TransModeler was developed from the input data described below. The lane-level road network was first developed almost entirely from scratch using high-resolution aerial imagery as a guide. Centroids and centroid connectors were imported from the regional travel demand model (TDM) to ensure consistency in the IDs of traffic analysis zone (TAZ) centroids that serve as the origins and destinations of trips generated by the RTC's regional travel demand model. The common TAZ and centroid representation is the primary link between the travel demand and DTA models and allows for the ready sharing of trip matrices. The highly accurate road network was subsequently exported to create a line layer for TransDNA that included fields describing left- and right-turn bay lengths and their number of lanes. The development of the TransModeler database is described in the remainder of this section.

2.1 Data Sources

A variety of data are required to build DTA models. At a minimum, these data include aerial imagery to build the geography and geometry of the street network, signal timing data with which to simulate the operations of signalized intersections, and traffic count/speed data by short time interval to calibrate the model. General Transit Feed Specification (GTFS) data may be used to import transit route information into the model. Other types of data, such as detailed traffic counts and travel time measurements, are used for validating the model. The DTA model for the RTC was developed from the following data sources:

- Aerial imagery freely available from web map services like Google
- Signal timings provided by the RTC
- Traffic count data provided by the RTC
- Speed data from INRIX
- Google travel times
- GTFS data

2.2 Model Design

TransModeler, in which the DTA model was developed, and TransCAD, in which the regional TDM is built, share a common representation of origins and destinations, both in the form of TAZ IDs. This common identification of trip origins and destinations allows trip matrices generated by the TDM to be used as input to the DTA model and simulated.

The DTA model includes every street that is in the regional TDM planning model network. Many other streets were added so that all signalized and other major intersections that could be discerned from aerial imagery were included.

In addition to their use as a reliable traffic model for traffic impact assessment, there are other substantial benefits to DTA models that are worth mentioning. The DTA model's Geographic Information System (GIS) and relational database platform make the model a powerful, lane-level repository of traffic data. Specifically, the model can be used as a database to store and

update geographic and geometric information. Additionally, the model can also serve as a signal timing inventory for the RTC region to complement the tools that the Freeway & Arterial System of Transportation (FAST) maintains. Finally, the platform also provides an integrated GIS-3D modeling environment that can be leveraged to visualize scenarios and to facilitate public and stakeholder involvement in the project evaluation process.

2.3 Street Network Development

The geographic line layer representing the road network in a TDM in any planning software platform can be used to generate a preliminary simulation database in TransModeler. Hence, the planning network for the RTC's model in TransCAD was a potential resource for creating the simulation database for the DTA model. However, road editing and network development tools in TransModeler have made it cost-effective to develop networks for entire metropolitan areas by hand over high-resolution aerial imagery, a process that lends itself to other important network development tasks, such as identifying bus and HOV lanes and signalized intersections that may not be in the planning network. The simulation database for the RTC planning region was thus created. Additional streets were added to cover all signalized intersections that were identifiable in the imagery. Other tools, such as Google Earth and Google Street View, were used to confirm important geometric details such as lane utilization and turn prohibitions at intersections.

TransModeler provides built-in access to web map services that allow map content such as Google Maps, Google Satellite, OpenStreetMap, and USGS Topographic Maps to be downloaded automatically to the map window. Aerial imagery from these web-based sources was used to determine roadway, intersection, and interchange geometry. Where construction was visible in the imagery or roadway projects were known or suspected to have occurred in recent years, historical imagery or other web-based sources were used to determine 2015 geometry.

At the conclusion of the development of the street network, error-checking routines in TransModeler were used to scan the database for common coding errors. This ensured that there were no missing lane connections, unnecessarily short segments, or errors in intersection or roadway geometry. Other coding errors were encountered and corrected as the model's development and the calibration of the model progressed.

2.3.1 Geometric Detail

Very little geometric detail is spared in the DTA model. A point of emphasis in the model's development was to achieve a highly accurate representation of intersection shape and dimension, which to a large degree govern an intersection's or interchange's operating capacity. In addition to the geometric shapes (e.g., horizontal curvatures) of intersecting streets, effort was made to accurately represent turn bay lengths, lane widths, turn lane channelization, vehicle trajectories through intersections, and other geometric elements. Figure 2-1 and Figure 2-2 demonstrate the level of detail in the model at two locations in the RTC region.

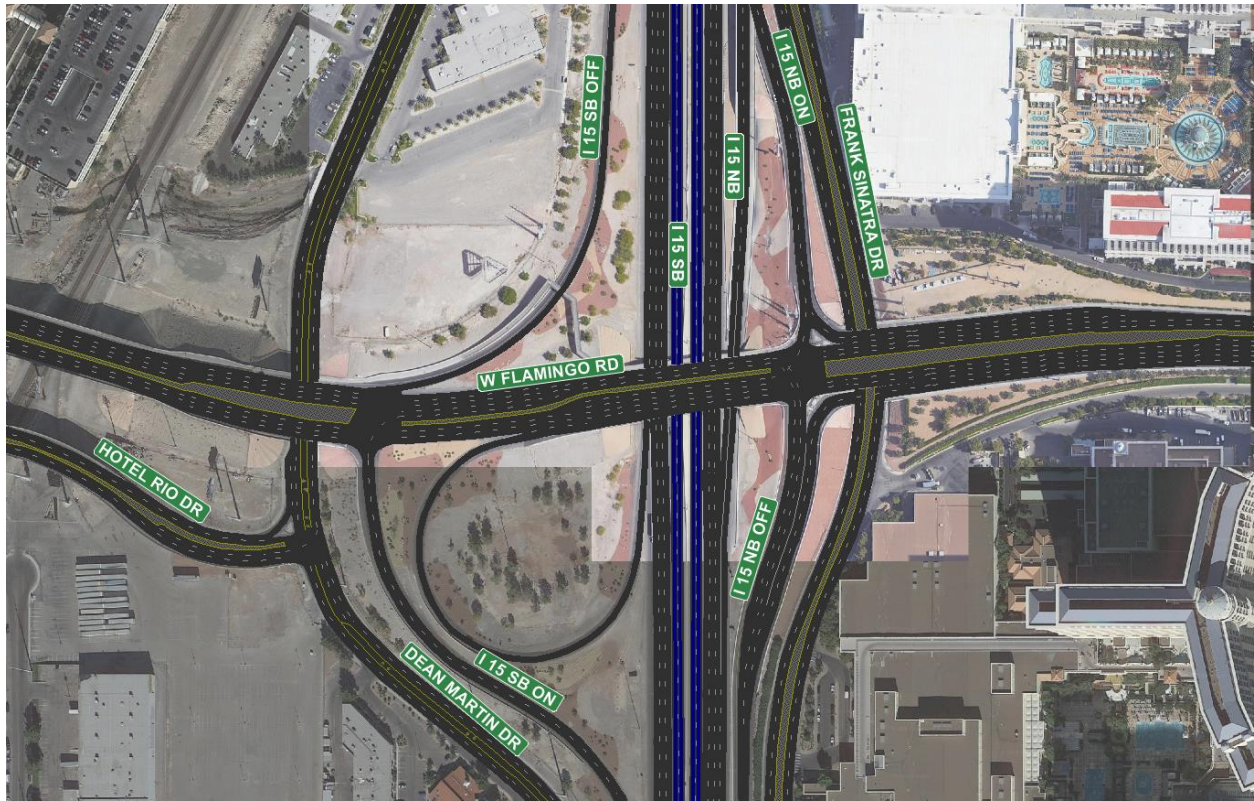


Figure 2-1. Interchange at I-15 and W. Flamingo Road



Figure 2-2. A pair of roundabouts along N. Town Center Drive

2.3.2 Roadway Functional Classification

Determining and applying the appropriate roadway functional class to links in TransModeler has an important influence on driver behavior and route choice in the model. The speed limit is the most important road class attribute in the microscopic simulation model. A driver's desired speed, the speed at which the driver will travel in the absence of the influence of traffic signals or other vehicles, is a function of the speed limit, with more conservative drivers adhering closely to the speed limit and more aggressive drivers traveling faster.

Road class and speed data from the 2015 Amendment 1 TDM model network were used to assign road classes to all applicable roads in the simulation model. The functional class of roads in the DTA model that were not included in the TDM model were estimated. Figure 2-3 shows a line representation of the street network color-coded by road class in the DTA model.

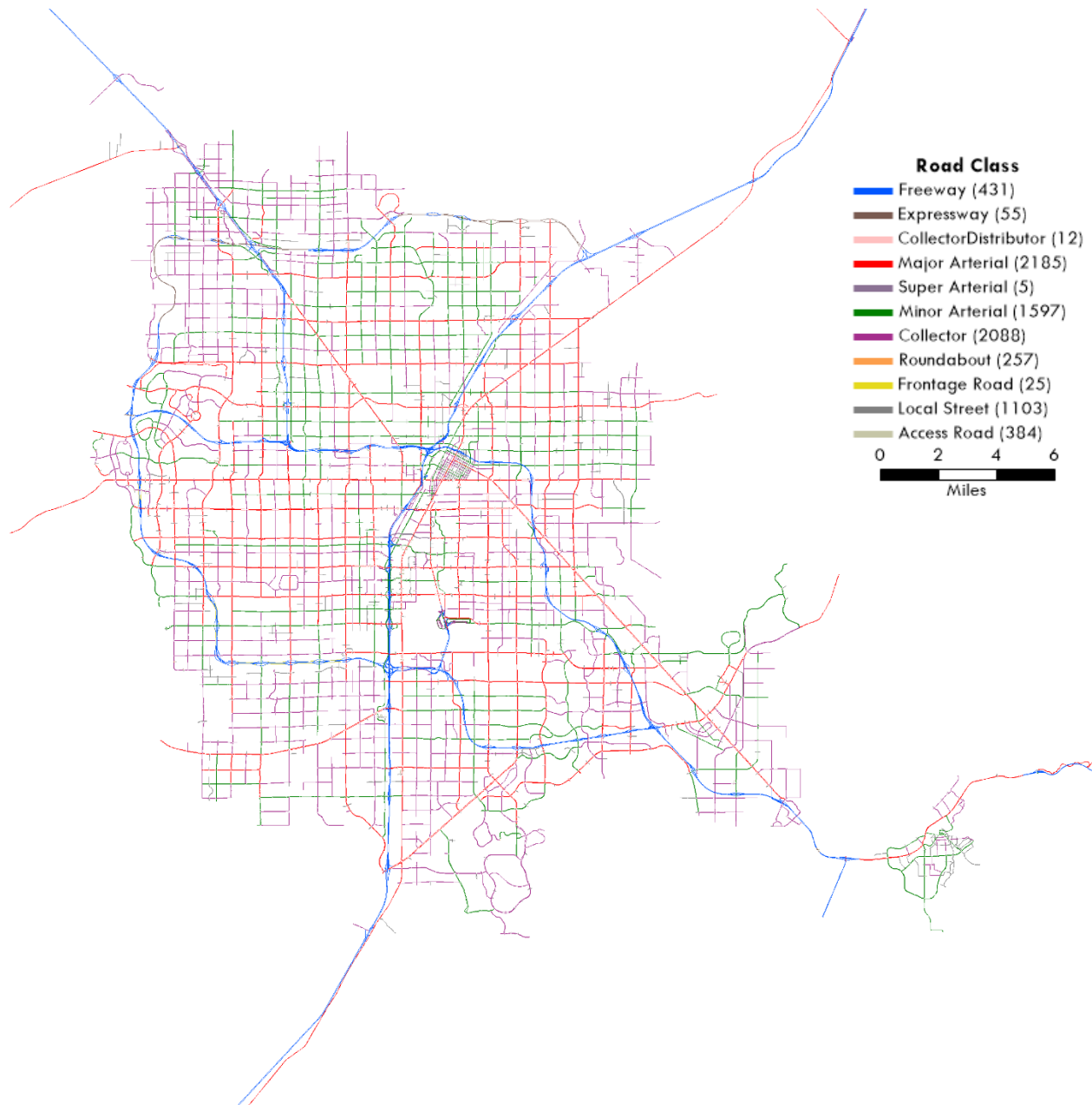


Figure 2-3. Map of street network color-coded by functional class

2.4 Traffic Control Input Development

Traffic signals are crucial to traffic operations on surface streets, and the DTA model has a detailed representation of traffic signal timings accurate enough to support what-if scenario evaluation with a high degree of operational sensitivity. The model can support analysis of transit signal priority, train pre-emption, and various other traffic signal timing strategies.

Signal timing data, including timing data at ramp meters, were provided by FAST. RTC staff also assisted in providing additional data on phase assignment (e.g., Phase 1 serves the EBL movement) that were not available in many of the signal timing spreadsheets. Of the 1,437

signalized intersections in the study area, 1,414 were FAST signals and 1,060 had available signal timing data that were imported. The signal timings at the remaining 377 signals were estimated based on projected 2015 peak period turning movement demand, common signal timing parameters in the area, and engineering judgment. Throughout the network, actuated signal operations were assumed and simple detector geometries, with stop-bar call and extension detection, were applied.

There are 68 ramp meters in the study area. Timing parameters were obtained for 38 of those locations and were assumed for the remainder. At ramp meters for which no data were available, traffic-responsive operations were assumed to be running during the most common times of day (6:00 AM – 9:00 AM and 3:00 PM – 6:00 PM) with the typical occupancies and rates provided to us by the RTC. Queue detectors were also assumed to be operational, and if the queue occupancy was exceeded, ramp metering was assumed to be turned off.

A map illustrating the locations of ramp meters is provided in Figure 2-4, and a map illustrating the locations of signalized intersections in the model is provided in Figure 2-5.

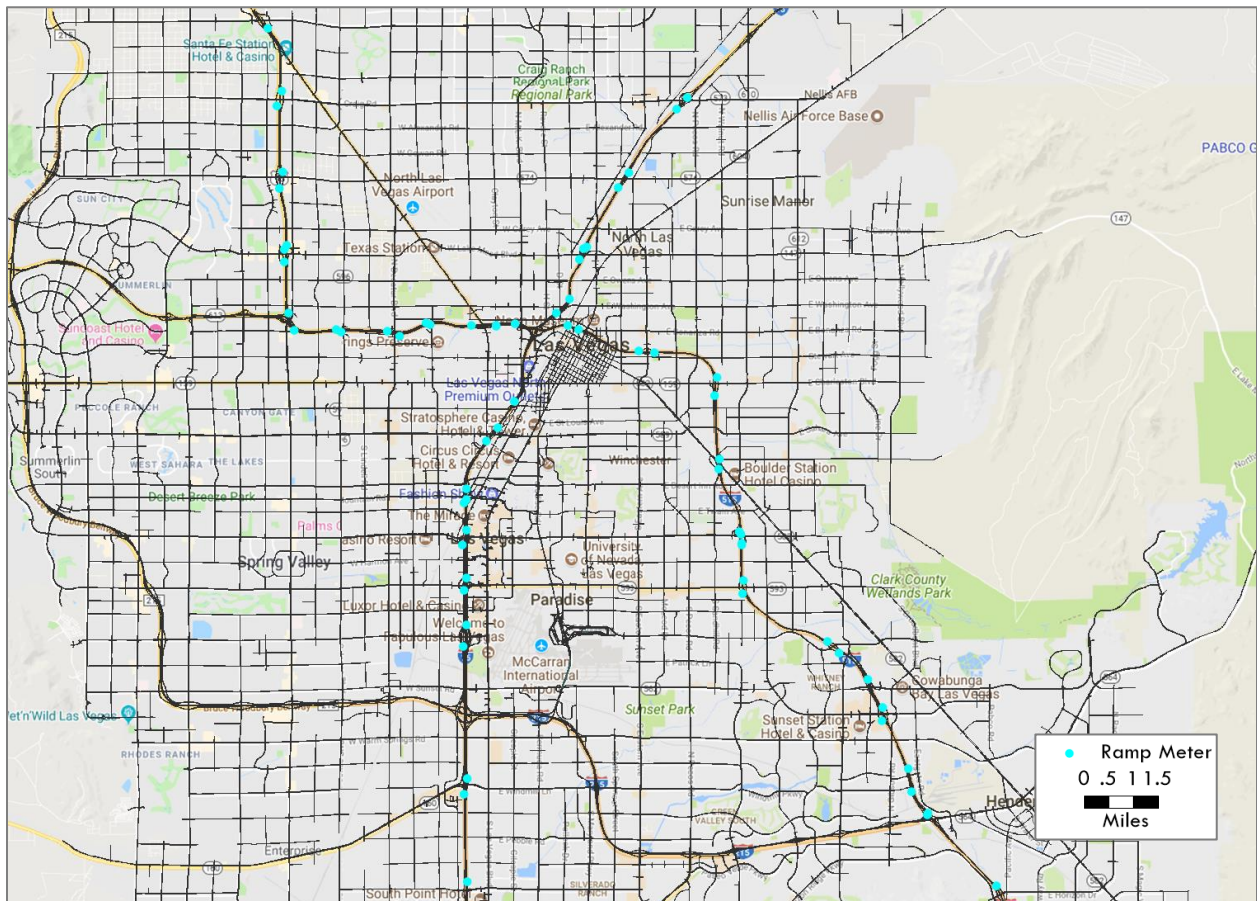


Figure 2-4. Map of ramp meter locations in the DTA model

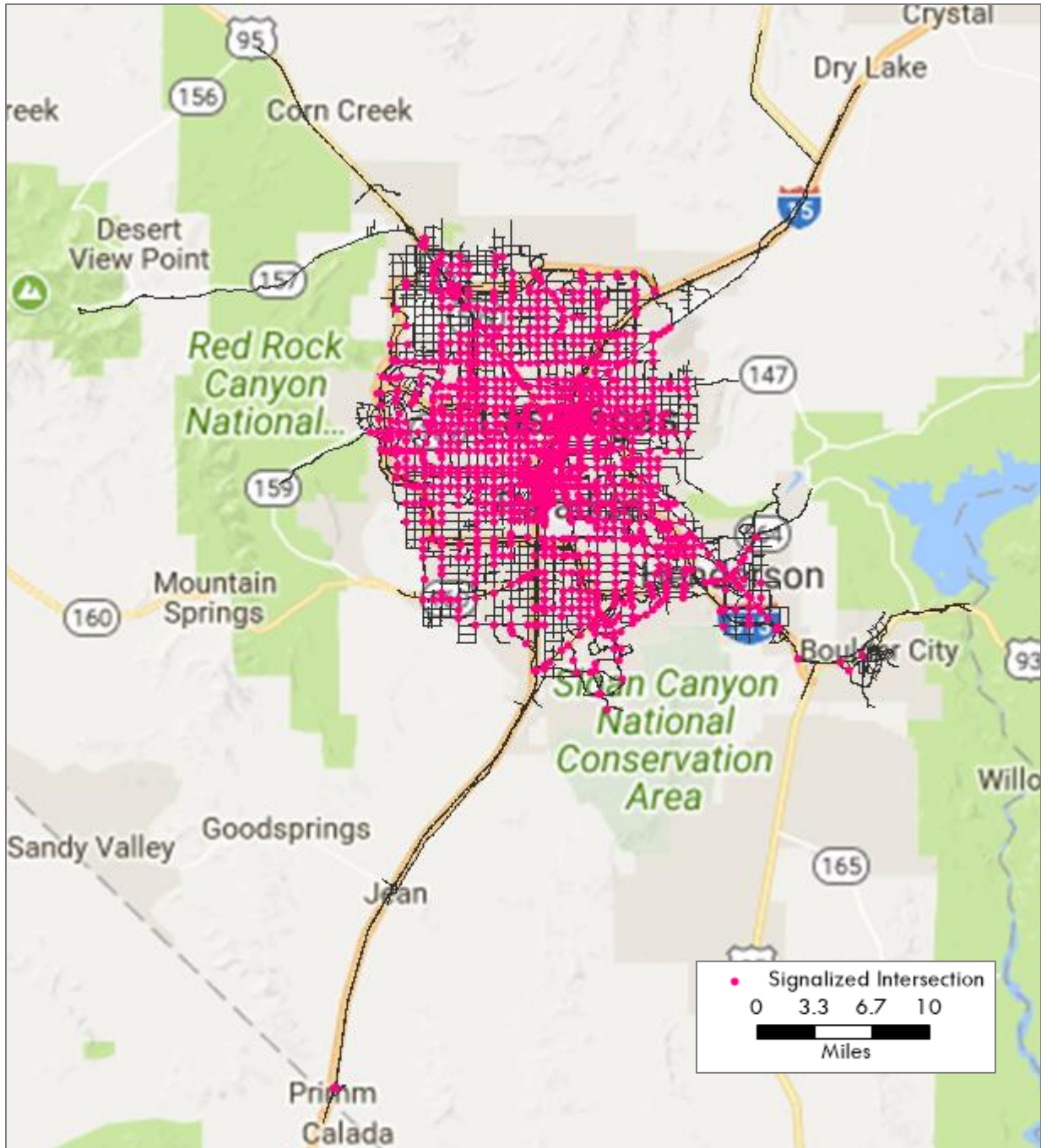


Figure 2-5. Map of signalized intersection locations in the DTA model

2.5 Traffic Count Data

Traffic count data were obtained for the entire study area from five sources:

1. Nevada Department of Transportation (NDOT) short-term 15-minute counts
2. Express lane counts
3. ATR counts
4. Southern Nevada Traffic Study (SNTS) counts in 15-minute bins for three locations

- a. I-15
- b. I-215
- c. Summerlin Parkway

5. FAST detector data (counts and speeds) in 15-minute bins

The simulation database, which is the geo-relational database that stores the geography and geometry of the street network, is populated with these count data, and our calibration analyses focus on these data in coordination with the speed data discussed below. Express lane counts were unfortunately unusable for the purposes of calibration because volumes were not differentiated by lane. Counts that conflicted with one another were also discarded as they would adversely affect the calibration process.

For example, in this location along I-515 NB, we have four count locations and the total PM peak period (2:00 PM – 6:00 PM) volumes are labeled below. If you start from the east and go west, $19,390 - 2,047$ exiting at the off ramp + $4,466$ entering the on ramp = $21,809$. Yet the count in orange is only $17,407$. Other neighboring counts agree with the $19,390$ count so we weighted the $17,407$ count with a zero weight.

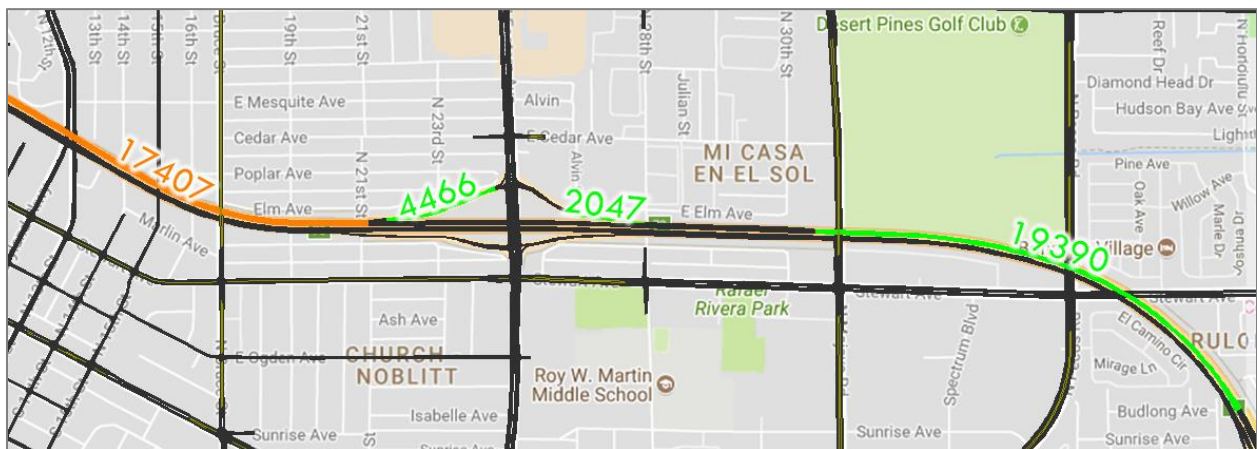


Figure 2-6. Example of count location weighted zero

In all, there were 939 valid counts for the AM period and 954 valid counts for the PM period used for calibration distributed throughout the region. Figure 2-7 illustrates the locations of counts throughout the network. Counts are associated with segments in the model. Although it is difficult to identify individual counts, Figure 2-7 gives a sense of the roughly even distribution of the counts throughout the network.

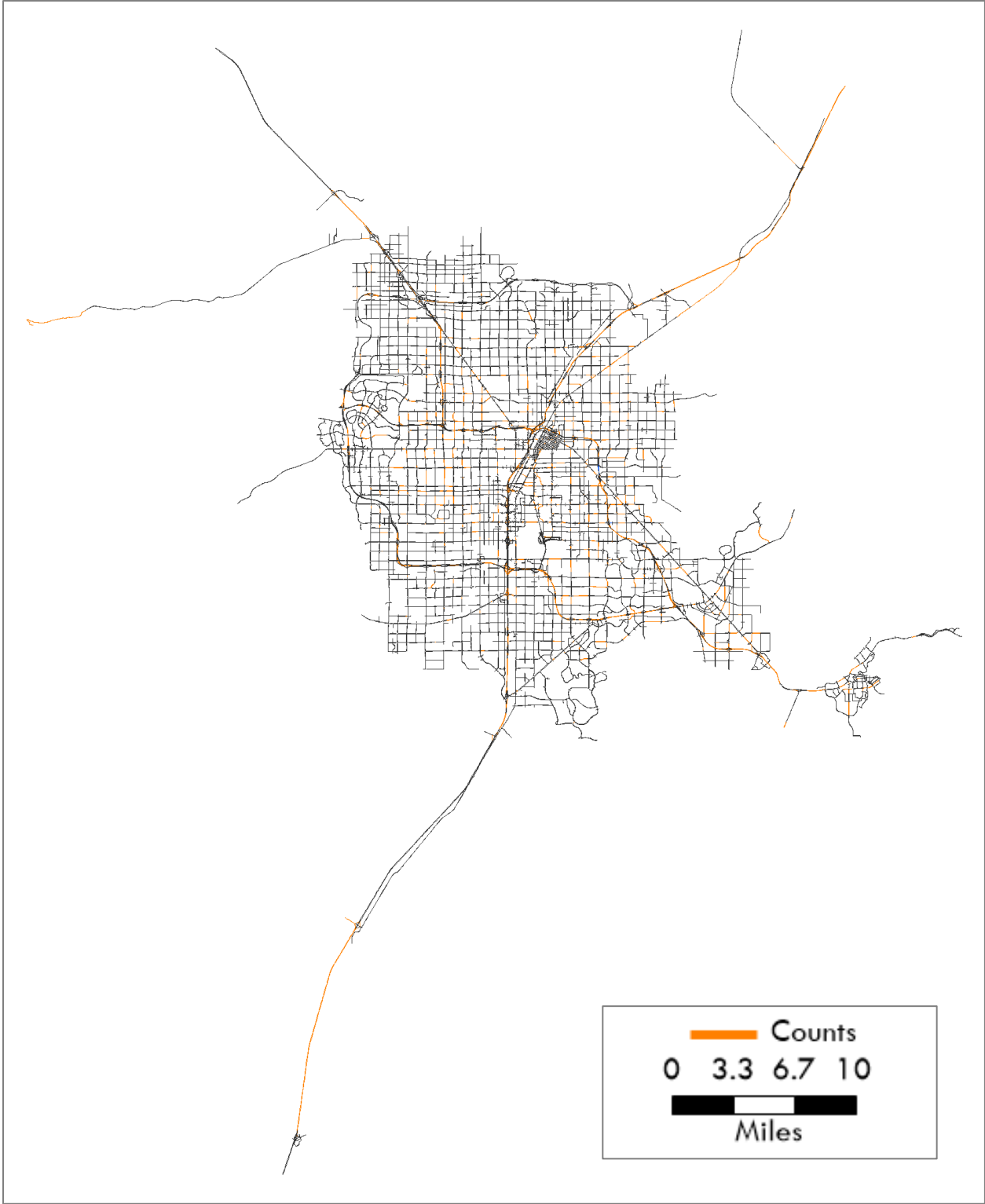


Figure 2-7. Count locations

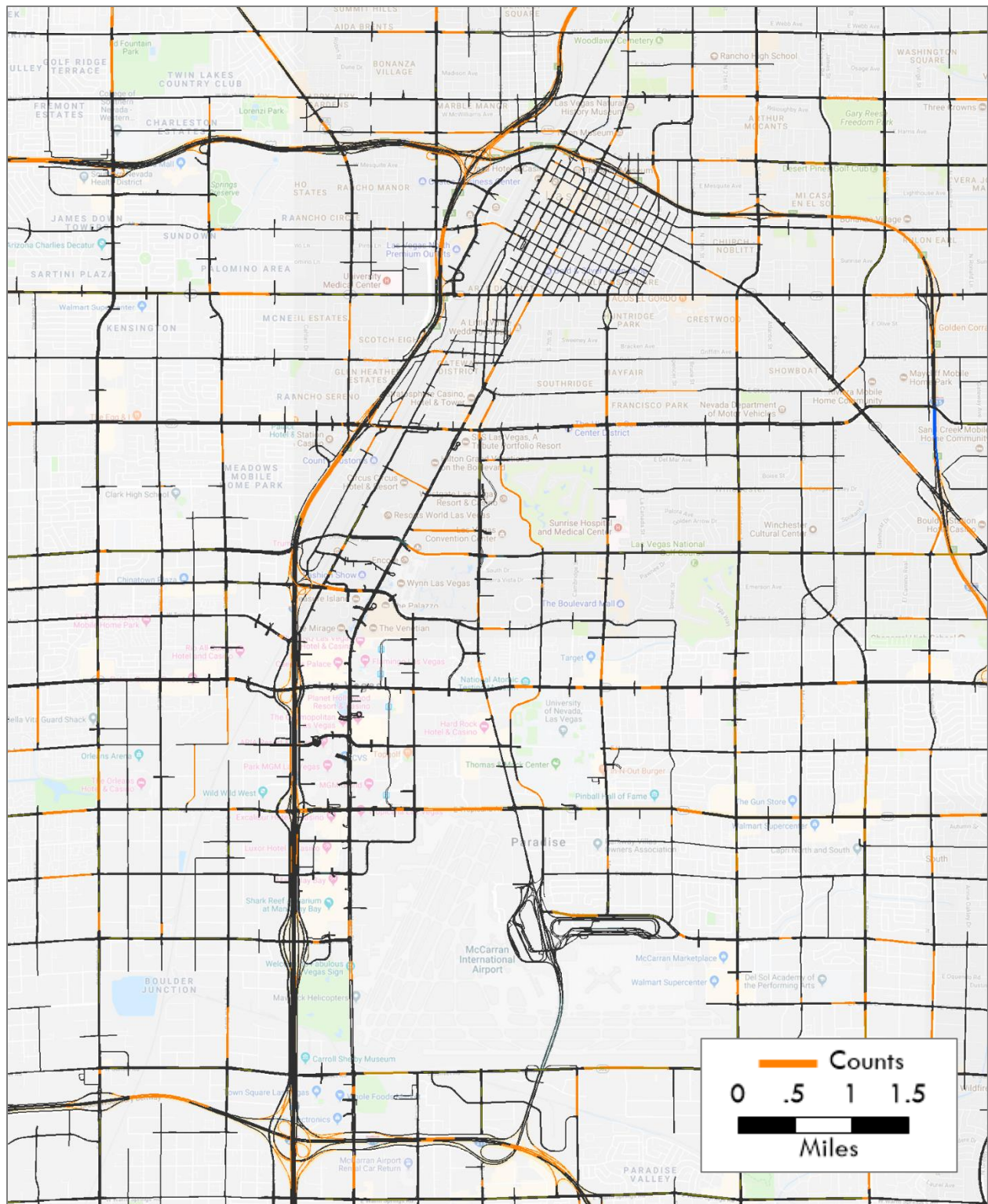


Figure 2-8. Count locations near the Strip and Airport

2.6 Speed Data

Speed data are critical to understanding where bottlenecks occur in the network. INRIX is a global Software as a Service (SaaS) and Data as a Service (DaaS) company that provides roadway speed data from mobile phones, connected vehicles, trucks, and fleet vehicles equipped with GPS devices. INRIX speed data from Wednesdays between March 1, 2016 and May 31, 2016 were obtained and averaged to use in the calibration process.

2.7 Travel Time Data

In order to validate the model, we obtained sample travel time data using Google's Directions API (application programming interface), one of a variety of web services offered through the Google Maps Platform. The Directions API license that was used limits the number of queries that can be submitted per day. We selected centroids of 59 TAZs distributed throughout the network, making sure to select at least two TAZs per K-District. The locations of the 59 origin TAZ centroids are shown in Figure 2-9.

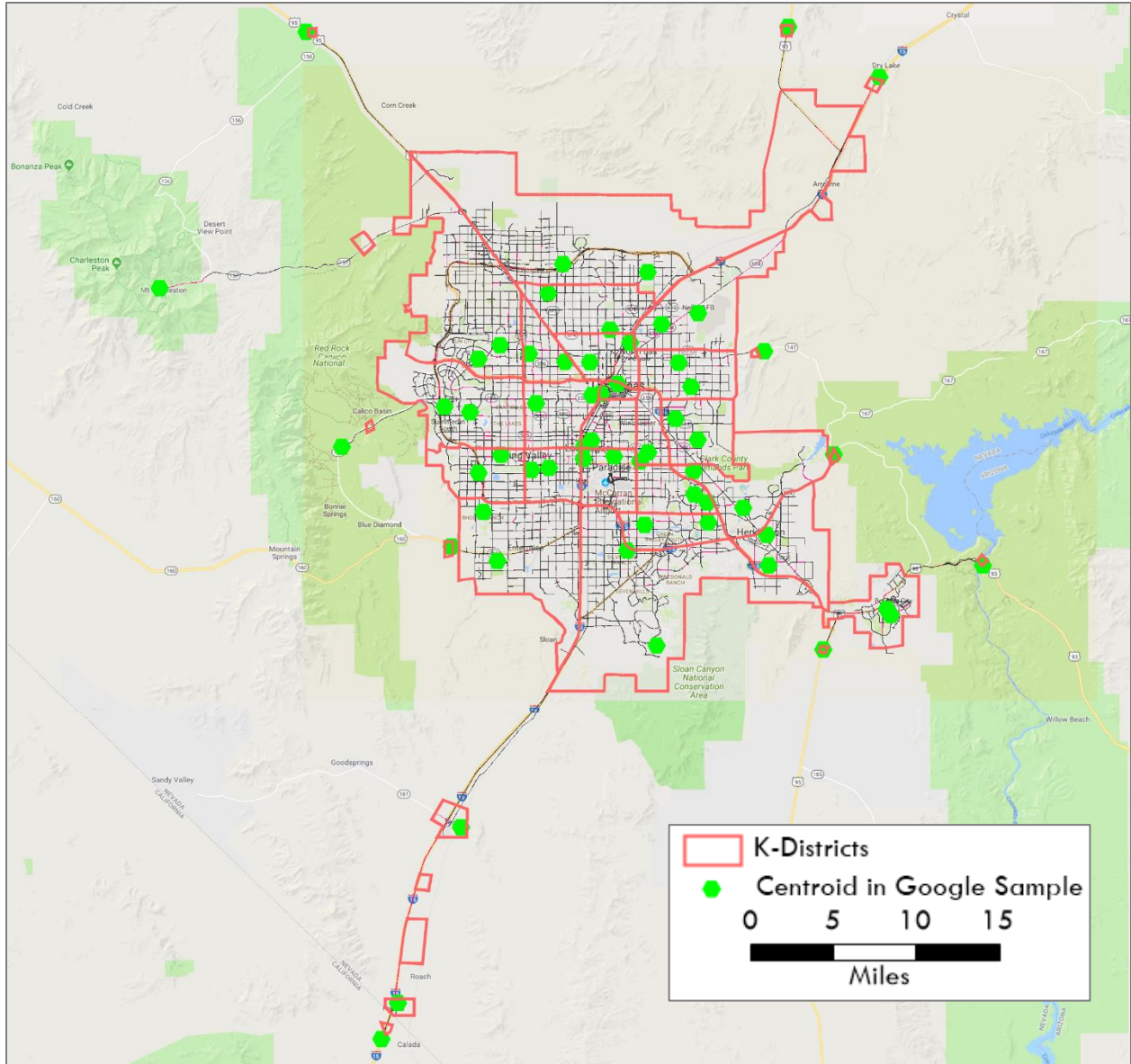


Figure 2-9. Locations of TAZ Centroids in Sample for Google Travel Times

We then queried travel times with those 59 centroids serving as the origins to all 1,658 centroids as the destinations (97,822 OD pairs) every half hour during the AM and PM model periods. Thus, travel times for 97,822 OD pairs were queried for 8 departure times: 7:00 AM, 7:30 AM, 8:00 AM, 8:30 AM, 2:00 PM, 2:30 PM, 3:00 PM, 3:30 PM, 4:00 PM, 4:30 PM, 5:00 PM, and 5:30 PM. Since data cannot be queried in the past, we queried a typical spring day, Wednesday, April 10, 2019.

We also queried some data (7:30 AM, 8:00 AM, 4:00 PM, 4:30 PM, 5:00 PM, 5:30 PM) on Wednesday, July 17, 2019 to see if travel times fluctuated throughout the year. We found that travel distances stayed exactly the same 68-75% of the time, indicating the same route was likely assumed by Google during both months. When the travel distance was the same, the travel times were very similar in April and July, as shown by the scatterplots in Figure 2-10. Even when

the travel distance was not the same, the travel times were still very similar with only a few instances of significantly different travel times (Figure 2-11).

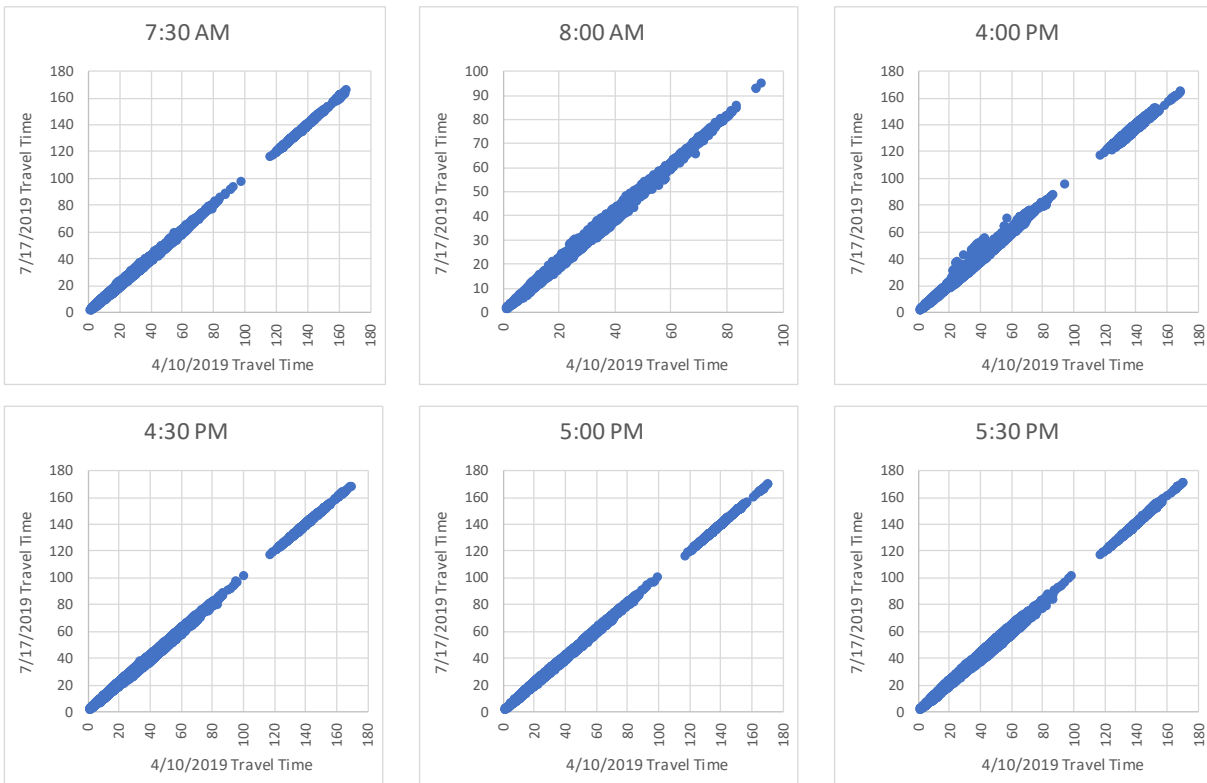


Figure 2-10. Scatterplots Comparing Google Travel Times when Travel Distances are the Same

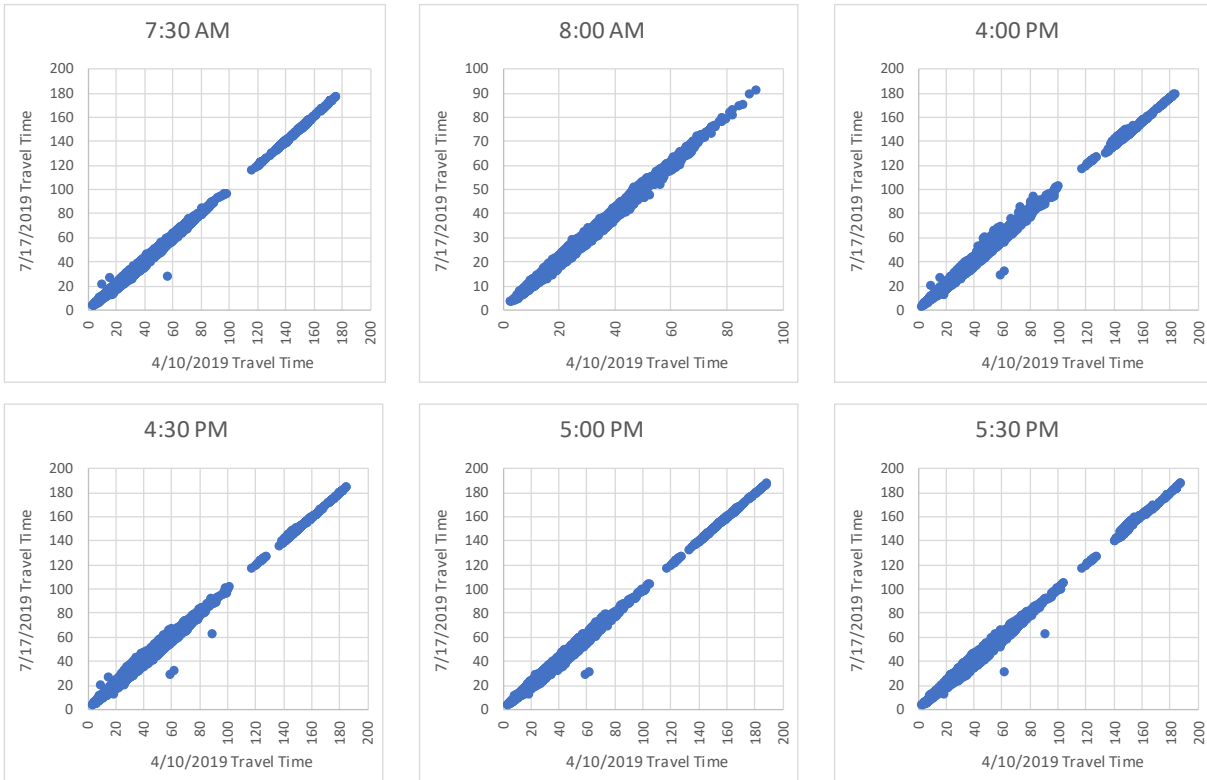


Figure 2-11. Scatterplots Comparing Google Travel Times when Travel Distances are Different

The sample of Google travel times was narrowed to internal-to-internal (II) OD pairs whose entire paths, both according to Google and to the model, would traverse links inside the model. Given that, 88% of AM simulated OD pairs and 87% of PM simulation OD pairs in the respective 15-minute departure interval had a corresponding Google travel time with which to compare. The resulting scatterplots are available in Section 4.0 Validation.

2.8 GTFS Data

We added transit routes to the network using GTFS data publicly available from <https://transitfeeds.com/p/rtc-southern-nevada/47>. To represent 2015 service, we downloaded the February 4, 2015 data and imported Service ID 4_merged_357527228, which ran from February 22, 2015 to November 7, 2015. This resulted in 212 transit routes being added to the network as shown in Figure 2-12.

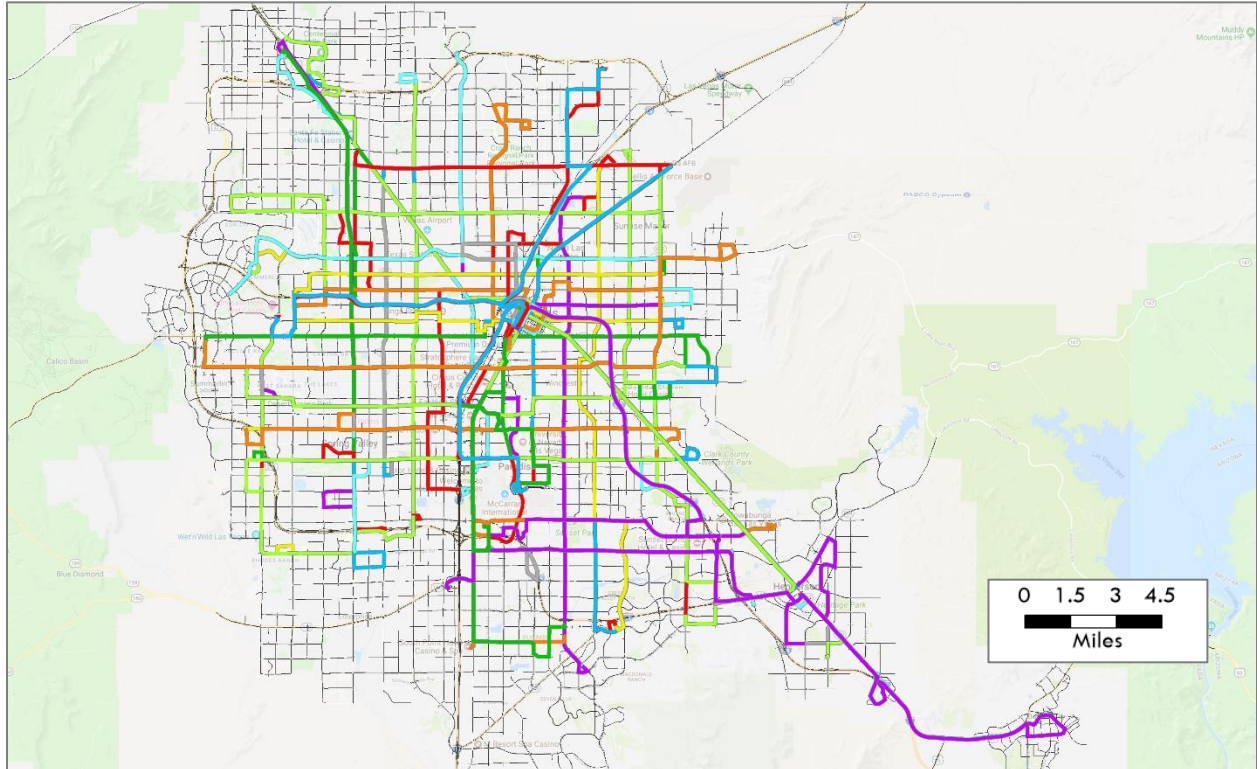


Figure 2-12. Imported transit routes

2.9 TransDNA Model Development

For the mesoscopic DTA in TransDNA, a line layer was derived from the simulation network developed for the DTA in TransModeler and described earlier in Section 2.3. Hence, the line layer contains all the roadway links in the TransCAD planning model but has the same added street and centroid connector detail that is needed to support simulation and DTA. In other words, all geometric enhancements made to the TransModeler network are therefore reflected in the TransDNA line layer. These enhancements include the addition of fields in the line layer to represent the presence of left-turn and right-turn bays, number of turn bay lanes, and turn bay lengths. These fields are important inputs to TransDNA, in which the influence of turn bays on traffic flow can be reasonably well captured without the need to split links when the lane configuration changes.

The representation of intersection geometrics as line layer attributes also has the advantage of minimizing the number of links in the network, enabling simulation with low running times. Greater numbers of links increase running times because they slow down shortest path calculations, which take longer as the number of nodes traversed increases and which are performed many times over in the course of a DTA in order to update route choices as congestion patterns evolve.

3.0 Calibration

Calibration and validation of the TransModeler DTA model were aimed at achieving (1) confidence that the DTA model and its underlying traffic flow model are capable of reflecting 2015 conditions, including regional traffic patterns and bottleneck locations, and (2) confirmation that the model is properly coded and that signal timing estimations and centroid connectivity are reasonable. Key results from this effort, such as the time-varying origin-destination (OD) flows, were later used as inputs to the TransDNA DTA model.

3.1 Driver Behavior Adjustments

3.1.1 Vehicle Class Distribution

The vehicle class distribution defines the mix of vehicle types (e.g., auto, SUV/pickup, truck, etc.) to be simulated. Data from the *2013 On-Road Vehicle Classification Study* were used to calculate AM and PM peak period vehicle class distributions.

3.1.2 Freeway Transfer Penalties

TransModeler has route choice parameters that assign a penalty for movements entering or exiting the freeway. These parameters are meant to deter paths that may leave the freeway on an exit ramp and immediately return on an entrance ramp. However, these penalties can also deter reasonable route choices, such as paths that enter the freeway only to travel on it for a very short distance before leaving on the next exit ramp. In our calibration efforts, we saw arterials being underutilized versus freeways. In an effort to balance demand for paths utilizing freeways and the local street network, freeway transfer penalties were increased to 60 seconds for exiting the freeway and 120 seconds for entering the freeway.

3.1.3 Centroid Connector Travel Time Error

Like all regional models, the microsimulation model does not simulate within-zone traffic and thus may not accurately depict the starting points of trips at centroid origins, nor the ending locations of trips at centroid destinations. In some zones, there are large numbers of centroid connectors. A centroid connector at the origin and at the destination must be either randomly assigned according to weights, a method that has a variety of problems (e.g., infeasible or unreasonable paths may result in some situations), or chosen as part of the route choice calculation.

Like travel times and delays on road segments, travel times can be assigned to centroid connectors, and those travel times can be similarly randomly perturbed. The higher the random error, the more widely distributed traffic will be to loading (or unloading) points around the zone. The lower the random error, the greater the likelihood that route choice will favor a small number of centroid connectors in the zone, leaving some centroid connectors unused.

To encourage a wider distribution of traffic among loading points in a zone, in general centroid connectors were assigned travel times of five minutes. Specific centroid connectors were sometimes assigned travel times greater than or less than that to encourage or discourage use of a

particular centroid connector relative to others serving the same centroid. Additionally, the centroid connector travel time error, which is defined as a percentage of the centroid connector travel time, was set to be 50%. This means that, for example, any given driver in the model may perceive the travel time on a centroid connector with a 5-minute travel time to be between 2.5 and 7.5 minutes. The high error is meant to allow for enough variance to overcome the delay that might be experienced at a traffic signal immediately downstream of the loading point from the centroid connector. This way, the choice of centroid connector would not be entirely dominated by the delays experienced on the links in the immediate vicinity of the centroid.

3.1.4 User A at I-15 Express Lanes

The I-15 Express Lanes are parallel lanes along I-15 that run from Sahara Boulevard to Silverado Ranch Boulevard. Drivers enter and exit the express lanes only at specific locations. The choice to use the Express Lanes is modeled as a stochastic shortest path model seeking to minimize travel time. When there are parallel routes and the travel times are similar, such as those represented by either using the express lanes or not using the express lanes, it is difficult for the model to distribute vehicles between the two routes in a realistic manner.

To address this issue, we designated 75% of all vehicles as User A vehicles and reserved the I-15 Express Lanes for User A vehicles. User A vehicles are eligible to use the express lanes but can also choose to use the general purpose lanes instead. This ensured that the demand for the Express Lanes would not exceed the capacity of the lanes but also preserved the ability of the route choice model to select paths for vehicles.

3.2 Simulation-Based Dynamic Traffic Assignment

The principal advantage of DTA over traditional static assignment is the detailed treatment of the way congestion builds and subsides over time and in varying locations. When and where congestion develops owes largely to the way trip departures are distributed over the period of interest.

Route choice behaviors are central to the DTA model, and hence, central to the calibration of the model. Before considering the fit between model volumes according to the DTA and volumes observed in the field, it is important to consider how the model volumes in the DTA are determined.

The DTA model volumes are ultimately decided by the route choice decisions that drivers make, which are a function of departure time and expected travel conditions in the network. The expected travel conditions emerge from the route choice and consequent congestion patterns that arise collectively from the route choices of all travelers in the model. In order for reasonable route choices to be simulated, drivers must have knowledge of the congested, or loaded, travel times they expect to experience during their trip. Those travel times are not known a priori and thus are estimated from a microscopic traffic simulation of the period of interest (e.g., AM, PM).

Thus, a microscopic simulation of the complete period is executed iteratively, with the method of successive averages (MSA) applied to output travel times and turning delays between iterations. The route choices of each run are a function of the travel times simulated and averaged over

prior runs. The primary objective of this iterative DTA framework is to equilibrate route choices such that drivers cannot switch to alternate paths and improve their travel times, a condition of a form of User Equilibrium (UE), when the model is sufficiently converged.

The travel times are averaged in order to smooth them over the iterations to prevent inefficient and counter-productive switching back and forth between good and bad routes from one iteration to the next. The DTA runs until it has converged to a target gap, defined as the percent root mean square error (RMSE) between the travel times and delays of the previous iteration and the travel times and delays of the current iteration, or until a maximum number of iterations is reached.

Generally, however, the maximum number of iterations rather than the target gap is relied upon as the stopping criterion in the application of the simulation-based DTA. Because the simulation model is a stochastic Monte Carlo simulation (i.e., each simulation is initiated with a different random seed and will produce variable results) and because vehicle trips are integer (i.e., they cannot be divided into tiny fractions as they are in the static traffic assignment methods), target gaps of the order of magnitude expected of high-quality static traffic assignments may not be achieved. However, many static models may be neither well-converged nor very accurate with respect to counts.

Given that it is only the trend, not the absolute value, in the target gap that is relevant in the simulation-based context, the only matter of relevance is that the DTA be run until the target gap cannot be further reduced. In the application of the simulation-based DTA, convergence was generally deemed to be sufficient in about 50 iterations.

After performing a DTA, paths used in the model can easily be browsed, reviewed, and checked for reasonableness. Routes observed visually between OD pairs and passing through selected critical links all satisfy a priori expectations. Unreasonable routes are filtered out of the set of route choices through the DTA iterations.

Not only are poor route choices generally eliminated in the DTA, but route choices vary appropriately by departure time. The route choices are stochastic, dynamic route choices such that every driver perceives travel times differently from every other driver and the average travel time that drivers expect on a given link varies depending on the time of arrival at the link along the path. Travel times are represented in the model in a piece-wise linear fashion from the midpoint of one time interval to the next. Thus, the expected travel time on a link varies continuously across time rather than discontinuously as in a histogram.

3.3 Dynamic Origin Destination Matrix Estimation (DODME)

Once a DTA has been run and travel times and turning delays estimated, simulations can be run to determine how well the simulated volumes and speeds on road segments in the study area match the counts and speeds in each 15-minute interval. The DTA is followed by application of Dynamic Origin-Destination Matrix Estimation (DODME), a process which simulates the full peak period, computes a relative root mean square error (RMSE) across the complete set of count and speed locations at 15-minute intervals, scores every trip on how well the counts and speeds are matched

at the count and speed locations it passed in the 15-minute interval in which it passed them, and performs one of four actions on trips that score most poorly:

1. Removal of the trip
2. Clone of the trip
3. Shift in trip departure time one 15-minute interval prior
4. Shift in departure time one 15-minute interval later

Conditions can be placed on the kinds of trips that can be removed, cloned, or shifted to constrain the DODME and impose human intelligence on the automated procedure.

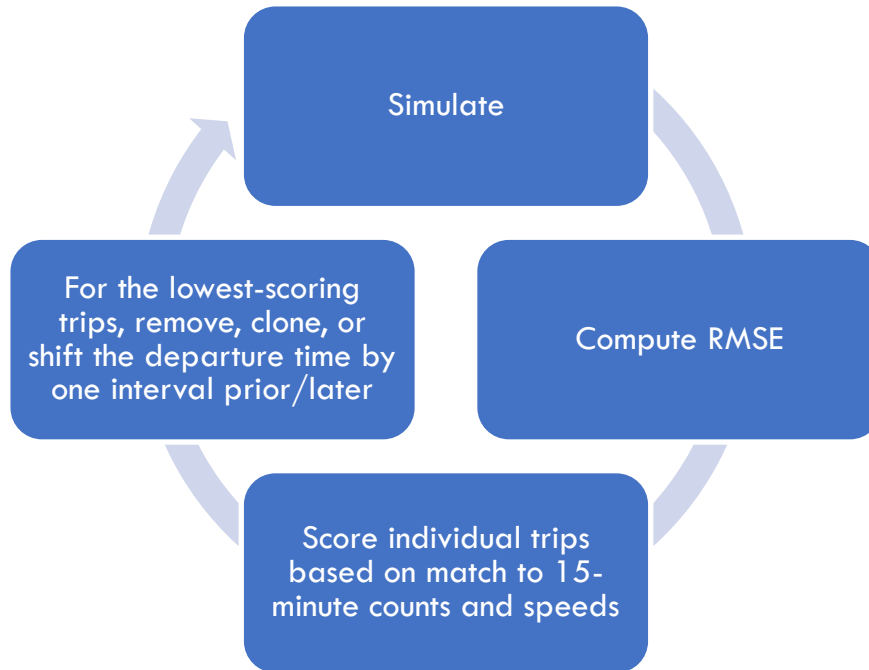


Figure 3-1. Illustration of the Dynamic Origin-Destination Matrix Estimation (DODME) Process

In each application of the DODME, numerous iterations are run, and the demand is adjusted in ways that are likely to improve the match with the counts. When the demand is judged to have changed significantly, the DTA is run again to update the expected travel times and turning delays and to achieve consistency between the changes in demand and congestion patterns on which route choices are based.

The DTA and DODME were thus applied iteratively until no further improvement could be achieved in the overall relative RMSE.

3.4 Calibration Results

Segment volumes and speeds in 15-minute intervals from the model were compared to available traffic data (as described in Section 2.5 Traffic Count Data and Section 2.6 Speed Data) to assess the goodness of fit of the model.

Percent Root Mean Square Error (%RMSE) is often used in statistical analysis to compare simulated volumes with traffic counts. %RMSE reflects differences between model volumes and traffic counts on individual links (versus differences in the aggregate sums) and also provides information on the magnitude of the error relative to the counts. In the context of comparing model flows and counts, %RMSE values are usually between 10% and 100%. Low %RMSE values typically reflect model volumes that are very similar to traffic counts while high %RMSE values reflect the opposite. The complete %RMSE results are summarized below in Table 3-1.

	%RMSE	Count
AM		
All	31.1%	11,536
Freeways	23.8%	3,408
Arterials	34.4%	6,416
PM		
All	29.9%	23,544
Freeways	25.8%	6,880
Arterials	29.4%	13,216

Table 3-1. %RMSE and percent error threshold summary

To further support the DTA model’s goodness of fit with the count data, the DTA model volumes are compared to the traffic counts for all roads in Figure 3-2 through Figure 3-3. In these scatterplots, the x-value of each point represents the 15-minute traffic count volume and the y-value represents the 15-minute model volume. If the model volumes were always equal to the traffic counts, all points would lie directly on the diagonal dotted line. Points that lie below the diagonal line are count locations where the model volume was lower than the traffic count. Points that lie above the diagonal line are count locations where the model volume was higher than the traffic count. The scatterplots demonstrate reasonably good agreement between assigned volumes and counts with the simulated volumes overall being slightly lower than traffic counts.

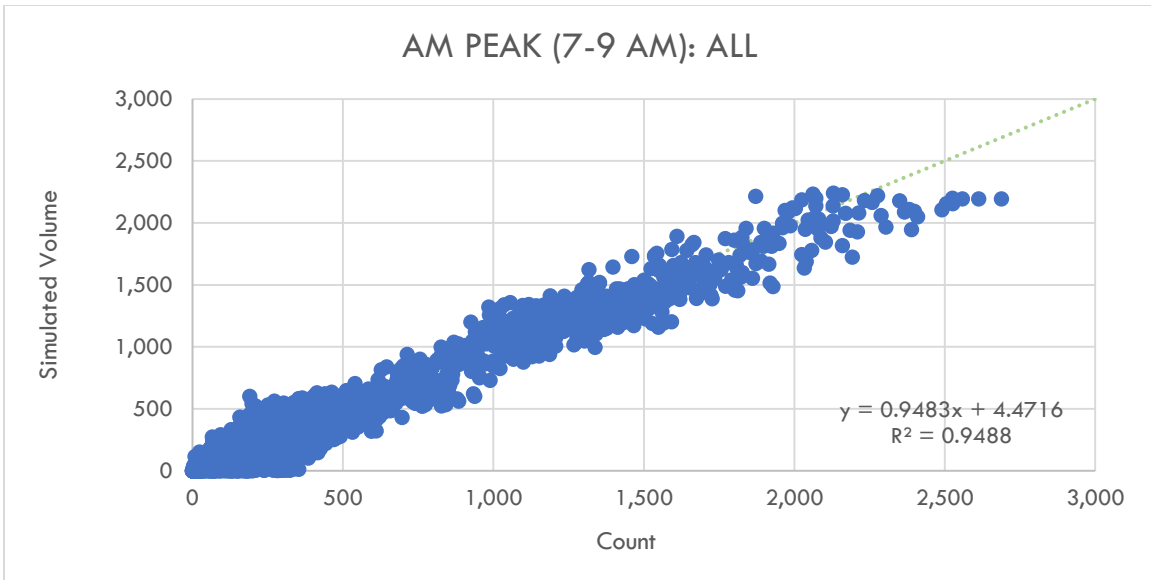


Figure 3-2. A scatter plot comparing AM DTA model volumes and AM traffic counts on all roads

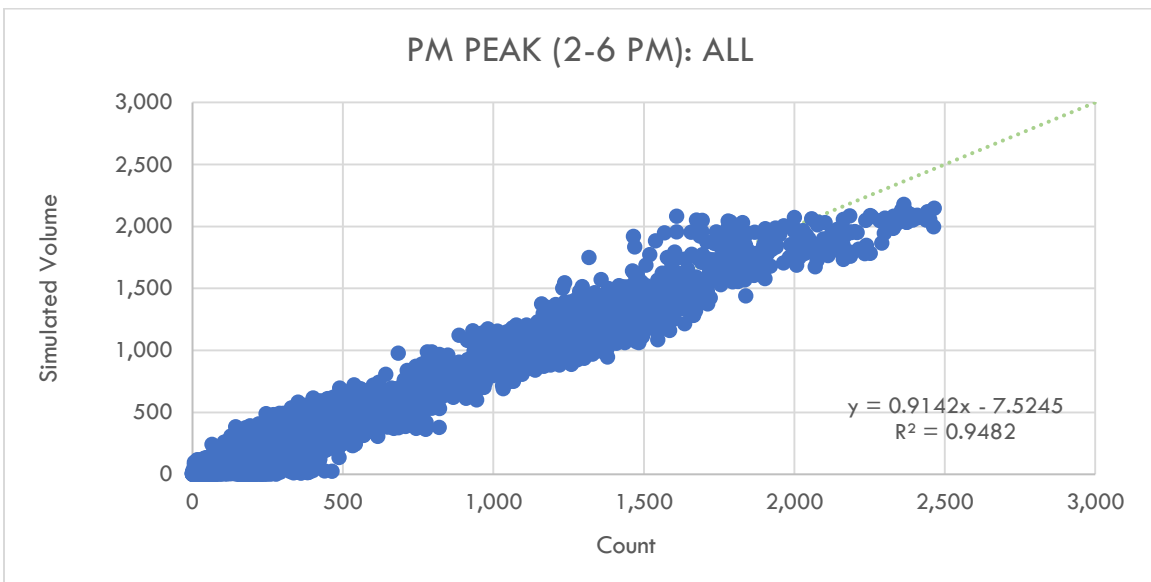


Figure 3-3. A scatter plot comparing PM DTA model volumes and PM traffic counts on all roads

Figure 3-4 through Figure 3-5 make the same comparison between model volumes resulting from the DTA and traffic counts for major arterials only.

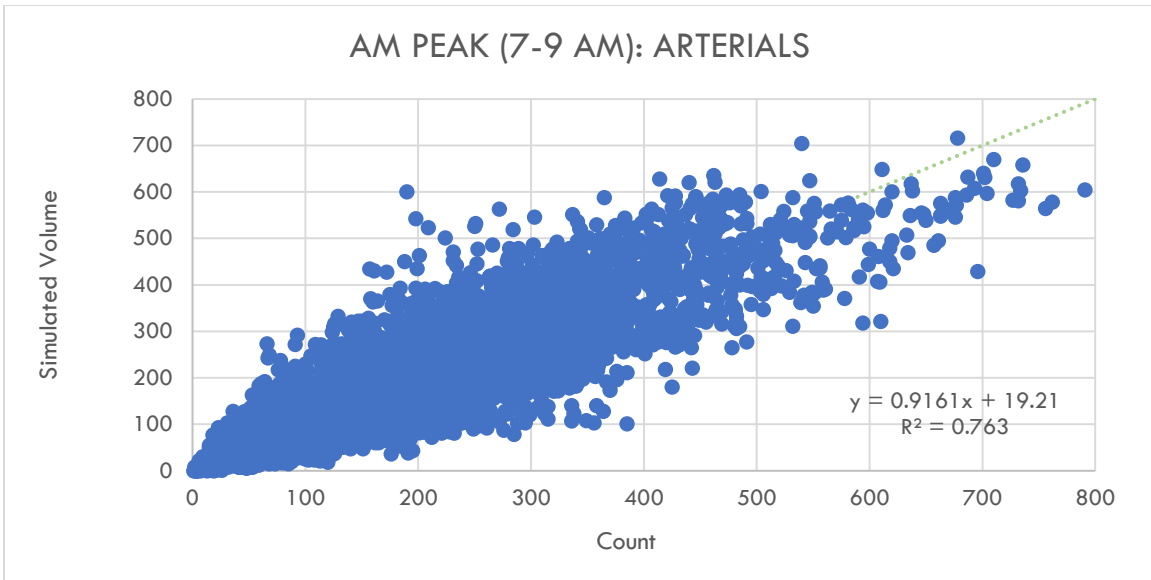


Figure 3-4. A scatter plot comparing AM DTA model volumes and AM traffic counts on major arterials only

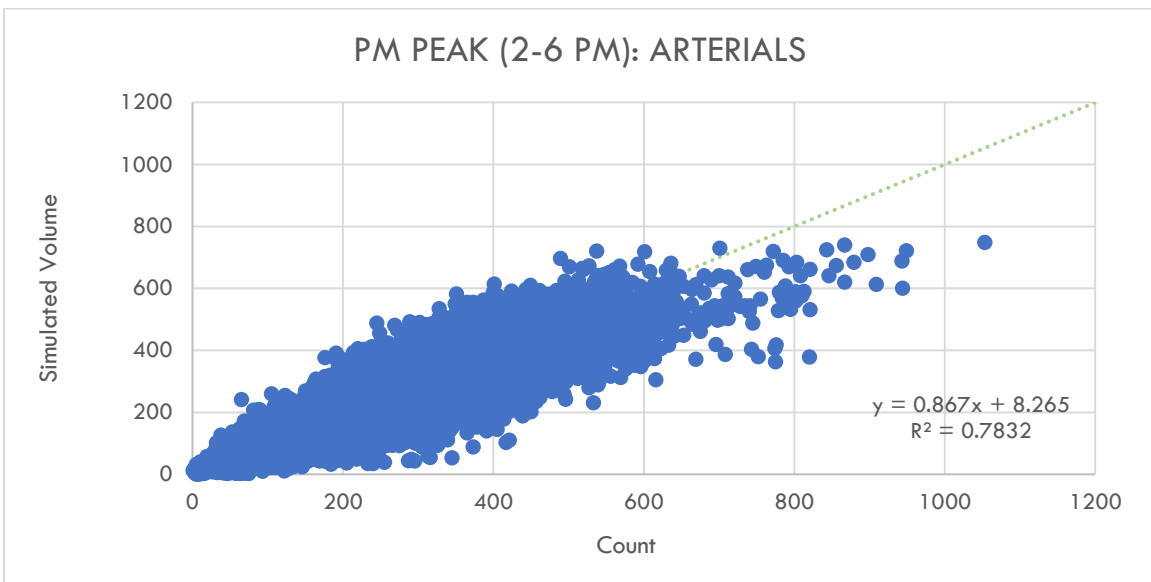


Figure 3-5. A scatter plot comparing PM DTA model volumes and PM traffic counts on major arterials only

Finally, Figure 3-6 through Figure 3-7 make the same comparison between model volumes and traffic counts for freeways only.

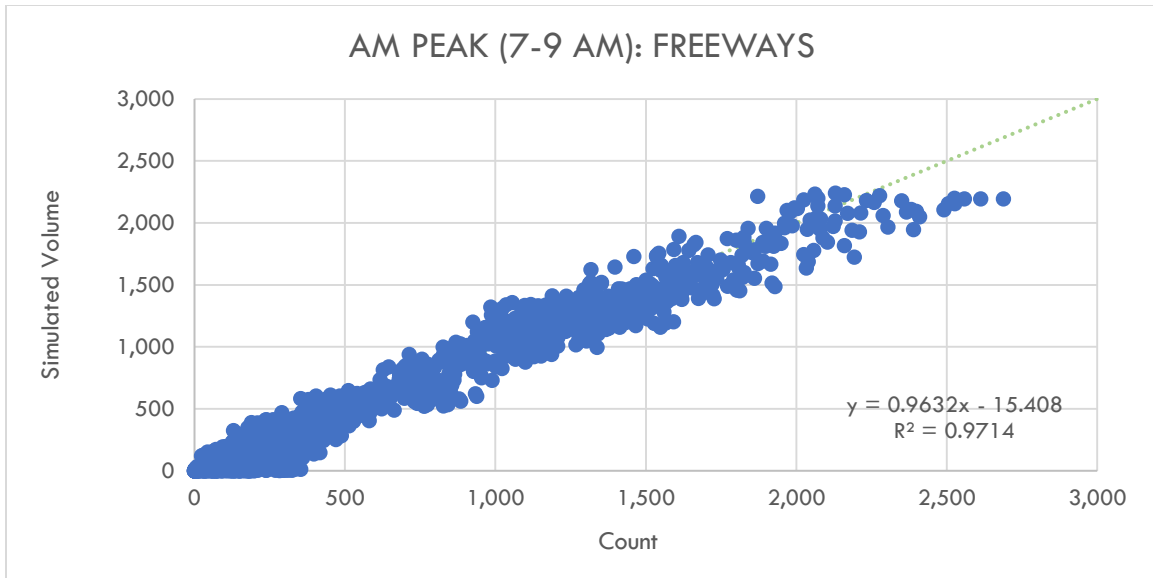


Figure 3-6. A scatter plot comparing AM DTA model volumes and AM traffic counts on freeways only

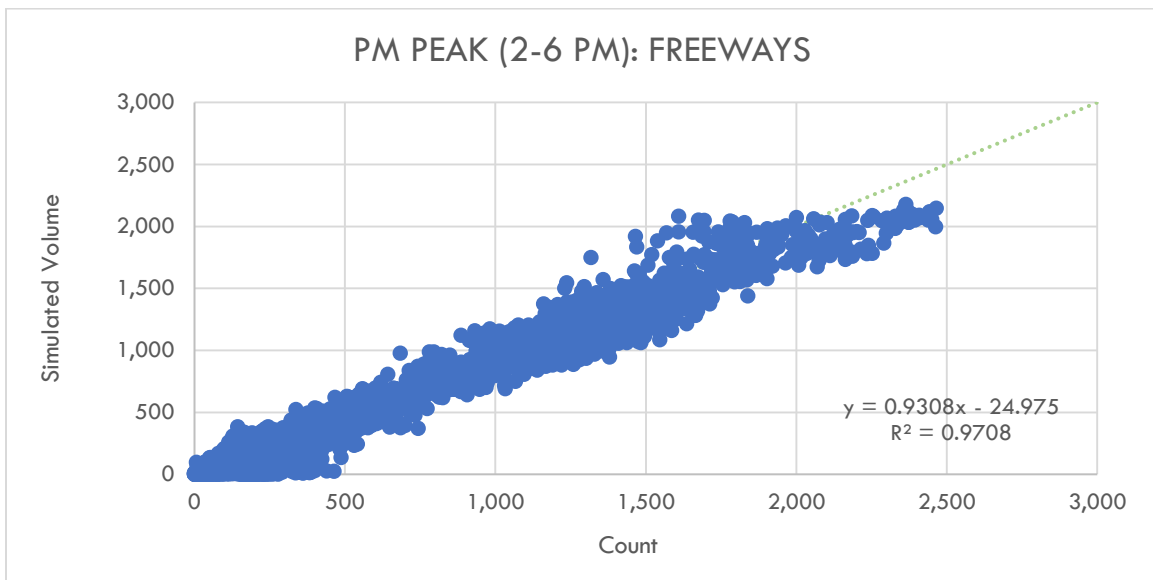


Figure 3-7. A scatter plot comparing PM DTA model volumes and PM traffic counts on freeways only

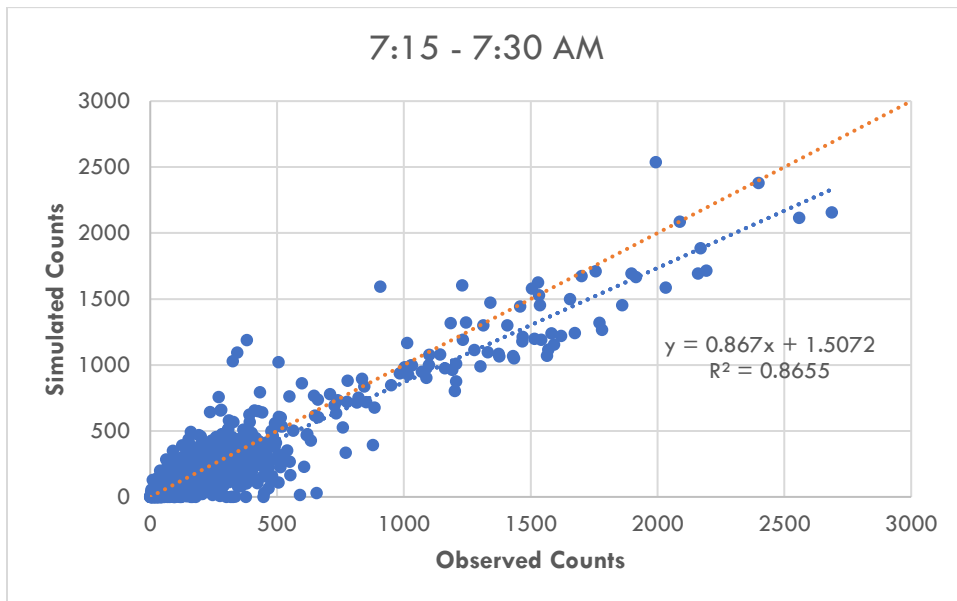
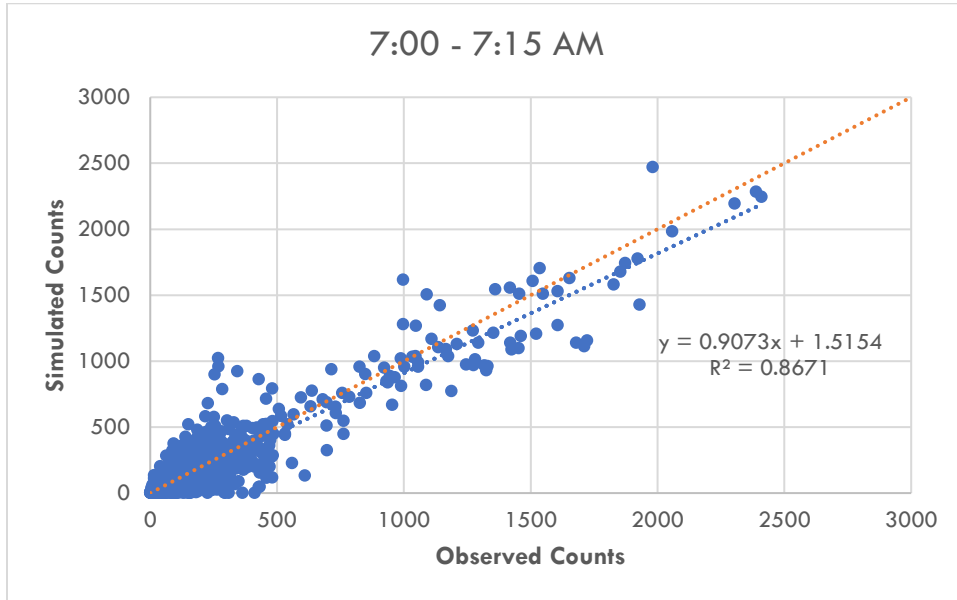
3.5 TransDNA Model Calibration

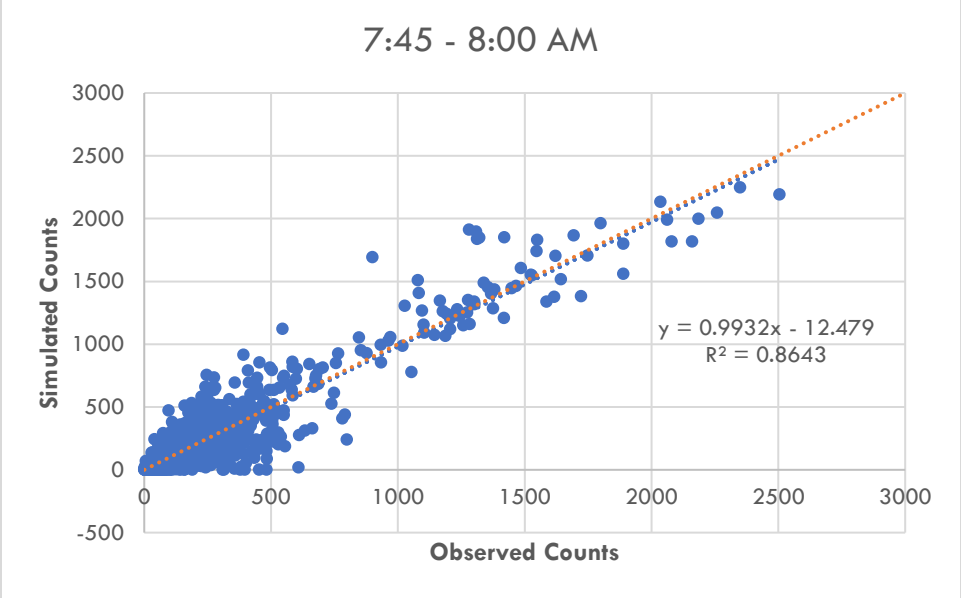
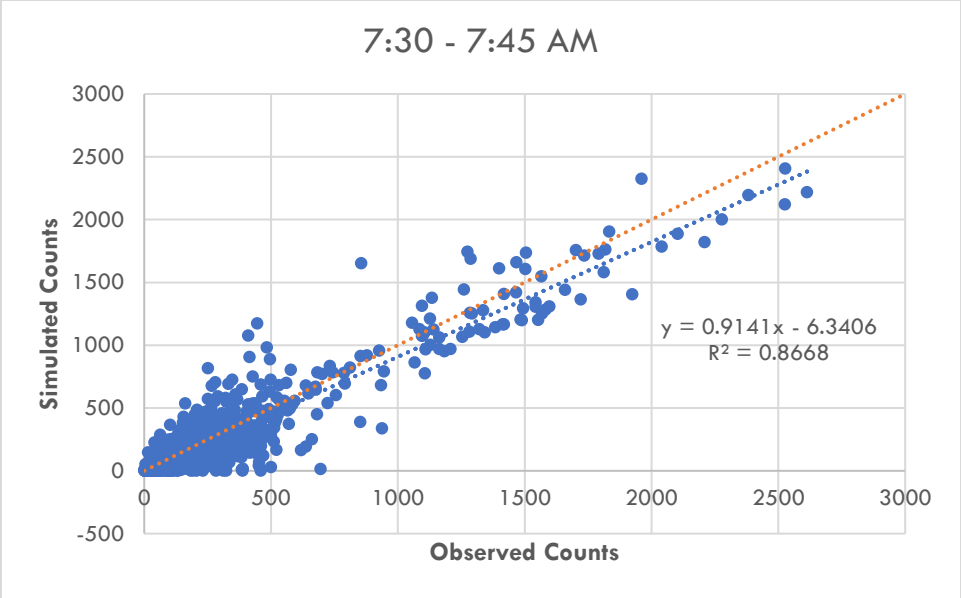
TransDNA is a mesoscopic simulation-based DTA model that shares its time-varying demand input needs with microscopic models such as the TransModeler DTA. In addition, the calibration of mesoscopic DTA models involves the estimation/adjustment of supply-side inputs and speed-density parameters. Supply calibration of a mesoscopic simulation model involves the specification of speed-density functions and capacities by link class.

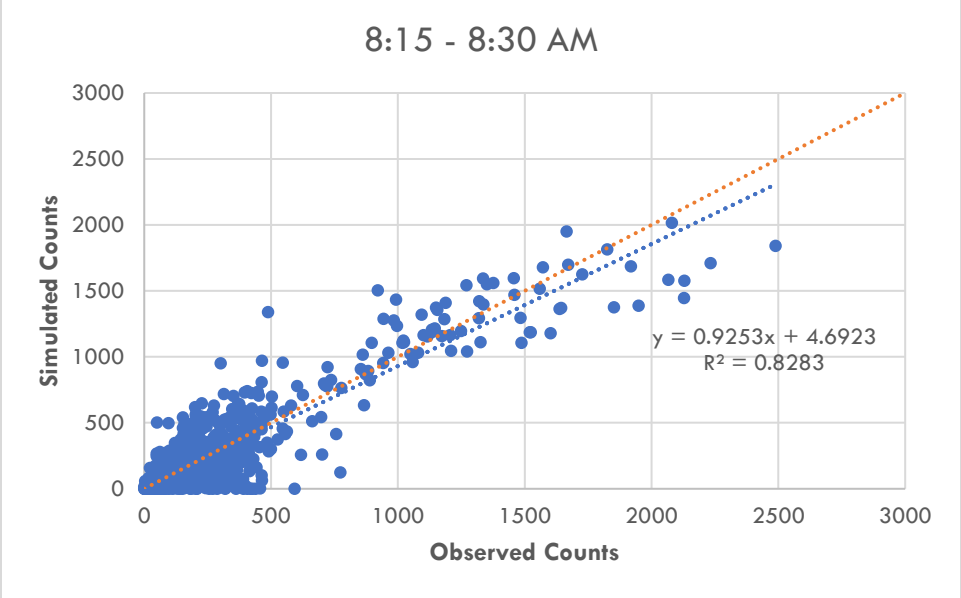
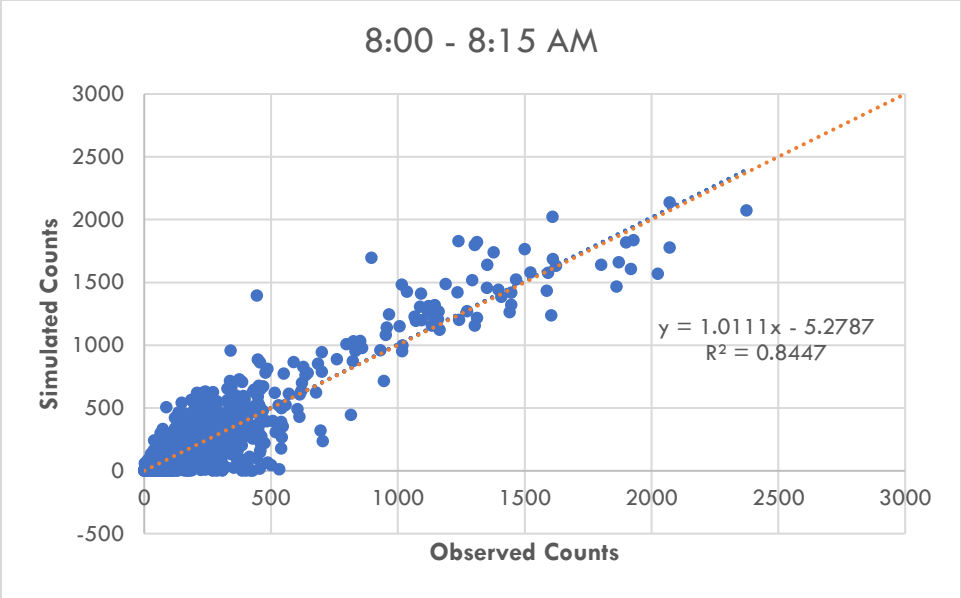
The OD demand for Las Vegas was obtained from the calibrated micro-simulation model developed in TransModeler. The route choice coefficients, speed-density functions and capacities

are the defaults provided in TransDNA. These parameters have been chosen based on our literature review as well as Caliper's own calibration based on field sensor data.

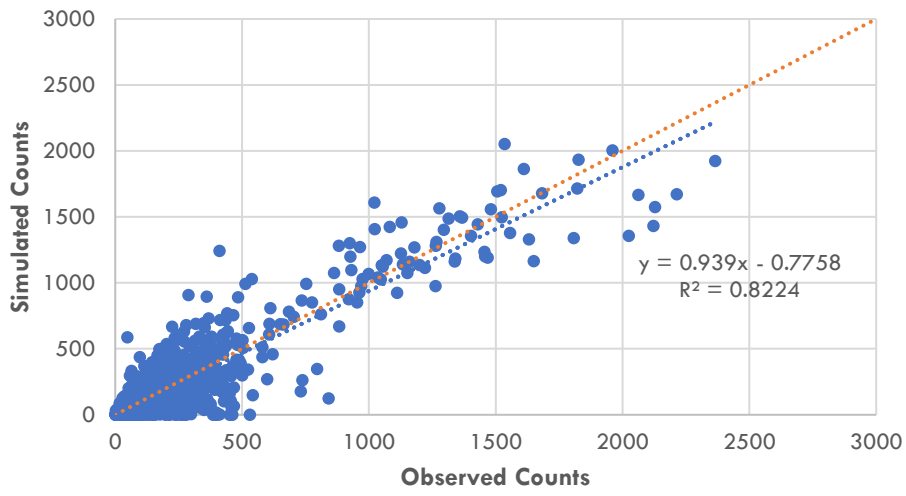
A sample of the model's fit to observed traffic count data is shown below, for the AM peak (7:00-9:00). Each chart compares the observed count (on the horizontal axis) to the corresponding output from the model (on the vertical axis) for a 15-minute time interval within this peak. The red dotted line represents perfect fit while the blue dotted line is the linear regression through the points. While these represent a reasonably accurate model, it should be noted that further calibration (especially on the OD demand side) will be beneficial to the model.



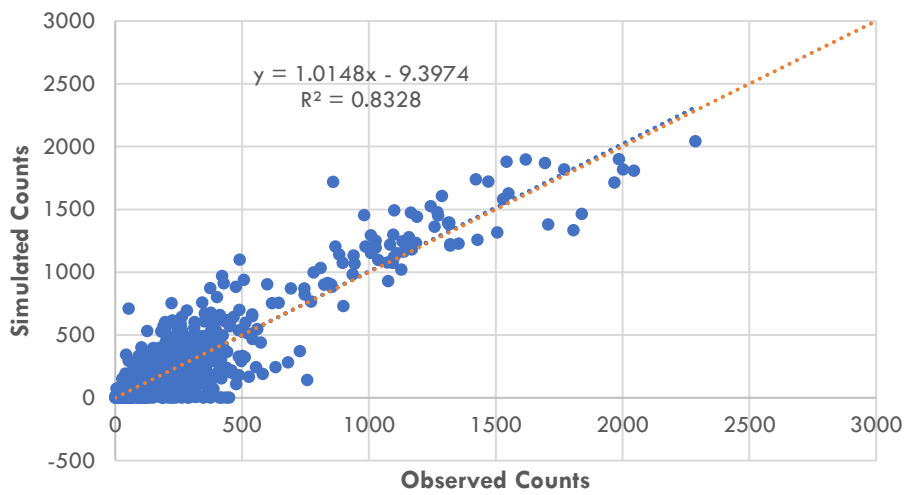




8:30 - 8:45 AM



8:45 - 9:00 AM



4.0 Validation

Once the calibration process was completed, the TransModeler DTA model was validated by comparing simulated travel times to Google travel times. The goal of validation was to establish goodness of fit between simulated trip times from the model and those estimated by Google for a large sample of OD pairs distributed throughout the region.

As discussed in Section 2.7, Google travel time data were queried for a typical spring day, Wednesday, April 10, 2019. Ideally, travel time data would be obtained for 2015, the calibration year of the model, for validation. However, historical travel time data were not available, and Google's Directions API can only be queried for future dates, though its results are based on historical data.

Simulated travel times were obtained by producing dynamic skim matrices of the entire network, which summarize the simulated travel times by departure interval for every OD pair.

During the AM peak period, Google travel times were obtained for four 15-minute departure periods: 7:00 AM, 7:30 AM, 8:00 AM, 8:30 AM. The Google travel times are compared to the simulated travel times in Figure 4-1 through Figure 4-4.

During the PM peak period, Google travel times were obtained for eight 15-minute departure periods: 2:00 PM, 2:30 PM, 3:00 PM, 3:30 PM, 4:00 PM, 4:30 PM, 5:00 PM, 5:30 PM. The Google travel times are compared to the simulated travel times in Figure 4-5 through Figure 4-12.

Each chart displays the equation for the regression line that best fits the data as well as the coefficient of determination R^2 , a statistical measure of how closely the data fit to the regression line. Similar to the charts in Section 3.4, if the simulated travel times were always equal to the Google travel times, all points would lie directly on the diagonal dotted line, the slope of the line would be 1.0, and the R^2 value, which is a statistical measure of how closely the data fit to the regression line with the given slope, would be 1.0. Points that lie below the diagonal line are trips whose simulated travel time were shorter than the travel times predicted by Google. Points that lie above the diagonal line are trips whose simulated travel time were greater than the Google travel times. The charts illustrate that, in almost all periods, the simulated times fit quite tightly around the diagonal line, the R^2 values are quite high, and the slopes are close to 1.0.

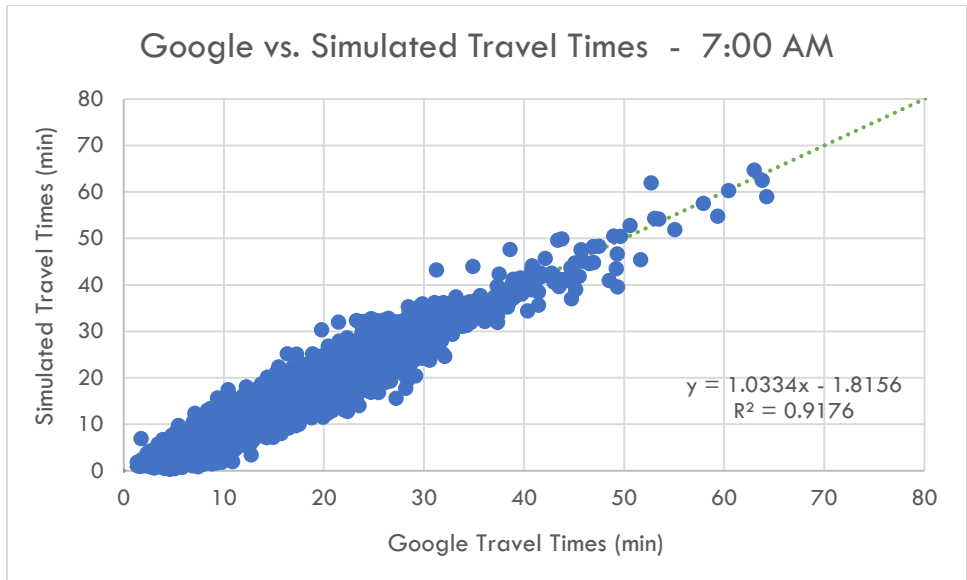


Figure 4-1. A scatter plot comparing AM DTA model and Google travel times: 7:00 AM

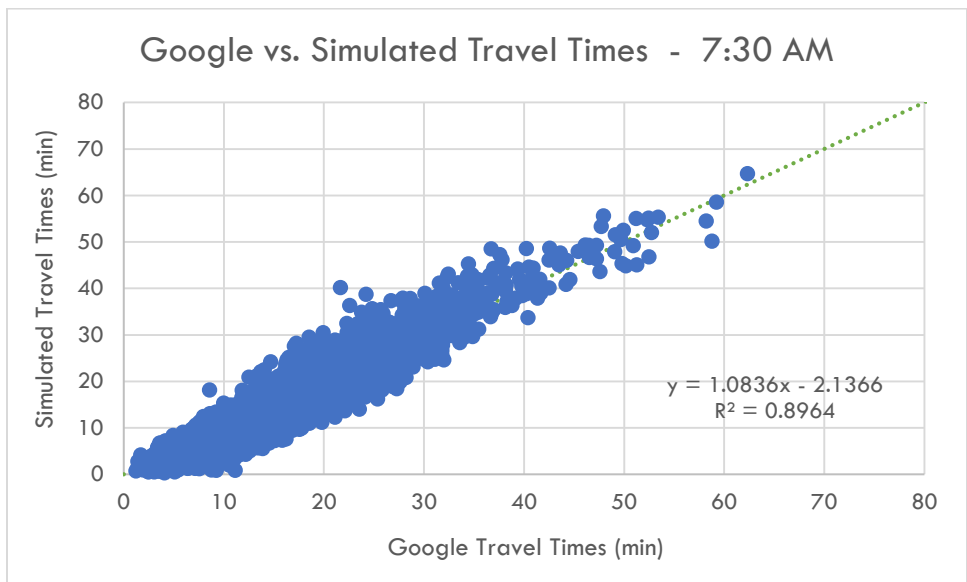


Figure 4-2. A scatter plot comparing AM DTA model and Google travel times: 7:30 AM

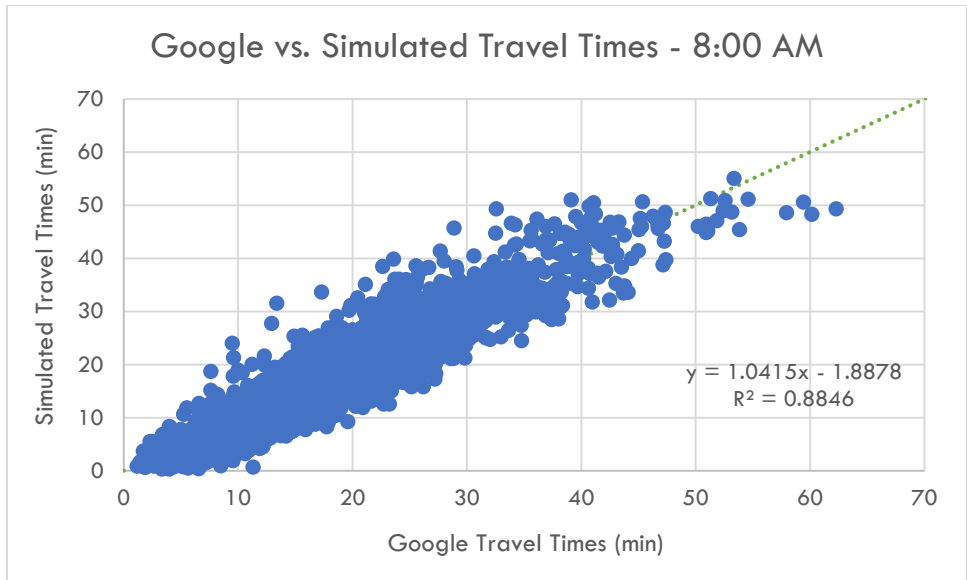


Figure 4-3. A scatter plot comparing AM DTA model and Google travel times: 8:00 AM

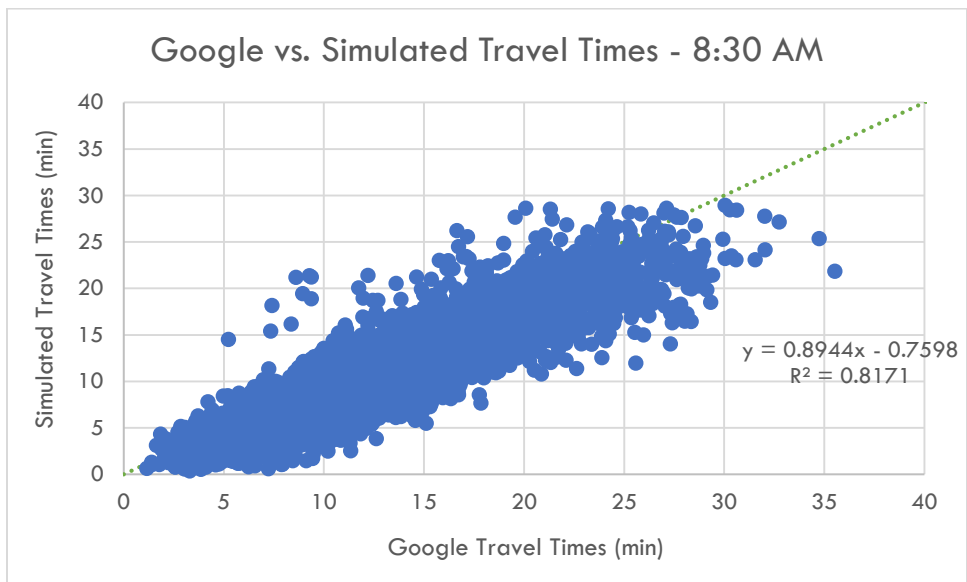


Figure 4-4. A scatter plot comparing AM DTA model and Google travel times: 8:30 AM

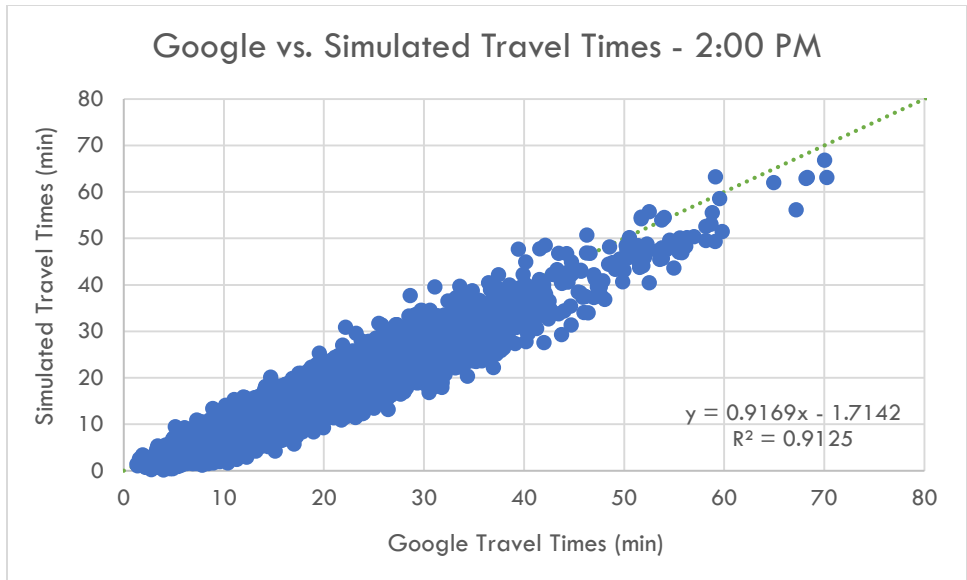


Figure 4-5. A scatter plot comparing PM DTA model and Google travel times: 2:00 PM

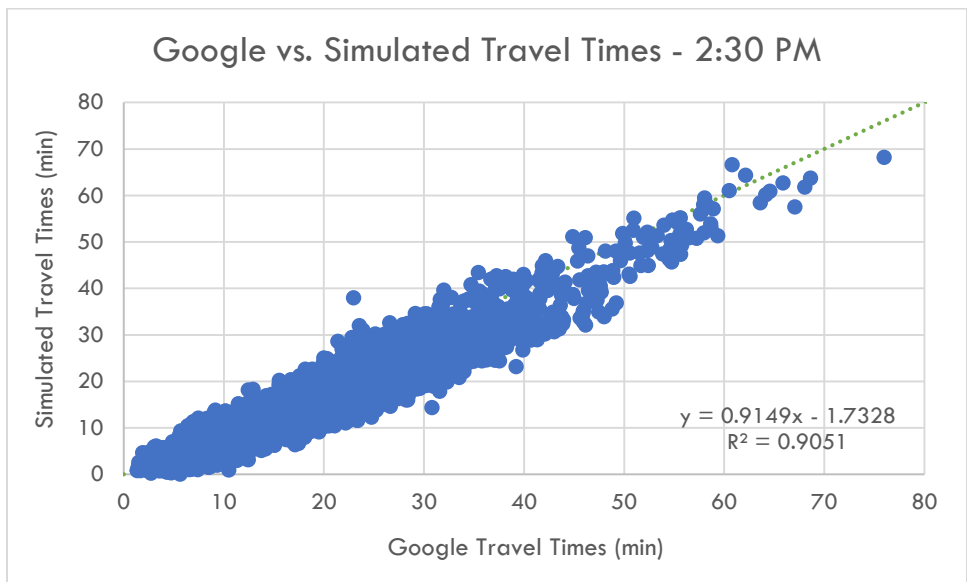


Figure 4-6. A scatter plot comparing PM DTA model and Google travel times: 2:30 PM

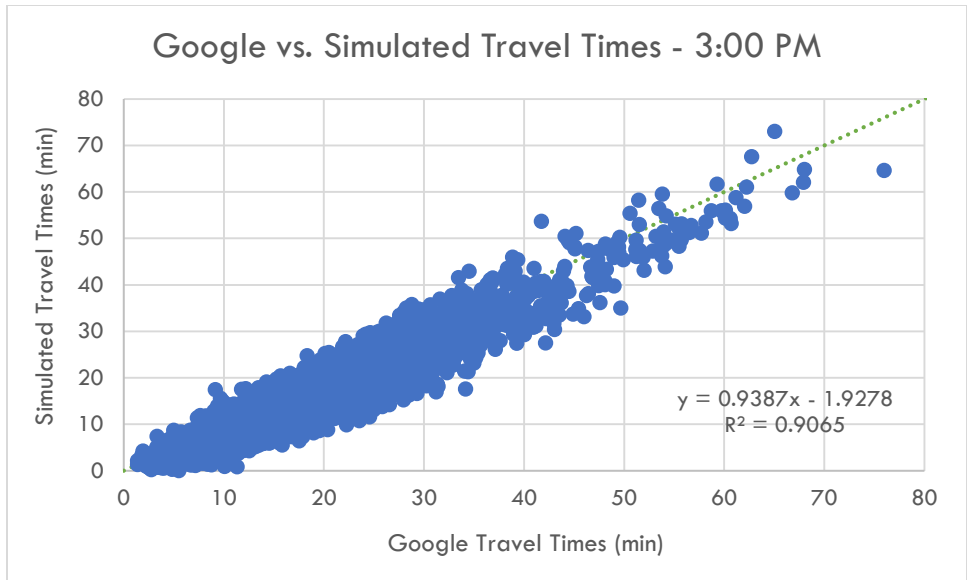


Figure 4-7. A scatter plot comparing PM DTA model and Google travel times: 3:00 PM

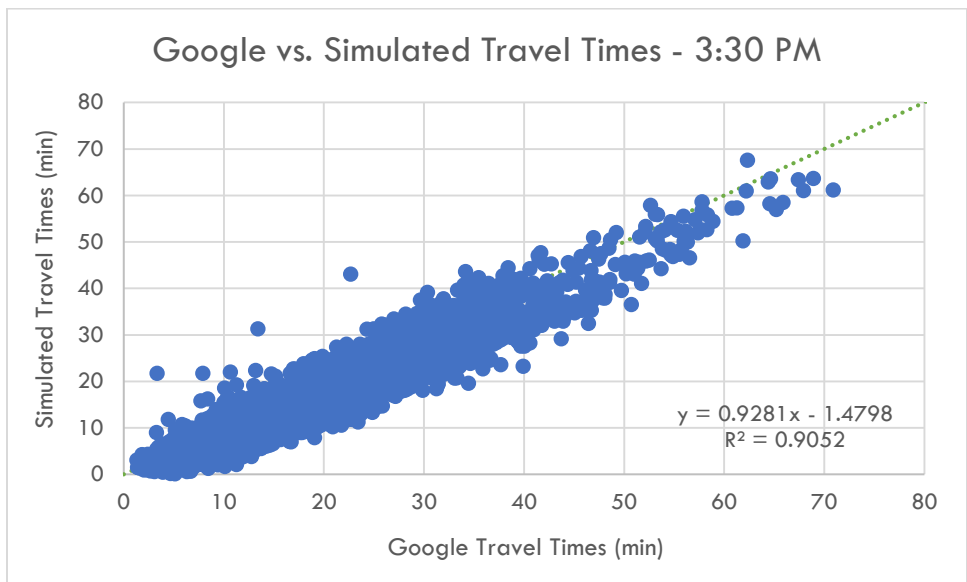


Figure 4-8. A scatter plot comparing PM DTA model and Google travel times: 3:30 PM

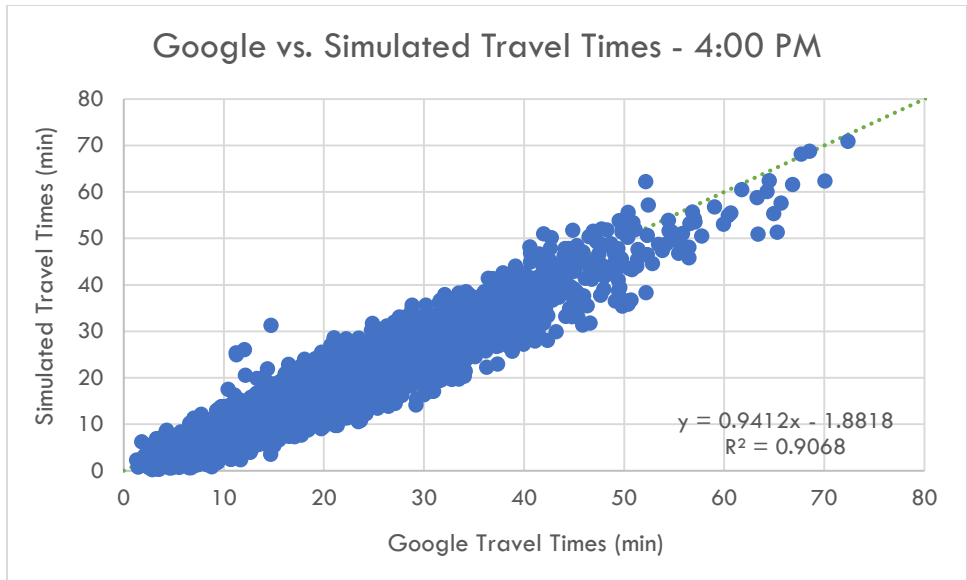


Figure 4-9. A scatter plot comparing PM DTA model and Google travel times: 4:00 PM

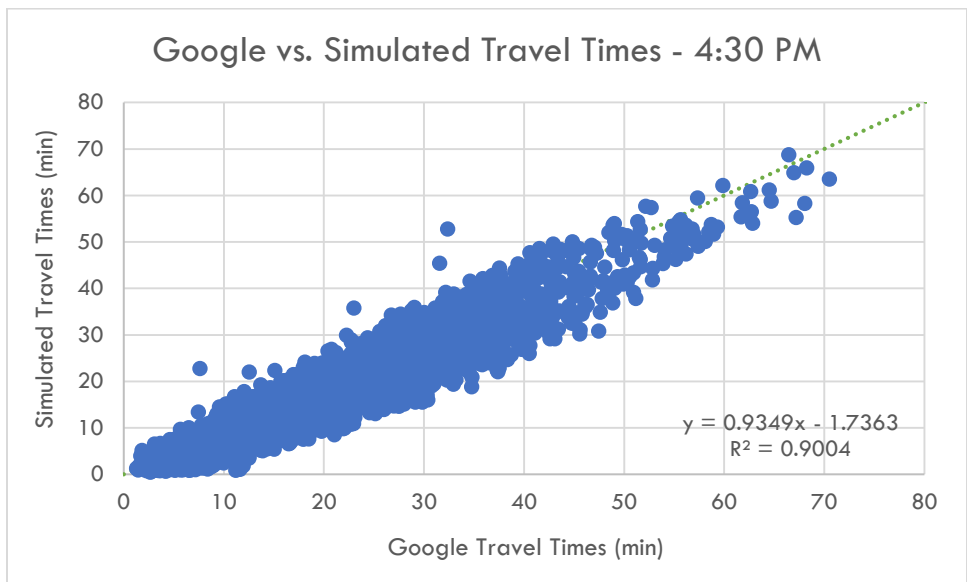


Figure 4-10. A scatter plot comparing PM DTA model and Google travel times: 4:30 PM

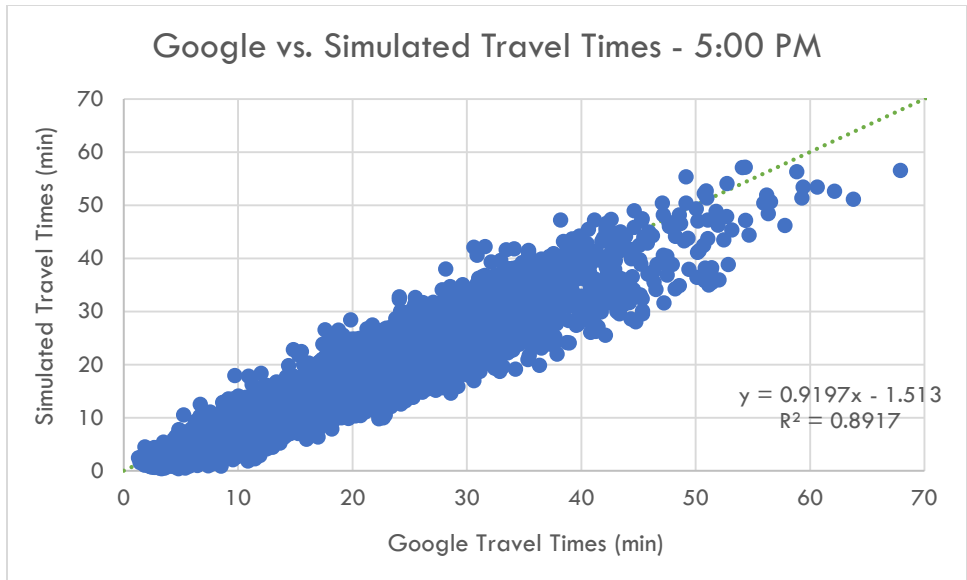


Figure 4-11. A scatter plot comparing PM DTA model and Google travel times: 5:00 PM

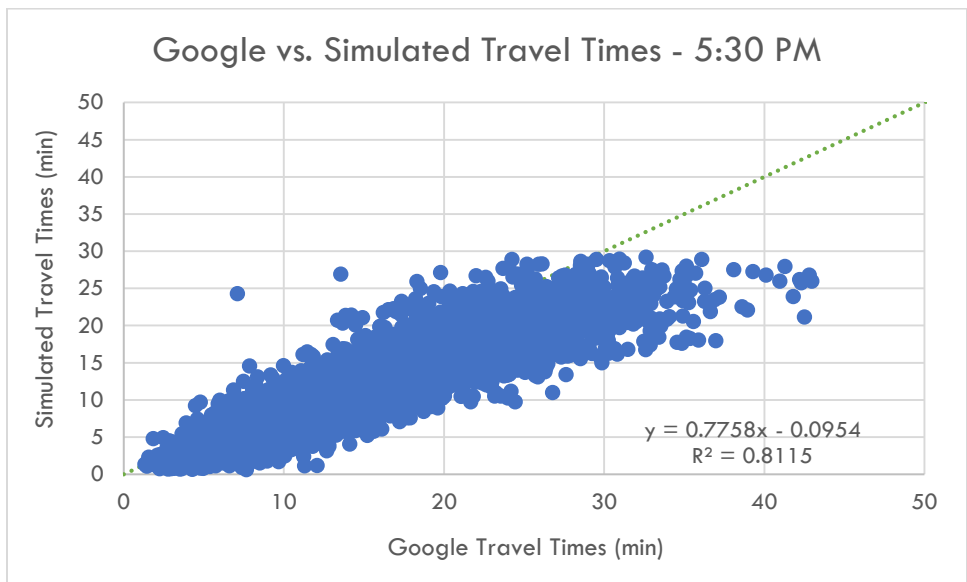


Figure 4-12. A scatter plot comparing PM DTA model and Google travel times: 5:30 PM

5.0 Model Application Guidance

5.1 Choosing the Right DTA for Your Analysis

When you wish to use DTA to analyze a project or scenario, it is important to choose the right DTA – the microscopic simulation-based DTA in TransModeler or the mesoscopic simulation-based DTA in TransDNA – for the application at hand. The choice will depend in large part on two broad questions, ideally asked in the following order of priority:

What operational sensitivity is needed to perform the analysis effectively?

What time and resources are available to perform the analysis?

First and foremost, if the project involves traffic control (i.e., traffic signal or ramp metering), intelligent transportation systems (ITS), or advanced traffic demand management strategies (ATMS), then the microsimulation-based DTA will provide the better treatment of operating conditions and hence the better tool for the analysis. Similarly, if the project entails significant freeway improvements that will alter merging or weaving operations, then the microsimulation will also provide the more accurate quantification of the benefits because mesoscopic models adopt a more aggregate approach to capturing the merging and weaving interactions that are so critical to traffic flow on freeway facilities. A user's guide for DTA with TransModeler is provided in Section 6.0.

Secondly, if the analysis calls only for a quick approximation of the project's benefits, for instance to test feasibility or to reduce a larger set of competing alternatives to a smaller set to be studied in greater detail subsequently, then the mesoscopic DTA in TransDNA is the recommended choice for its lower setup and running times relative to the microscopic DTA in TransModeler. A user's guide for DTA with TransDNA is provided in Section 7.0.

5.2 Microsimulation of Smaller Subareas in TransModeler

It is worth noting that if a particular analysis involves a relatively localized project – for instance the reconfiguration of an interchange or intersection geometry or even a widening project along a corridor – then a microsimulation-based analysis can be cost-effective and will provide the better (i.e., more accurate) analysis. However, running the regional DTA may not be appropriate. Rather, it is advised that a smaller study area be extracted from the regional model and used for the analysis. You can select links in the *Links* layer and export them to a new simulation database. When you do so, TransModeler will prompt you to export signal timings for the subarea at that time. To extract an estimate of the demand for the same selection set of links, choose **Simulation > Options** and check, *Report Subarea O-D and Dynamic Skim Data*, and choose the selection set from the *Selection* drop-down list. Then, run a simulation to produce the subarea OD matrix. If a high degree of confidence in the analysis is needed (i.e., the analysis will support an investment decision or engineering design and not simply answer a planning question), the subarea model should undergo calibration and validation to refine the data exported for the subarea to improve the subarea model's fit with observed conditions, just like any microsimulation study.

5.3 Creating OD Matrices for Future-Year Scenarios

There is no established practice for estimating traffic demand for future years, but several methods have been proposed in the research literature and used in practice. These methods are generally referred to as pivot-point methods because a calibrated base-year matrix is used to pivot from unadjusted trip tables produced by a travel demand model for a forecast year V_f to adjusted trip tables for the forecast year $V_{f,adj}$ based on a relationship between the unadjusted trip tables produced by the travel demand model for a calibrated base year V_b and the trip tables calibrated more tightly for the simulation model in the base year $V_{b,sim}$.

The simplest pivot model applies a correction to the unadjusted forecast demand V_f based on the ratio of the base year simulation demand $V_{b,sim}$ to the unadjusted base year demand V_b :

$$V_{f,adj} = V_f \frac{V_{b,sim}}{V_b}$$

A useful [synthesis of pivot methods](#) can be found in the Australasian Transport Research Forum 2012 Proceedings.

Standard matrix operations in TransCAD and TransModeler can be performed using commands in the **Matrix** menu in order to compute adjusted forecast trip tables. In the context of the TransModeler and TransDNA DTA models, $V_{b,sim}$ represents the calibrated trip tables that are input to those models, V_b represents the base year (i.e., 2015) trip matrix produced by the RTC travel demand model in TransCAD, and V_f represents a forecast year trip matrix also produced by the travel demand model.

Further, because the forecast volumes V_f produced by the travel demand model will be static, single-period demand, the same temporal distribution reflected in the dynamic (i.e., 15-minute) trip matrices in the DTA models may be assumed.

Because there is no standard practice for development of dynamic forecast trip tables for regional DTA models, it is recommended that the RTC consider further research activity to ascertain which pivot methods work best and/or to explore the various pivot methods in projects to which the DTAs are applied in order to gain direct project experience with the alternative methods.

6.0 TransModeler DTA User's Guide

This User's Guide for the DTA model provides information about the model as well as guidance on how the RTC and its partners can apply the model.

6.1 Introduction to Projects and Scenarios

A **simulation project** in TransModeler is a collection of files representing street, traffic demand, and signal timing data organized together by a simulation project file (.SMP). A simulation project file corresponds with a fixed representation of the roadway geography and geometry stored in a **simulation database**. For the given geometry stored in the simulation database, a simulation project can contain any number of **scenarios**. Scenarios may represent different years, times of day, signal timings, and other inputs that you may vary in order to study the performance of the transportation system under different conditions.

To evaluate the performance of the transportation system with a different roadway geography or geometry, a new **simulation database** would be built and a new **simulation project** referencing the new simulation database would be created.

A project that has signalized intersections requires only three inputs: a **simulation database**, one or more trip matrices, and a signal timing plan file (.TMS). However, TransModeler supports a wide variety of additional applications, from incident management to managed lanes analysis, which may require additional optional inputs.

6.1.1 The RTC Simulation Project

There is one project included with the operations model, and it contains two scenarios:

1. AM – Simulation from 6:00 AM to 9:00 AM, which includes the two AM peak hours from 7:00 AM to 9:00 AM plus one hour of warm-up.
2. PM – Simulation from 1:00 PM to 6:00 PM, which includes the four PM peak hours from 2:00 PM to 6:00 PM plus one hour of warm-up.

► To Open the Simulation Project

1. Choose **File > Open**. TransModeler will open the *File Open* dialog box.
2. Browse to the folder where you have copied the model.
3. Locate and highlight the simulation project RTC DTA.SMP.
4. Click *Open*. TransModeler will open the project and display it in a map window.

6.1.2 Scenarios

The *Project Settings* dialog box is where scenarios are created and managed in TransModeler. The *Project Settings* include a list of scenarios, the parameters that define each scenario (e.g., the start and end time of the period to be simulated), and the various input files used in each scenario. The input files used in the DTA model are described in Table 5-1.

Input File	Extension	Description
Simulation Database	DBD	A geographic file representing the road network and geometry (i.e., RTC DTA.DBD)
Trip Matrix	MTX	A matrix file storing the origin-to-destination volumes of drive alone, SR2, SR3, single unit trucks, and tractor trailer trucks produced by the regional planning model (e.g., PM DA.MTX)
Signals	TMS	A signal timing plan file containing the phasing and timing parameters that govern signal operations at signalized intersections and ramp meters (i.e., RTC SIGNAL TIMINGS.TMS).
Historical Travel Times	BIN	A table storing the average 15-minute travel times for all road segments in the simulation database on which route choices are, in part, based (e.g., AM HISTORICAL TRAVEL TIMES.BIN)
Turning Delay Table	BIN	A table storing the average 15-minute turning movement delays for all turning movements in the simulation database on which route choices are, in part, based (e.g., AM TURNING DELAYS.BIN)
Parameters	XML	A parameter file containing all of the driver behavior parameters that were modified as part of the calibration and validation of the operations model (i.e., PM PARAMETERS.XML)

Table 6-1. Input files defining a model scenario

► To Change Scenarios in the Simulation Project

1. Choose the name of the scenario from the **Project > Scenario** menu command.

OR

1. Choose **Project > Settings**. TransModeler will open the *Project Settings* dialog box.
2. Choose the name of the scenario from the *Current* drop-down list.
3. Click OK.


► To Review the Parameters and Input Files Defining a Scenario

1. Choose **Project > Settings**. TransModeler will open the *Project Settings* dialog box.
2. Choose the name of the scenario whose parameters and input files you want to review from the *Current* drop-down list.
3. Click the *Setup*, *Network*, *Input*, *Output*, *Routing*, *Parameters*, and *Options* tabs to review the various parameters and input files defining the scenario.
4. To read more about the parameters and input files, click F1 on the keyboard. TransModeler will open the *Project Settings* help topic in the TransModeler help files.
5. In the *Project Settings* dialog box, click *Cancel* to close the dialog box.

► To List All Input Files and Their Full File Paths For a Scenario

1. Choose **Project > Scenario > File Manager** from the menu system.

► To Create a New Scenario in a Simulation Project

1. Choose **Project > Settings**. TransModeler will open the *Project Settings* dialog box.
2. Choose the scenario that you want to simulate with and without the development demand from the *Current* drop-down list.
3. Click . TransModeler will open the *Create New Scenario* dialog box.

4. Enter the scenario name (e.g., *PM with Managed Lanes*), and click OK. TransModeler copies the scenario you chose in Step 2, duplicating all of its parameters and input files, and makes it the current scenario.
5. Click OK. TransModeler adds the new scenario and makes it the active scenario in the project.
6. If you want to save the new scenario in the project, choose **File > Save**.

6.1.3 Map Layers

When you open the simulation project in TransModeler, a map window is opened displaying the map layers making up the simulation database. These include the following layers:

- Link and node layers defining the streets and intersections
- Segment and lane layers representing detailed street cross-sections and lane geometries
- A TAZ layer displaying the traffic analysis zones from the planning model
- Centroid and centroid connector layers representing origins, destinations, and points of access to the streets
- Signal and sensor layers representing traffic signals and traffic signal detectors
- Vehicles
- Several count layers showing the geographic locations of field traffic counts

Other layers can be added to the map to aid visualization and model development and review. These may include water boundaries (e.g., lakes and rivers), aerial imagery, and other geographic data. TransModeler supports a wide variety of geographic file formats, from ESRI Shapefiles to aerial imagery formats such as JPEG, GeoTIFF, and MrSID.

► To Add or Remove Map Layers

1. Choose **Map > Layers** from the menu system. TransModeler will open the *Map Layers* dialog box.
2. To remove a layer, highlight it in the list, and click *Drop Layer*.
3. To add a new layer, click *Add Layer*, choose the type of file you want to add from the drop-down list on the *File Open* dialog box, locate the file, and click *Open*.
4. To hide or show a layer in the map, highlight the layer and click *Hide Layer* or *Show Layer*, respectively.
5. To read more about changing the contents of a map, click F1 on the keyboard. TransModeler will open the *Changing the Contents of a Map* help topic in the TransModeler help files.
6. In the *Map Layers* dialog box, click *Close* to close the dialog box.

Note that you might find it more convenient to manipulate the contents of a map using the *Display Manager*, which gives you immediate access to all of the layers in the map and to their style, labeling, and other customizable display settings. To read more about working with the *Display Manager*, hold the mouse over **Map > Display Manager Toolbar** in the menu system, and click F1 on the keyboard.

6.2 How to Perform a DTA in TransModeler

The DTA model can be run on various Build and No Build scenarios to evaluate the performance of alternative or proposed projects. The DTA can be run either from a cold start, in which drivers assume free flow conditions in the first iteration, or from a warm start, in which the solution of a previous DTA informs the route choice decisions of drivers in the first iteration. While a cold-start DTA should generally be run for a greater number of iterations, it is still an open research question whether fewer iterations are sufficient for a regional model having the scale and complexity of the RTC DTA model. 50 iterations are generally found to be sufficient for achieving reasonable convergence (i.e., when experienced trip times cease to change substantially with further iteration) whether beginning the DTA with a cold or warm start.



When significant changes to the network are made, for instance to simulate the impacts of a managed lanes project, a cold start is generally advised. A warm start is advised when modest changes are made to the network or to the input trip data.



When the DTA is completed, either when it is stopped manually or when the maximum number of iterations is reached, output travel time and turning delay tables describing congestion at the UE condition in the network will be created and opened. These files should be referenced as the HISTORICAL TRAVEL TIMES.BIN and TURNING DELAYS.BIN tables in the *Routing* tab of the *Project Settings* for the corresponding scenario before the scenario is simulated to produce performance measures.

► To Run the DTA Model in TransModeler from a Cold Start

1. Open the DTA simulation project RTC DTA.SMP.
2. Choose **Simulation > Options**.
3. Choose *Dynamic Traffic Assignment* from the *Run* frame.
4. A *Target Gap* of 0.5% can be retained as the default. The DTA should not converge to this gap. Rather, the DTA should be stopped manually when the convergence measure ceases to decline or at a maximum number of iterations.
5. Enter 50 in the *Maximum Iterations* box.
6. Check the *Start from free flow* box.
7. Accept all other default parameters, and click OK.
8. Choose **Simulation > Begin** to start the DTA.
9. If you are prompted for the output folder and historical travel time and turning delay table file names, provide them and click OK. TransModeler will start the DTA.
10. To stop the DTA when the convergence measure is no longer declining, choose **Simulation > End**. TransModeler will open the historical travel time and turning delay tables.

► To Run the DTA Model in TransModeler from a Warm Start

1. Open the DTA simulation project RTC DTA.SMP.
2. Choose **Project > Settings** and ensure that the historical travel time and turning delay tables of a prior DTA solution are chosen on the *Routing* tab.
3. Open the Simulation Toolbar by clicking .
4. Click  to open the Simulation Options dialog box.



5. Choose *Dynamic Traffic Assignment* from the Run frame.
6. A *Target Gap* of 0.5% can be retained as the default. The DTA should not converge to this gap. Rather, the DTA should be stopped manually when the convergence measure ceases to decline or at a maximum number of iterations.
7. Enter 50 in the *Maximum Iterations* box.
8. Uncheck the *Start from Free Flow* box.
9. Accept all other default parameters and click OK.
10. Click  to start the DTA.
11. If you are prompted for the output folder and historical travel time and turning delay table file names, provide them and click OK. TransModeler will start the DTA.
12. To stop the DTA when the convergence measure is no longer declining, click .. TransModeler will open the historical travel time and turning delay tables.

6.3 How to Maintain and Update the Model

6.3.1 Road Editing

As and the region's surface transportation system is upgraded, To preserve the DTA model's usefulness and readiness for project work, the road network in the DTA model should periodically be updated to reflect any roadway improvement projects that are completed in the region. The following directions give a brief overview on road editing in TransModeler.

Road editing is primarily done with tools on the *Road Editor*. The list of tools in the *Road Editor* is available in the Help topic, "Editing Simulation Databases," and is also copied below in Table 6-2.






Changes to a road network are made in an "editing buffer" where they are pending edits until you click *Commit* , at which point the changes are saved to the simulation database. To undo all changes made in an editing buffer, click the *Cancel* . There is no undo option for road edits after changes in a buffer are committed, but every change that can be made with the road editing tools can be reversed. A link that has been split into two can be rejoined, a lane connector that has been deleted can be re-added, a turn bay that has been added can be removed by deleting the lane and rejoining segments, etc. Actions using the road editing tools are not complete until the editing buffer in which they are taken is committed.

Button Name	Function
 Select	Select a feature for editing
 Edit Properties	Edit the properties of a feature
 Edit Attributes	Edit the attributes of a feature
 Add Link	Add a new link to the network
 Delete Segment	Delete a link or segment from the network
 Join	Join two links or two segments together
 Split	Split a single link into two links, or a single segment into two segments
 Add Lane	Add a new lane to a segment
 Delete Lane	Delete a lane from a segment
 Add Turn Bay	Add a left (or right) turn bay at an intersection
 Add Channelized Turn	Add a channelized right (or left) turn link at an intersection
 Add Acceleration Lane	Add an acceleration lane at an on-ramp junction
 Add Deceleration Lane	Add a deceleration lane at an off-ramp junction
 Add Bus Pull-out	Add a bus pull-out lane
 Add Lane Connector	Add a new lane connector between two lanes
 Delete Lane Connector	Delete a lane connector
 Move Stop Bar	Move the position of the stop bar along the connector
 Move Yield Position	Move the position where vehicles yield to opposing through movements
 Move Bend Points	Move bend points on a connector to change its shape
 Add Centroid Connector	Add a new centroid connector
 Delete Centroid Connector	Delete a centroid connector
 Add Sensor	Add a new sensor
 Delete Sensor	Delete a sensor
 Add Crosswalk	Click in the map to add a pedestrian crosswalk
 Delete Crosswalk	Click on a pedestrian crosswalk to delete it
 Add/Remove Median	Divide the two sides of a two-way street into separate one-way links
 Add/Remove TWLTL	Convert an existing lane into a shared center two-way left turn lane (TWLTL)
 Convert One-Way	Convert a two-way street to one-way or a one-way street to two-way
 Add Roundabout	Create a roundabout
 Smooth Curvature	Smooth the curvature of a segment (add or move shape points along a smooth curve)
 Reverse Direction	Reverse the direction of a one-way street
 Edit Elevation	Edit the elevation profile of a link or segment
 Label Elevation	Label the elevations of a segment's shape points in the map
 Remove Elevation Labels	Removes the elevation labels in the map
 Cancel	Abandon the changes made in the current edit buffer
 Commit	Save the changes in the current edit buffer to the simulation database
 Road Editor Configuration	Change the Road Editor Configuration






Table 6-2. Road Editing Tools in TransModeler

Step-by-step instructions for using all of the road editing tools can be found in TransModeler Help (**Help > TransModeler Help**) in the section “Editing Streets and Intersections.” Below you will find two brief instructions for adding new links and lanes – common actions when you want to add a street or implement a widening project, respectively, in the model.

► To Add a Link

1. Choose **Project > Road Editing > Road Editor** or click  on the *Project* toolbar to open the *Road Editor*.
2. To set basic parameters for the new link, click  to open the *Road Editor Configuration* dialog box. Otherwise, skip to Step 12.
3. Click the *New Features* tab.
4. To make the new link to intersect with the links that it crosses, check *New Links Intersect*.
5. To have a smooth curve be calculated automatically as you add the link, check *Click Curves*.
6. To make the new link one way, check *One Way*.
7. To change number of lanes on the right (AB) side, enter the number of lanes in the *Lanes on Right* edit box.
8. To change number of lanes on the left (BA) side, enter the number of lanes in the *Lanes on Left* edit box.
9. To change default elevation of the new link, enter an elevation in the *Elevation* edit box.
10. To choose a road class for the new link, choose a road class name from the *Road Class* drop-down list.
11. Click OK.
12. Choose .
13. Click at the starting point of the link.
14. To add one or more shape points, move the mouse to the next point and click.
15. To end the line, double-click on the endpoint. TransModeler displays the new link with endpoints and intermediate shape points.
16. Click  to commit your changes or  to cancel them.

► To Add a Lane

1. Choose **Project > Road Editing > Road Editor** or click  on the *Project* toolbar to open the *Road Editor*.
2. If you want to enable or disable the option to have lane connectors updated automatically, click  to open the *Road Editor Configuration* dialog box. Otherwise, skip to Step 6.
3. Click the *Options* tab.
4. Check or uncheck *Update lane connectors automatically*.
5. Click OK.
6. Choose .
7. Click on the segment to which you want to add a lane. TransModeler inserts a new lane at the clicked location.
8. Click  to commit your changes or  to cancel them.

6.3.2 Road Classification

Road classification is important not only for establishing speed limits in the model but also for ensuring proper driving behaviors, namely as driving behaviors relate to merging onto a freeway, regulating right of way at intersections, and gap acceptance entering roundabouts. Road class ranking determines priority between turning movements where signage or signals do not explicitly regulate right of way, for instance for left turning movements from a major to a minor street. TransModeler uses a road class' priority rank to determine which is the major and

which is the minor street (Help Topic “Displaying and Editing Intersection Turning Movement Priority”). Speed limits vary by road class in TransModeler and can be reviewed or changed for all road segments sharing the same road class.

The road classification parameters affecting microscopic simulation are briefly summarized in Table 6-3. For more information, please see the Help topic “Road Class Definition.”

Parameter	Function
Priority	A numeric code used to determine right of way between two at intersections where no signals or signs are present
Special Type	A type used to further distinguish different types of facilities: None - No special type Freeway - Link type is freeway (excluding on/off ramps) Roundabout - Link is part of a rotary or roundabout Rail - Link is for use only by trains Ramp - Link type is a ramp
Desired Speed Distribution	The desired speed distribution governing driver compliance with the speed limit
Speed Limit	Default speed limit
Free Flow Speed	The speed used to determine free flow travel times, which are assumed when calculating route choices when no historical travel times or turning delays are provided, and to impose a lower bound on the perceived travel time on a road segment even when historical travel times and turning delays are provided
Travel Time Perception Error	Percentage error used to randomize segment travel times when calculating the shortest path in the route choice model (only used when the Stochastic Shortest Path route choice method is chosen)
Saturation Flow	The saturation flow used as the base saturation flow rate in passenger car equivalents (PCE) per hour per lane when performing signal optimization and to compute lane group capacities and delays at signalized intersections in mesoscopic and macroscopic simulation.

Table 6-3. Road Classification Parameters


► To Review Road Classes and Speed Limits

1. Go to **Parameters > Road Classification > View Summary**
2. A *Road Class Summary* dataview will open where you can review all road classes and associated attributes, including the speed limit.

► How to Edit Road Classes and Speed Limits

1. Go to **Parameters > Road Classification > Edit Road Classes**
2. In the *Name* drop-down list, choose a road class.
3. On the *General* tab, edit *Priority*, *Special Type*, *Saturation Flow*, *Free Flow Speed*, and *Travel Time Perception Error*.
4. On the *Microscopic* tab, edit *Speed Limit* and *Desired Speed Distribution*.

► How to Change the Road Class of a Link

1. Make *Links* the active layer.
2. Click on the *Info* button .
3. Click on a link to open an *Info* dataview.

4. Scroll down to the *Class* attribute.
5. Click in the drop-down list and choose the desired road class.



6.3.3 Traffic Count and Speed Data

Directional traffic count and speed data is stored in the *Segments* layer. Table 6-4 lists the fields associated with traffic count and speed data and their descriptions.

Name	Description
AB Short Term Count ID	ID of Count sourced from NDOT 2015 short term count archives; AB direction
BA Short Term Count ID	ID of Count sourced from NDOT 2015 short term count archives; BA direction
AB ATR Count ID	ID of Count sourced from NDOT continuous counters; AB direction
BA ATR Count ID	ID of Count sourced from NDOT continuous counters; BA direction
AB SNTS Count ID	ID of Count sourced from Southern Nevada Traffic Study performed by HDR for NDOT; AB direction
BA SNTS Count ID	ID of Count sourced from Southern Nevada Traffic Study performed by HDR for NDOT; BA direction
Count Comment	Comments on count
Count Source ID	NDOT ATR or Short Term Count Source ID; Southern Nevada Traffic Study Count Source ID
Count Street	Name of the street on which the count is located
Count Exit	Name of exit associated with the count, where applicable
Count Location	Location of count
Count Date	Date of count
CNT_XXXX_AB	15-minute count in the AB direction where XXXX represents the time in military format (e.g., CNT_1415_AB is the count from 2:15PM-2:30PM in the AB direction)
CNT_XXXX_BA	15-minute count in the BA direction where XXXX represents the time in military format (e.g., CNT_0100_BA is the count from 1:00AM-1:15AM in the BA direction)
CNT_0700-0900_AB	Sum of counts between 7:00AM-9:00AM; AB direction
CNT_0700-0900_BA	Sum of counts between 7:00AM-9:00AM; BA direction
CNT_1400-1800_AB	Sum of counts between 2:00PM-6:00PM; AB direction
CNT_1400-1800_BA	Sum of counts between 2:00PM-6:00PM; BA direction
SPD_XXXX_AB	Average speed over a 15-minute period in the AB direction where XXXX represents the time in military format (e.g., CNT_0830_AB is the count from 8:30AM-8:45AM in the AB direction)
SPD_XXXX_BA	Average speed over a 15-minute period in the BA direction where XXXX represents the time in military format (e.g., CNT_1645_BA is the count from 4:45PM-5:00PM in the BA direction)
SPD_0700-0900_AB	Average speed between 7:00AM-9:00AM; AB direction
SPD_0700-0900_BA	Average speed between 7:00AM-9:00AM; BA direction
SPD_1400-1800_AB	Average speed between 2:00PM-6:00PM; AB direction
SPD_1400-1800_BA	Average speed between 2:00PM-6:00PM; BA direction
TAZ_ATYPE_CBD	1 if count is located in or on the boundary of a TAZ where ATYPE_NAME = CBD
TAZ_ATYPE_External Connec	1 if count is located in or on the boundary of a TAZ where ATYPE_NAME = External Connec
TAZ_ATYPE_Resort Corridor	1 if count is located in or on the boundary of a TAZ where ATYPE_NAME = Resort Corridor
TAZ_ATYPE_Rural	1 if count is located in or on the boundary of a TAZ where ATYPE_NAME = Rural
TAZ_ATYPE_Suburban	1 if count is located in or on the boundary of a TAZ where ATYPE_NAME = Suburban
TAZ_ATYPE_Urban	1 if count is located in or on the boundary of a TAZ where ATYPE_NAME = Urban
TAZ_KFACT_DIST_X	1 if count is located in or on the boundary of K-Factor District X, where X ranges from 0 to 24
Count_Weight_AM	Weight assigned to count in the AM period
Count_Weight_PM	Weight assigned to count in the PM period


Table 6-4. Description of Count Fields in Segments Layer

► To Review and Update Traffic Count Data

1. Make *Segments* the working layer by choosing it in the drop-down list on the *Standard* toolbar and click on  to open a dataview. Alternatively, right-click on the *Segments* layer in the *Display Manager* and choose *New Dataview*.
2. Scroll to the desired field and review the data.
3. You can also click on the *Info* button  and click on a segment to open an *Info* dataview to review the data for a specific segment.

The current traffic counts are largely from 2015 with a few counts from 2017 (namely, those from the Southern Nevada Traffic Study, or SNTS). In the future, as additional traffic count data become available, they can be added as additional fields to the *Segments* layer.

► To Add Fields for New Traffic Count Data

1. Choose ***Dataview > Table > Modify*** or click  on the *Standard* toolbar to display the *Modify Table* dialog box.
2. Click *Add Field* to add a new field. If you add a field and either start it or end it with “AB,” then immediately add another field, TransModeler will automatically name the new field the same as the previous field but change “AB” to “BA.” For example, if you click *Add Field*, name it “ExampleAB,” and then click *Add Field* again, the new field will automatically be named “ExampleBA.”
3. Choose a *Type* from the drop-down list.
4. Click *Move Up* and *Move Down* to reorder fields. You can highlight multiple rows before clicking *Move Up* and *Move Down* to move fields up and down in a group.
5. Rename a field by clicking in the *Field Name* edit box and typing a new name. If you add new traffic count fields, you may want to append the year to the field name to differentiate counts from one year from another year.
6. See the Help topic “Modifying the Structure of a Table” for other ways to modify the table.

7.0 TransDNA DTA User's Guide

This section serves as a TransDNA DTA user's guide for RTCSNV. It describes the files, setup, and options for running mesoscopic DTA using the calibrated model created by Caliper. While the contents of this user guide deal with the specifics of running the Las Vegas models, a comprehensive description of TransDNA's mechanics, parameters, and options will be found in the TransDNA chapter of the forthcoming Travel Demand Modeling with TransCAD 9 user's guide.

TransDNA is a mesoscopic traffic simulation engine that works directly on TransCAD line layers. It can be accessed via the *TransDNA* menu in TransCAD 9.0.

The Las Vegas models cover both the AM and PM peaks, with an hour appended at the beginning to account for loading time leading up to the start of the peak period in the RTCSNV TransCAD model: 6:00-9:00 AM and 1:00-6:00 PM time periods. Separate sets of inputs have been created for each of these time periods, though they share some common files such as the line layer and network files.

This user guide covers:

- The organization and brief description of the relevant files
- A description of the road link classifications adopted by the model
- Steps to run TransDNA
- Viewing and working with standard output files
- Basic scenario analysis options

7.1 TransDNA File Organization

The TransDNA folder contains two folders and five key files. The Demand folder contains OD matrices, trip tables and historical travel time/turning delay tables for both the AM and PM periods. The Output folder is empty and will hold all output files generated by TransDNA. The demand and other files are enumerated and described below.

7.1.1 The Line Layer

The file "Links 2018-11-01.dbd" is the line layer representing the Las Vegas road network. It is a standard geographic file containing centerline geography and attributes of the nodes and links. The extent of the network is shown in Figure 7-1.

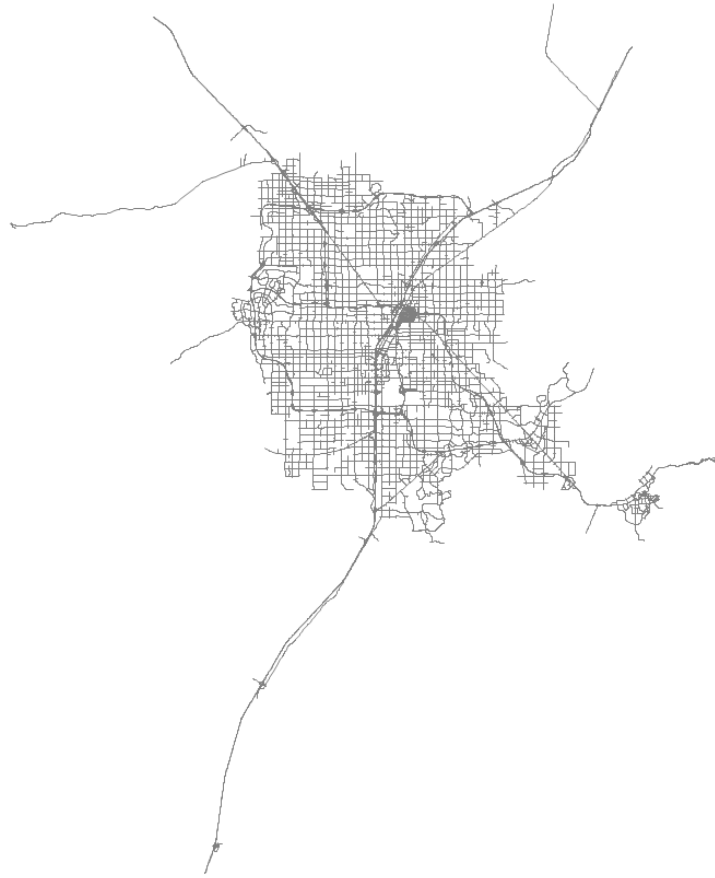


Figure 7-1. The Las Vegas line layer for TransDNA

A closer view of the link layer is shown in Figure 7-2.

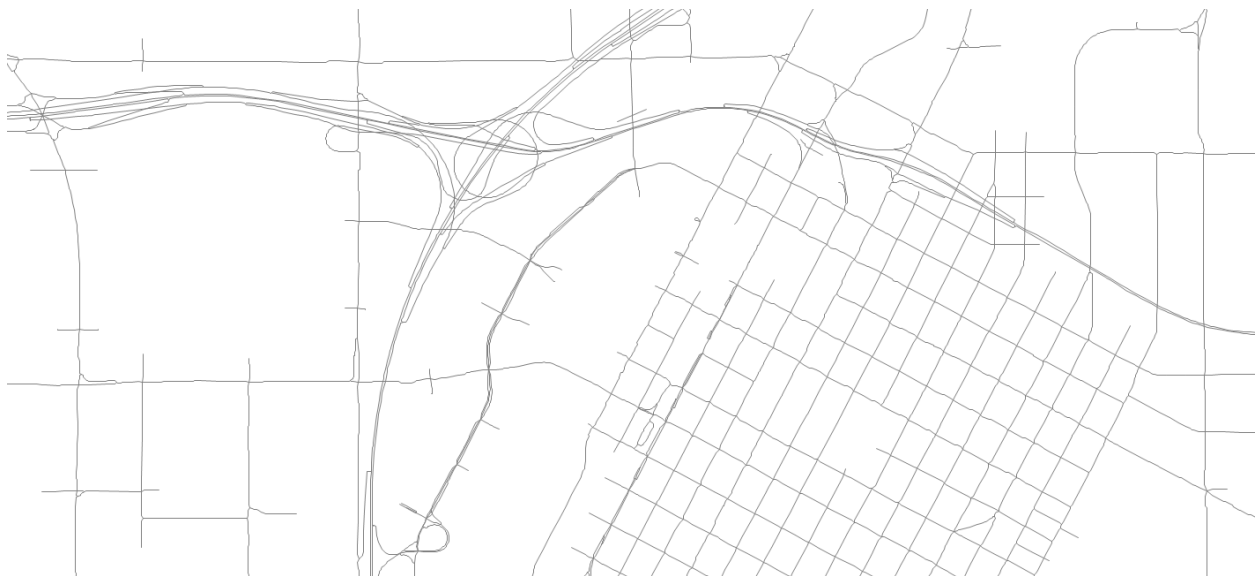


Figure 7-2. A zoomed-in view of the Las Vegas line layer in TransDNA

The link and node attributes of relevance to mesoscopic simulation are:

- Control Type
- Travel Lanes
- HOT Lanes
- Added Lanes on Left
- Left bay Length (in feet)
- Added Lanes on Right
- Right Bay Length (in feet)
- Road Class
- Free Flow Speed (in mph)
- Capacity per Lane (in vph)
- Travel Time Variability

7.1.2 The Network File

The file `Las_Vegas_Network_File.net` is a standard TransCAD network file that specifies the subset of links of relevance to the simulation. It also includes the selection of nodes that are centroids, as well as turning movement penalties to be used during the dynamic routing process.

7.1.3 The Workspace File

The `Las_Vegas.wrk` file is a TransCAD workspace. Opening this file will open the line layer in a map window and associate the network file with this map. The workspace is a convenient and quick way of loading multiple files into TransCAD in a single step.

7.1.4 The Demand Files

The Demand sub-folder contains a set of OD matrices for each of the AM and PM simulation periods. The time period appears as a prefix to each file. The DA, SR2, SR3, TRK – ST and TRK – TT files are matrix files containing the TAZ-to-TAZ vehicle trip volumes for drive-alone (single occupancy), shared ride (double or higher occupancy) and truck (short and trailer) vehicles. These files will be disaggregated into a list of individual vehicle trips at the start of the DTA. During this stage, each trip is assigned additional attributes as necessary, such as driver value of time, driver group and vehicle class. TransDNA will save this trip list to a TransCAD binary table (*.BIN), which may then be directly loaded for future simulations without having to re-compute the trip characteristics and paths from the OD matrices.

7.1.5 The TransDNA Project Files

A TransDNA project file has a .DNA extension and is used to store settings pertaining to TransDNA assignments. Two such files, `LasVegas_AM.DNA` and `LasVegas_PM.DNA`, have been created for the AM and PM models, respectively. A project file can be loaded into TransCAD to read in the pre-generated settings for the desired scenario. The settings can then be reviewed, modified and saved through the *Scenario Manager* dialog box (Section 7.3).

7.2 Road Link Classification and Speed-Density Functions

TransDNA needs to know each link's type so that its performance under various traffic conditions can be accurately inferred during simulation. The `AB_RoadClass` and `BA_RoadClass` fields in the line layer contain numeric codes pertaining to various road classes, whose definitions can be found by choosing *TransDNA-Parameters > Edit Road Classes*.

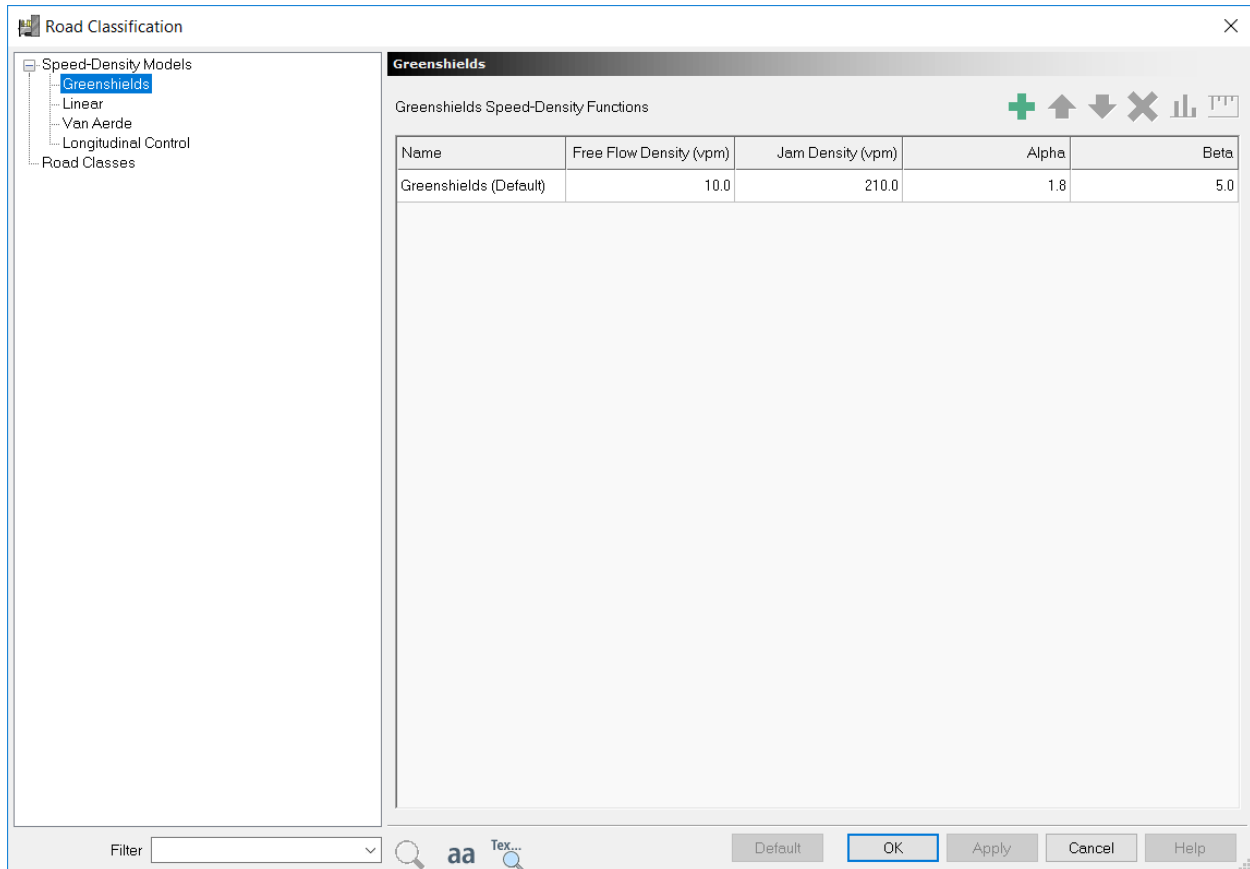


Figure 7-3. The Road Classification Dialog Box in TransDNA

Each road class is associated with a speed-density function that is used to compute the average vehicle speed for the prevailing traffic density. Many mathematical function forms have been proposed in the literature for the speed-density function. While four such functions are available in TransDNA, the Greenshields model is the most widely used and well-tested. Refer to the Travel Demand Modeling with TransCAD user manual for details about these functions.

Each speed-density equation is associated with a set of parameters that determine its shape, and consequently, its response and sensitivity to evolving traffic density. The *Road Classification* dialog box displays the default parameters for each speed-density function form, including the Greenshields function. In addition, TransDNA comes with default parameters for several link types, calibrated against real-world speed and density (detector occupancy) data. Click on *Road Classes* in the left pane to view these parameters and road classes (Figure 7-3).

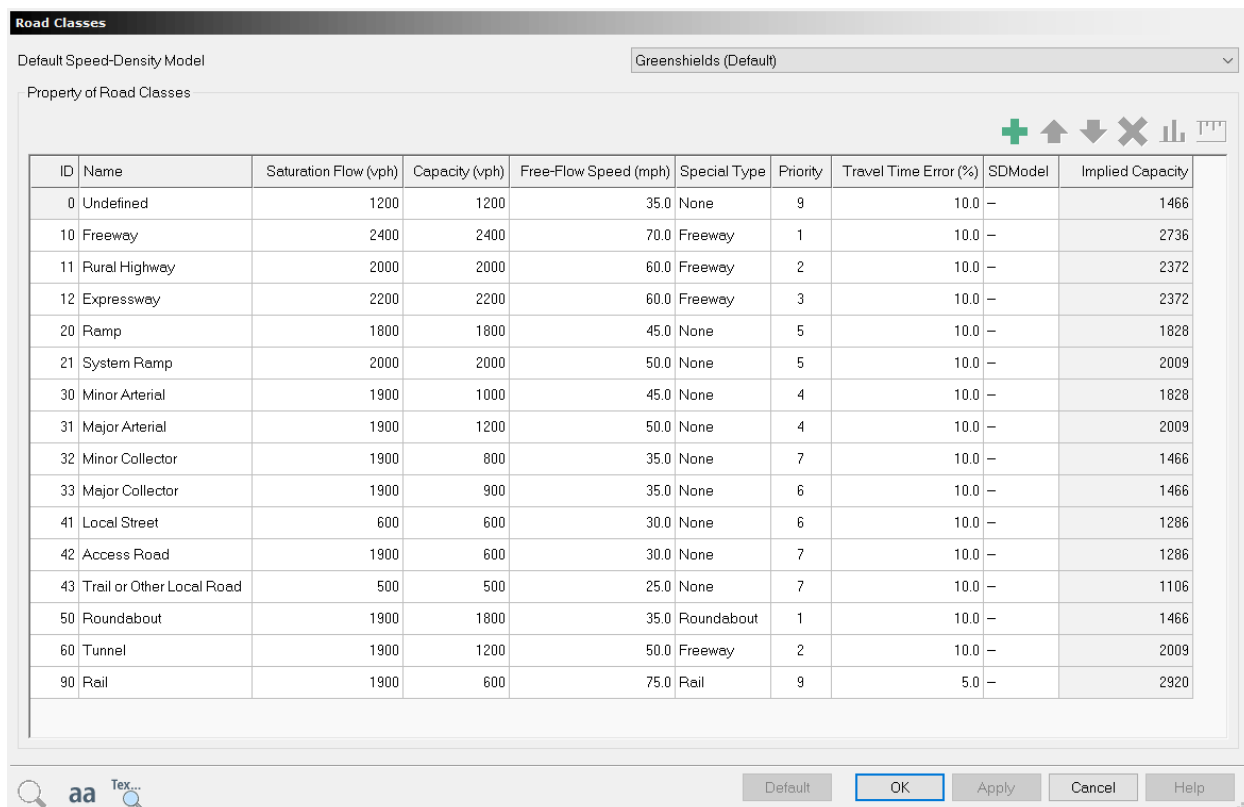


Figure 7-4. Speed-Density Model Parameters in TransDNA

The AB_RoadClass and BA_RoadClass values are matched with the IDs in the ID column in Figure 7-4 to map the links to their relevant TransDNA speed-density functions.

7.3 How to Perform a DTA in TransDNA

A DTA is run in TransDNA by loading a TransDNA Please refer to the TransDNA chapter in the TransCAD planning manual for a more detailed description of the various simulation options.

► To Run the DTA Model in TransDNA from a Cold Start

1. Choose **File > Open Workspace** and choose Las_Vegas.wrk. If the workspace has been deleted, you can recreate it by opening the line layer (Links 2018-11-01.dbd), dragging the network file (Las_Vegas_Network_File.net) onto the open map, and saving the workspace through the **File > Save Workspace As** menu.
2. TransDNA is accessed through the *TransDNA* menu. Choose **TransDNA > Scenario Manager** to open the *Scenario Manager* dialog box.
3. Click *Load* and browse out a TransDNA project file (.DNA). The AM and PM files have already been created for this dataset. TransCAD will load the settings in the dialog box.

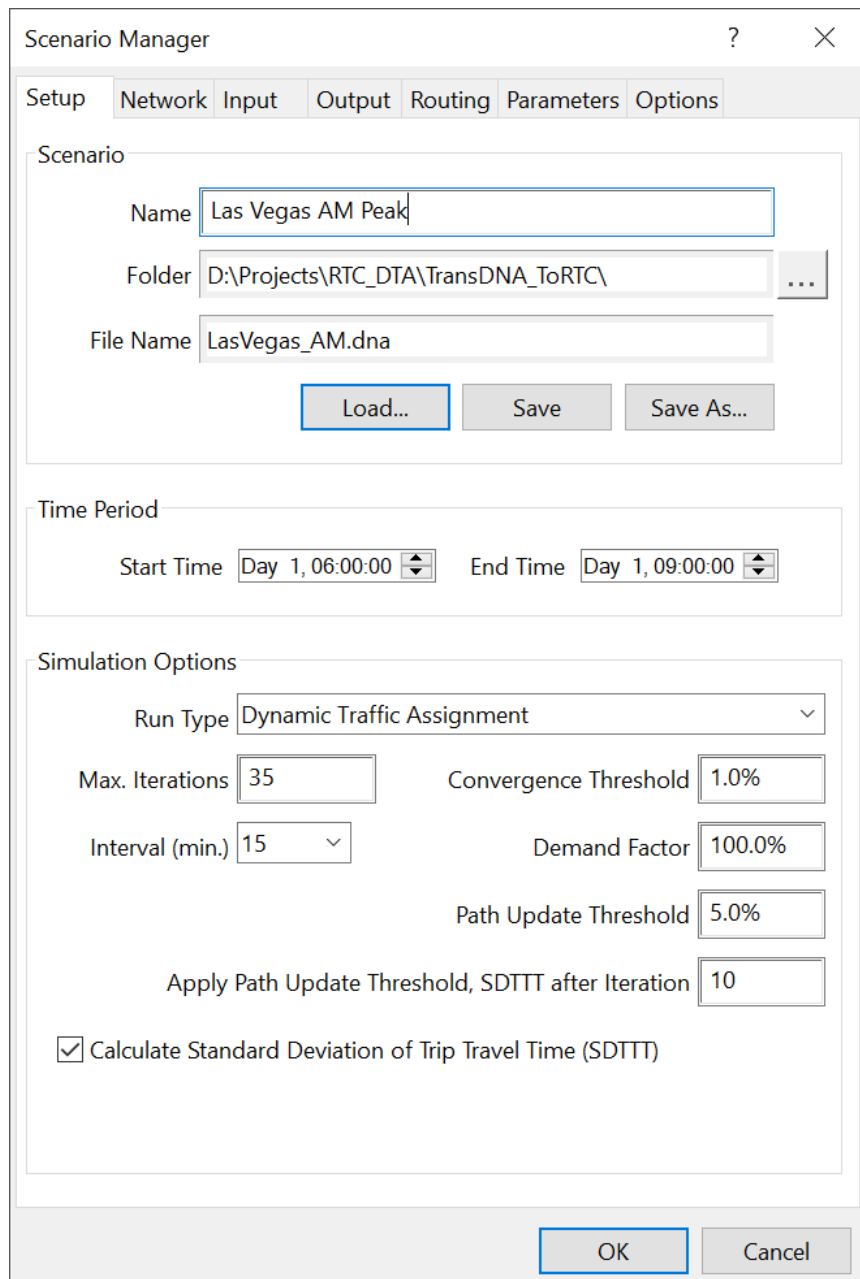





Figure 7-5. The Scenario Manager Dialog Box in TransDNA

4. The *Settings* tab contains information pertaining to the high-level parameters of the scenario.
 - a. The *Name* and *Folder* boxes indicate the scenario name and the location of the data folder for this scenario.
 - b. The *Time Period* frame indicates the start and end times of the simulation.
 - c. The *Simulation Options* frame lets you choose the simulation mode and its associated parameters. The calibrated dataset is configured for Dynamic Traffic Assignment (DTA). One-shot simulation and batch simulation may also be performed once the model has already been calibrated.

5. The *Network* tab contains information about centroids and link attributes:
 - a. The *Network* frame displays the current active network (.NET) file. This is only for information. If you wish to change the network file, you can either drag the new file onto the map or use **Networks/Paths > Drop** followed by **Networks/Paths > Settings** to add a new file. You can also create a network file from scratch using **Networks/Paths > Create**.
 - b. Use the *Link Fields* frame to view the line layer attributes that are currently being used in the scenario.
6. The *Input* tab contains information about the travel demand, signals and tolls.
7. The *Output* tab lets you specify the folder location for all TransDNA output files. You can also enter the time interval width for output data collection and choose settings for the dynamic color theme for visual inspection during a simulation run.
8. The *Routing* tab allows you to choose historical link travel time and turning movement delay tables if they exist from a previous TransDNA run.
9. The *Parameters* tab allows you to choose the node discharge model to be used. If you have made changes to the speed-density functions or road classes, you can choose those modified parameter and road class files. You can also control the vehicle movement and network state update step sizes if you wish to test the impacts of these parameters in running time and model accuracy.
10. The *Options* tab lets you slow down the speed of the simulation (if necessary), fix the random seed (for example, if you wish to reproduce identical results across runs) and set the units of measurement.
11. Click OK. TransCAD will open the TransDNA toolbar (7.4).
12. Click the play button  and choose the output file location(s) to start the DTA.

► To Run the DTA Model in TransDNA from a Warm Start


1. Choose **TransDNA > Scenario Manager** to open the *Scenario Manager* dialog box.
2. Click the *Routing* tab.
3. Click the  and choose a historical travel time table produced from an earlier DTA (Section 7.5.3).
4. Click OK. The settings will be processed to ensure consistency before the TransDNA toolbar is displayed at the bottom of the TransCAD window:
5. Click the play button  and choose the output file location(s) to start the DTA.








7.4 The TransDNA toolbar

You can use the TransDNA toolbar to control the simulation and interact with the network links (Figure 7-6).



Figure 7-6. The TransDNA Toolbar

- Use the pause toggle button  to temporarily halt the simulation. Press the button again to resume the simulation.

- Press the stop button  to terminate the current run.
- Press the Stopwatch button  to have the simulation pause when it reaches a specific time in the future.
- The Time window indicates the current temporal position of the simulation.
- The Time Factors windows indicate the desired and actual running time speeds, represented as a multiple of the real-time clock. An actual time factor of 20, for instance, indicates that the simulation is running 20 times faster than real-time.
- The  and  buttons allow you to slow down and speed up the simulation.
- The four Vehicles windows show the number of vehicles in the network, vehicles in queue, completed trips and remaining trips respectively.
- The Chart Link Info button  allows you to click on a link to query its traffic state evolution from the start of the simulation. If you have made multiple runs, you can use the Choose Run button  to set the specific run for which you want to query the links.
- The Show Warnings button  opens a browser window with any warnings generated during the simulation. You can review this file to trouble-shoot network, path and demand issues.

7.5 Working with TransDNA Outputs

TransDNA displays its DTA outputs in three different ways.

7.5.1 Visualizing Network Performance Dynamically in TransDNA

You can interact with the live simulation via the map by viewing the dynamic color theme. You can pan and zoom the map to focus on areas of interest (Figure 7-7).

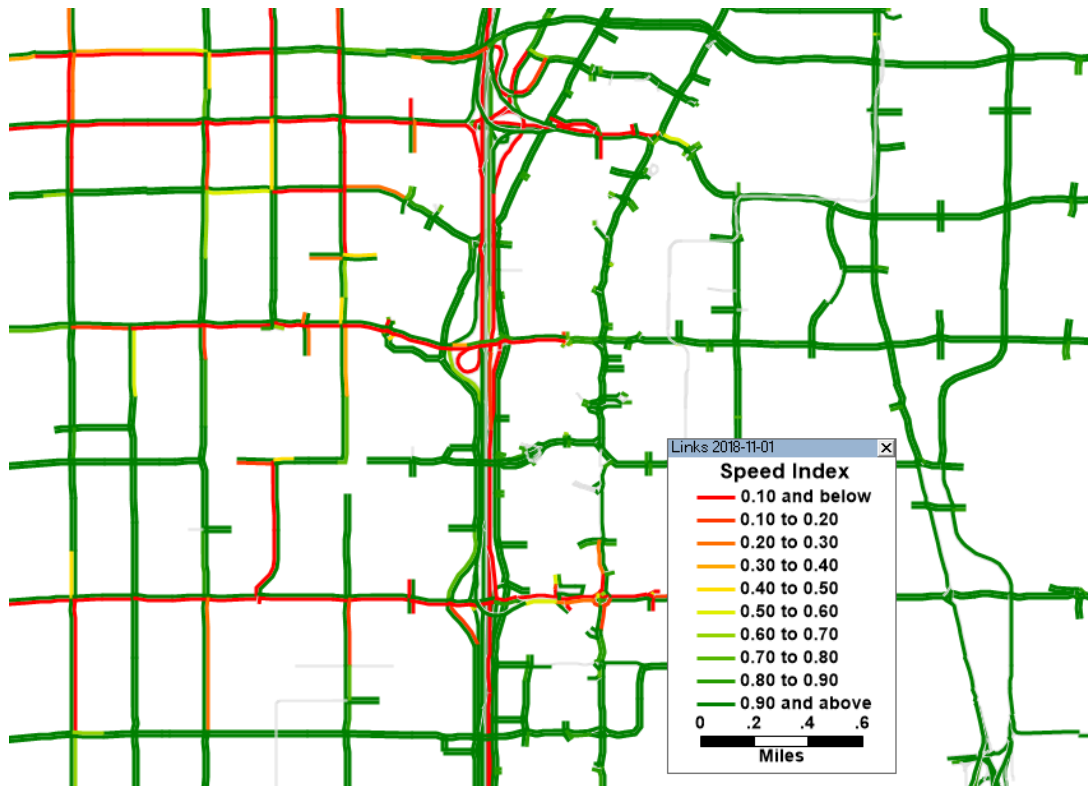


Figure 7-7. A Dynamic Color Theme in TransDNA

Use the scenario manager to change the settings for the theme display. For instance, you can control the refresh rate of the theme to change the frequency with which the theme is updated with the latest simulation results. By default, the theme refreshes every 5 seconds (Figure 7-8).

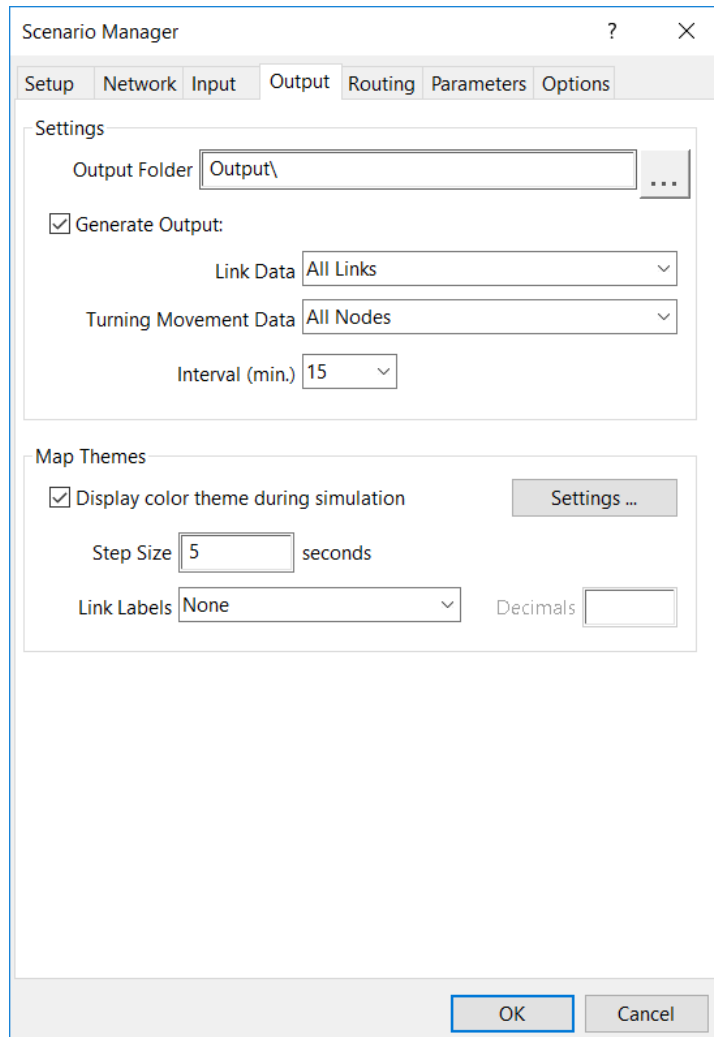


Figure 7-8. Dynamic Theme Settings in the TransDNA Scenario Manager

Click the *Settings* button in the *Map Themes* frame to make more detailed theme setting choices. You can choose different fields to determine the thickness and color of the theme. The width is set to a fixed width by default. Use the *Fields* drop-down list in the *Width* frame to choose a field.

The color theme displays the speed index by default. The speed index of a link is its prevailing speed divided by its free-flow speed, which normalizes the speed to fall between 0 and 1. This speed index is potentially easier to interpret than speed, as it provides a comparison to the maximum possible speed on the link.

Use the *Fields* drop-down list in the *Color* frame to choose from speed, density, and speed index (i.e., speed divided by free flow speed). You can also choose the color palette by choosing the colors for the two ends of the range and one via point (Figure 7-9).

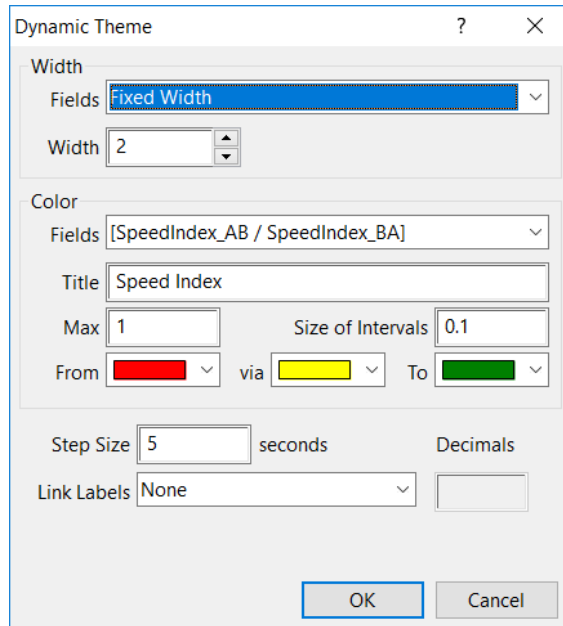


Figure 7-9. Dynamic Theme Settings During Assignment

The *Dynamic Traffic Assignment* dialog box displays the progress of the DTA by iteration (Figure 7-10).

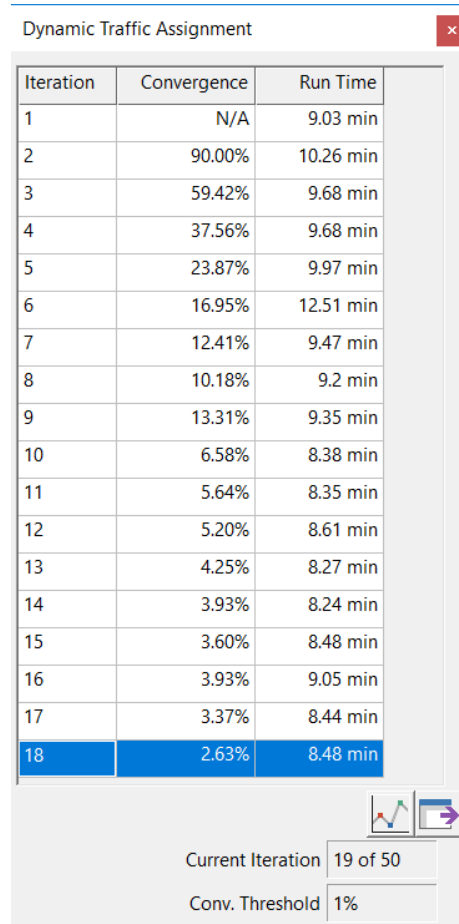



Figure 7-10. DTA Progress by Iteration in TransDNA

Each row contains the iteration number, convergence metric and the run time for that iteration. Convergence is measured as a consistency between the input travel times to drivers at the start of the iteration, and those they experienced during the simulation. The run time estimates the total time taken for each iteration, including both the network loading and the process of updating individual drivers' route choices before the start of the next network loading.

Click the *Chart Convergence* button  to chart the progress of the DTA (Figure 7-11).

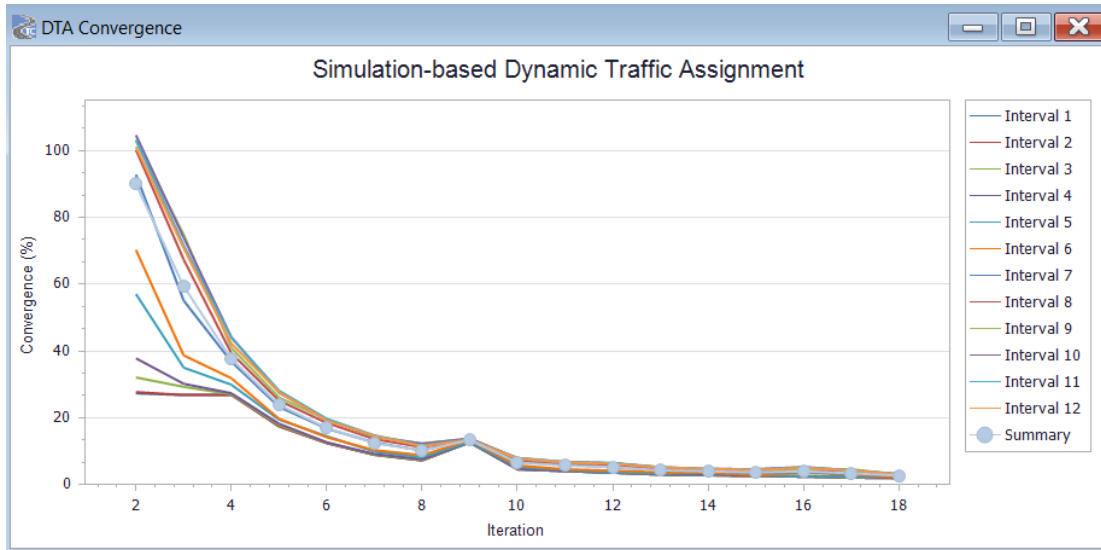




Figure 7-11. Chart of DTA Convergence by Interval and Iteration

Click the *Save to File* button  to save the numerical convergence data to a table (.BIN file).

7.5.2 Charting Individual Link Performance in TransDNA

You can also query a link's evolving traffic pattern, obtaining charts of its traffic flow, speed and density up to the current time. Choose the *Chart Link Info* button  in the TransDNA toolbar (Section 7.4), and then click on the desired link in the map to generate a set of three charts for that link (Figure 7-12).

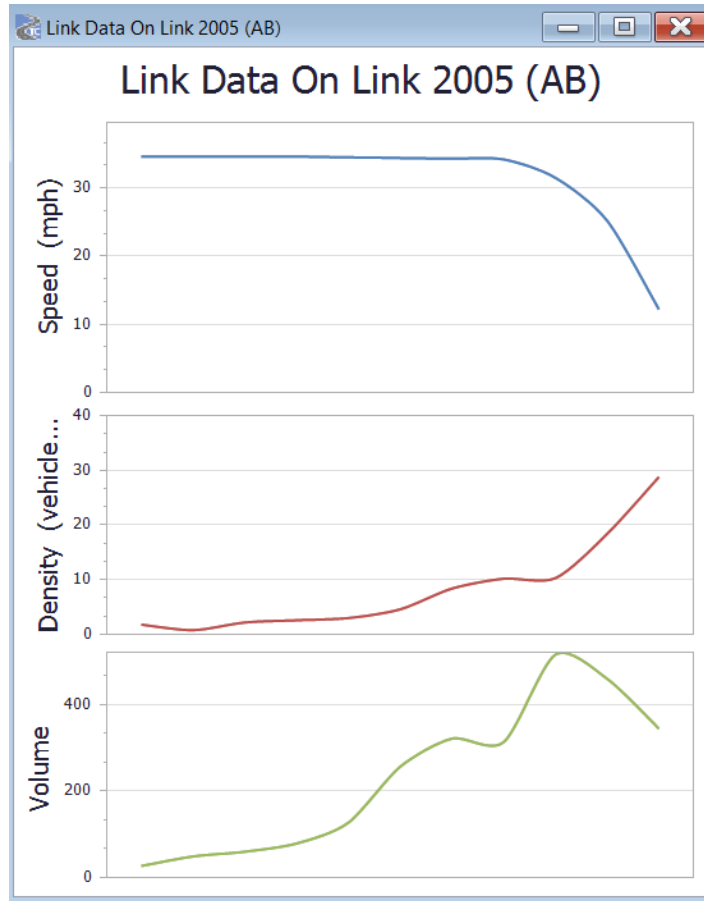


Figure 7-12. A Chart Depicting Link Performance in TransDNA

7.5.3 Reviewing DTA Output Files in TransDNA

TransDNA also writes out various files that you can review and process for further analysis. These files are written into a time-stamped sub-folder within the output folder:

- A table of convergence metrics by departure time interval and for each DTA iteration, stored in DTA Convergence.bin.
- Time-dependent outputs of link performance (volume, speed, density, spillback, travel time and delay), stored in LinkInfo_{iteration number}.bin.
- Time-dependent outputs of turning movement travel times and delays, stored in NodeInfo_{iteration number}.bin.

Once the DTA run is completed, the following files are written into the main output folder:

- The final time-dependent link counts and travel times, in Historical Travel Times.bin.
- The final turning movement counts and delays, in Historical Travel Times_.bin.
- The final LinkInfo file, copied into Link Volumes.bin.
- The final NodeInfo file, copied into Turning Volumes.bin.

Historical Travel Times.bin and Historical Travel Times_.bin can be used to warm-start a new DTA from the results of a prior DTA run (Section 7.3).

7.6 Scenario Analysis with TransDNA

TransDNA currently supports a range of popular scenario analyses including changes to the demand, number of left-turning, through and right-turning lanes, turn bay lengths, free-flow speeds, capacities and link performance functions. Given the mesoscopic nature of the simulation, the modeler must map/reduce specific scenarios to more aggregate but direct model inputs such as those listed above. An expansion of TransDNA's feature set is currently in progress and will be released as they become available for general use in the software.