Analysis, Modeling, and Simulation (AMS) Testbed Development and Evaluation to Support Dynamic Mobility Applications (DMA) and Active Transportation and Demand Management (ATDM) Programs

Calibration Report - Pasadena

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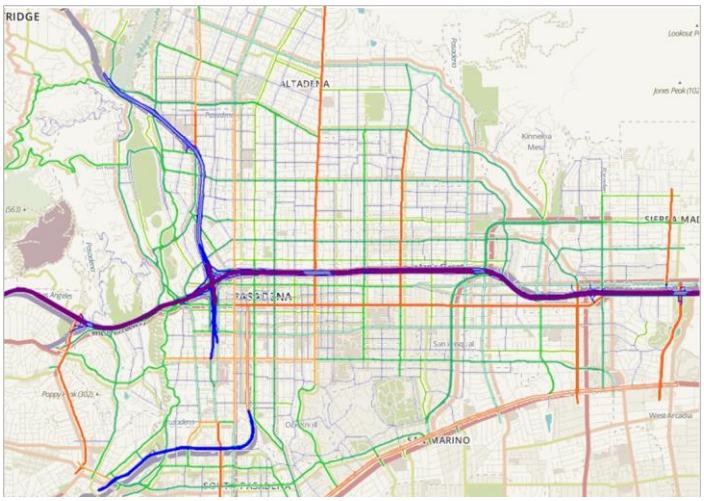

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16. Abstract

The primary objective of this project is to develop multiple simulation testbeds/transportation models to evaluate the impacts of DMA connected vehicle applications and the active transportation and demand management (ATDM) strategies. The primary purpose of this report is to document the calibration process for AMS Pasadena Testbed. The report expands on detailed testbed description including the geographic location, modes, operational conditions and cluster analysis details. The report discusses the field observed data and the calibration targets used to calibrate the simulation models. Listed in this report are also the margins of error for each calibration effort for each baseline model. The simulation models were calibrated to three specific operational conditions using the following performance measures: hourly freeway volumes, speed profile and travel times.

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Chapter 1. Introduction

This report documents the Pasadena Testbed team's efforts to calibrate the traffic simulation model so that it represents the operational conditions in the testbed area. The cluster analysis results were used to derive the model area's representative traffic operational data.

The testbed team applied the multi-resolution modeling approach to model the urban travels within and throughout this area. Using the citywide dynamic traffic assignment (DTA) modeling work by the City of Pasadena, the team developed the testbed area model network and base demand patterns using a sub-area network generation process. The testbed microscopic simulation VISSIM model is then initialized from the same sub-area network. Much of the city's DTA model dataset, such as traffic counts and arterial travel time measurements, were also inherited for the testbed VISSIM model calibration and validation. The TRANSIMS network was developed by exporting then converting the VISSIM network file. TRANSIMS network was calibrated at both the macro and mesoscopic level of resolution.

This report describes the procedure used to calibrate the network to three operational conditions identified during the cluster analysis process. These conditions are:

1. High demand, low to medium incident frequency/severity, medium corridor travel times
2. Medium to high demand, high incident frequency/severity, medium or low corridor travel times
3. High demand, medium incident frequency/severity, high corridor travel times.

This report is organized into six chapters as follows:

- **Chapter 1 – Introduction:** This chapter presents the report overview and objective.
- **Chapter 2 – Data Collection for Model Calibration:** This chapter presents the data collection source, the results of the cluster analysis, proposed operational conditions, and selected baseline scenarios.
- **Chapter 3 – Pasadena Testbed Multi-Resolution Model Calibration:** This chapter presents the calibration approach, thresholds from National Cooperative Highway Research Program (NCHRP) 255 used to validate the simulation model and model comparison to field observed performance.
- **Chapter 4 – TRANSIMS Calibration:** This chapter presents the calibration methodology used for the TRANSIMS mesoscopic models.
- **Chapter 5 – Simulation Integration:** This chapter discusses the strategies and integration process between VISSIM and TRANSIMS.
- **Chapter 6 – Conclusion:** This chapter discusses the conclusions of the calibration process and highlights the limitations presented.

Chapter 2. Data Collection for Model Calibration

2.1 Testbed Model Initialization from City's DTA Dataset

The Pasadena Testbed model dataset was initialized from the city's dynamic traffic assignment (DTA) model, which was based on the live traffic simulation system built in 2011 under USDOT contract DTFH6111C00038 (data environment and report accessible from www.its-rde.net). Please note that, from Figure 2-1, the testbed network is a sub-area that contains the major E-W freeway corridors (I-210/CA-134) and part of the city's downtown area. This dense urban network covers 11 square miles.

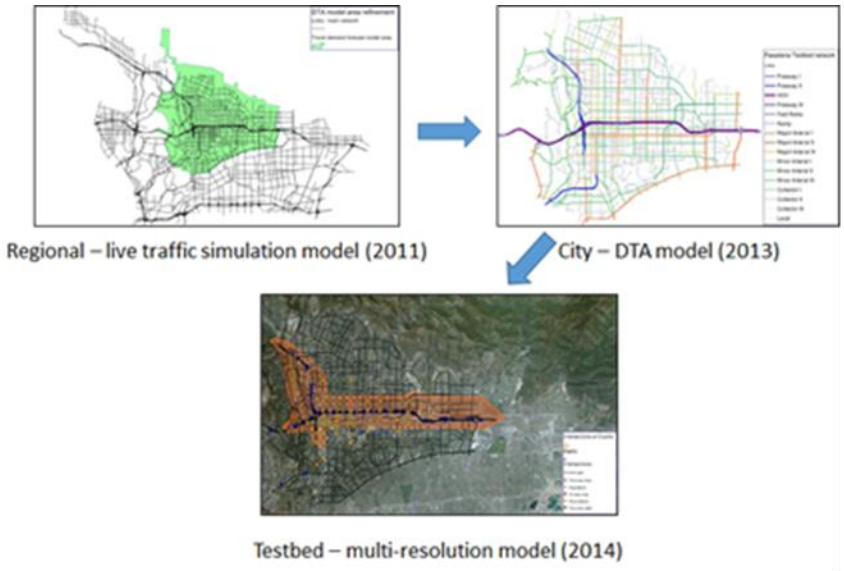


Figure 2-1: Pasadena Testbed Model Initialization from Previous Modeling Efforts in the Region [Source: Heusch Boesefeldt America (HBA)]

The initial testbed model dataset included the following modeling components:

1. Network topology, model parameters and attributes, traffic control:
    - Link and turn relations, and link types (e.g., HOV lanes)
    - Link capacities, free flow speeds, number of lanes, and fundamental diagrams for link flow dynamics
    - Intersection control types, lane grouping and layout, and control data (Figure 2-2)
2. Travel demand input
    - User classes (or *demand segments*) by high occupancy vehicles (HOV) and single occupancy vehicles (SOV)
    - Cellular phone trajectory based hourly demand origin-destination matrices.

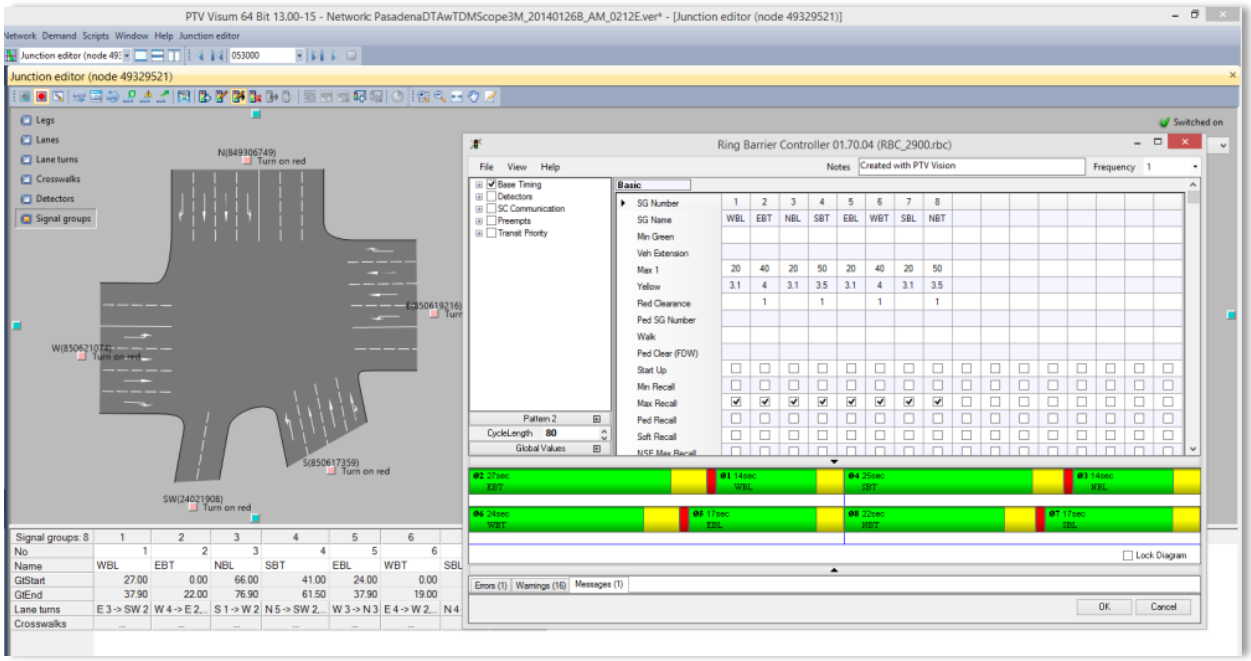


Figure 2-2: Example Intersection Geometric and Control data: Colorado Street and Lake Avenue [Source: HBA]

In addition, a considerable number of calibration data were also inherited from the city's DTA model, as shown in Figure 2-3 and Figure 2-4.

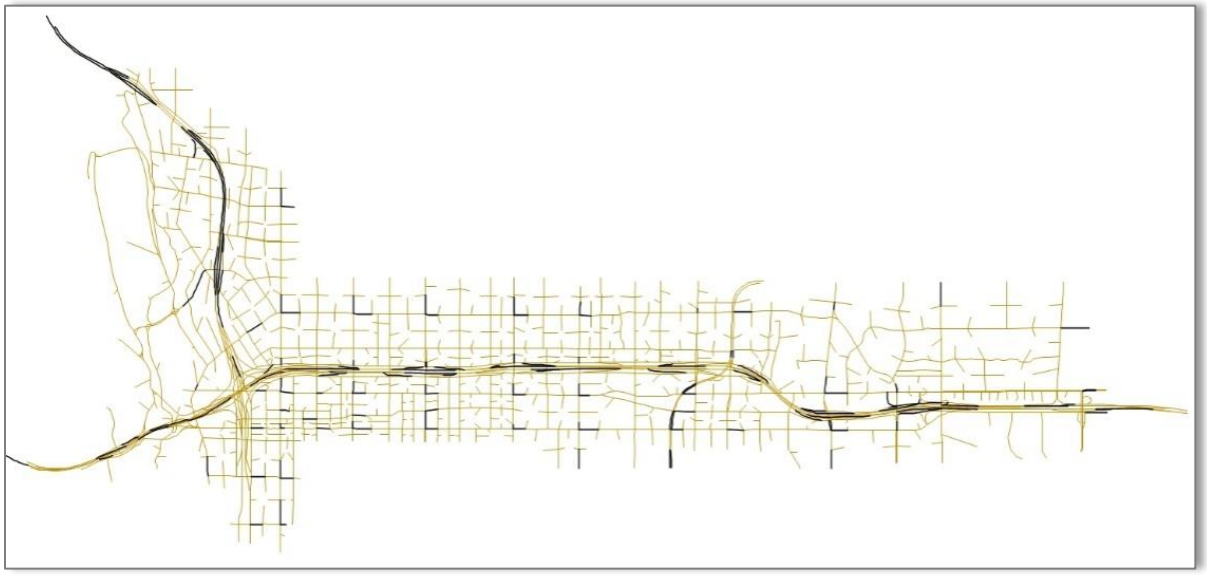


Figure 2-3: Calibration Dataset in the Testbed Area Highlighted Links with Hourly Traffic Counts, in Total 226 Locations Including Urban Streets and Caltrans PeMS Stations [Source: HBA]

Note that only one PM peak period value was reported for urban arterial corridor travel times. Other support data from past transportation studies suggested that these corridors have flat travel speed/travel times during the entire PM peak period. For freeways with PeMS data archives, their travel times were aggregated from vehicle detection station (VDS) data over each model hour.

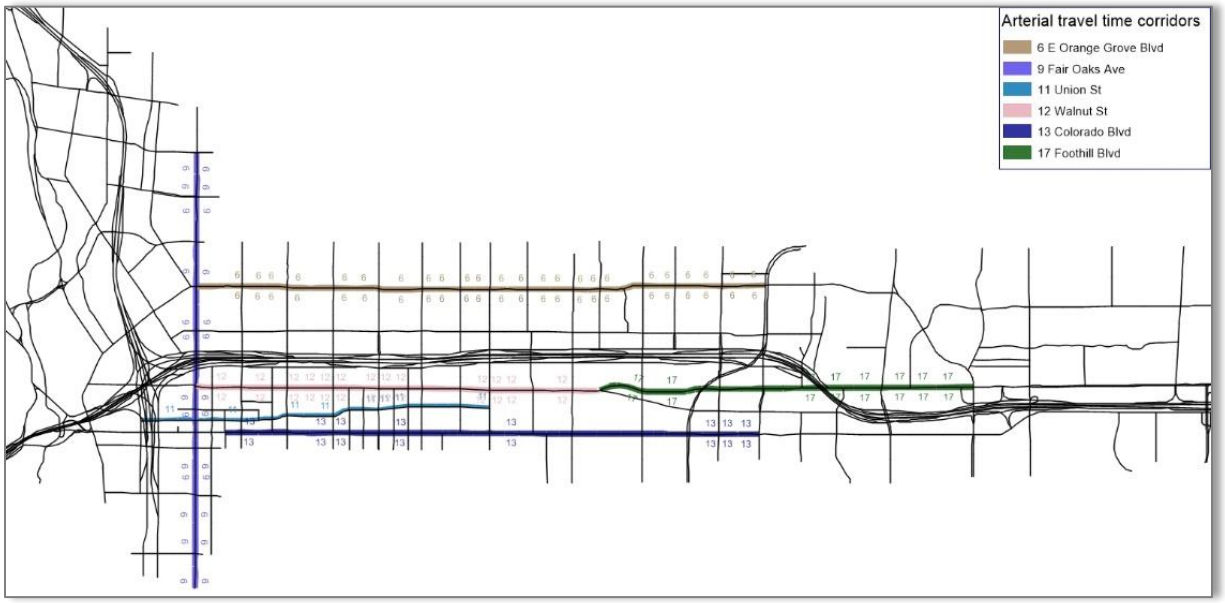


Figure 2-4: Calibration Dataset in the Testbed Area: Arterial Corridors with Travel Time Measurements [Source: HBA]

Table 2-1 summarizes the testbed model (PM) statistics.

Table 2-1: Testbed Model Statistics

Model objects	Statistics
Nodes	1621
Signals	189
Links (directional)	3310
Links (bi-directional)	1939
Zones (total)	288
Zones (external)	90
Vehicles (OD total) hour1500	82,000
Vehicles (OD total) hour1600	84,000
Vehicles (OD total) hour1700	90,000
Vehicles (OD total) hour1800	77,000

2.2 Modeling Operational Conditions: Customization from Cluster Analysis

2.2.1 Identifying the Most Representative Day for the Operational Conditions from Cluster Analysis

The cluster analysis works as follows: using the continuous data archive on Caltrans PeMS data portal and weather data sources (www.wunderground.com), the Pasadena Testbed team could assemble a dataset for one-year worth of data (June 1, 2013 through May 31, 2014; 363 days in total, excluding two days with missing data). This comprehensive dataset included traffic flow rates, weather, bottleneck throughput, and freeway corridor travel times. These datasets were organized into a vector of nine data attributes by direction of travel, peak periods (6AM-9AM, 3PM-7PM), and day:

- Vehicle miles traveled, by direction (I-210 EB/WB)
- Travel times, by direction (I-210 EB/WB)
- Incidents, by total number of incidents during the peak periods, incident frequency (by day), and severity by average incident duration
- Precipitation, by peak period totals.

Table 2-2 and Table 2-4 show the cluster analysis results for the AM and PM peaks, respectively referenced from the Analysis, Modeling, and Simulation (AMS) Analysis Plan for the Pasadena Testbed report. Table 2-3 and Table 2-5 list the descriptions for the AM and PM peak clusters from the analysis using details from the list above.

Table 2-2: AM Peak Period (6-9AM) Cluster Analysis Results

Cluster	1	2	3	4	5	6	7	8	9
No. Records	47 (13%)	82 (23%)	31 (9%)	9 (2%)	7 (2%)	57 (16%)	8 (2%)	46 (13%)	76 (21%)
VMT EB (mi)	177863	171566	164733	92133	124032	65961	144639	109565	181184
VMT WB (mi)	192502	200069	191652	91819	145631	57488	167292	108892	204035
TT EB (min)	8.49	9.22	9.40	8.18	9.42	8.06	7.73	8.49	8.46
TT WB (min)	10.90	11.65	10.85	8.58	9.92	8.62	8.79	8.96	10.82
Total No. Incidents	124	70	38	8	1	33	31	28	131
Total Incident Duration (min)	4298	1366	1169	671	10	670	808	789	3631
Incident Frequency (Incidents/day)	2.64	0.85	1.23	0.89	0.14	0.58	3.88	0.61	1.72
Incident Severity (Avg. Incident Duration)	34.66	19.51	30.76	83.88	10.00	20.30	26.06	28.18	27.72
Precipitation (in)	0.000	0.000	0.000	0.000	0.003	0.000	0.038	0.000	0.000

(Low values have green text, average values have black text, and high values have red text.)

Table 2-3: AM Peak Period Cluster Descriptions

Cluster	Percentage of Year in Cluster	Description
1	13%	High Demand, High Incident Frequency, High Incident Severity, Weekdays
2	23%	High Demand, Low Incident Frequency, Low Frequency Severity, Weekdays
3	9%	Medium to High Demand, Weekdays
4	2%	Low Demand, Low Incident Frequency, High Incident Severity
5	2%	Medium Demand, Low Incident Frequency, Low Incident Severity
6	16%	Low Demand, Low Incident Frequency, Low Incident Severity, Sundays
7	2%	Medium to High Demand, High Incident Frequency, Rain (1 day, 0.30 inches total)
8	13%	Medium Demand, Low Incident Frequency, Saturdays
9	21%	High Demand, Weekdays, medium incident frequency and duration

Table 2-4: PM Peak Period (3-7PM) Cluster Analysis Results

Cluster	1	2	3	4	5	6
No. Records	49 (13%)	16 (4%)	115 (32%)	51 (14%)	76 (21%)	56 (15%)
VMT EB (mi)	215240	192914	258823	235390	243383	224525
VMT WB (mi)	233468	204825	262669	242130	265283	258573
TT EB (min)	11.17	8.90	11.97	11.92	16.14	19.20
TT WB (min)	9.89	9.05	9.95	9.79	10.71	11.21
Total No. Incidents	116	30	260	143	192	145
Total Incident Duration (min)	3207	560	7862	4453	5942	4289
Incident Frequency (Incidents/day)	2.37	1.88	2.26	2.80	2.53	2.59
Incident Severity (Avg. Incident Duration)	27.65	18.67	30.24	31.14	30.95	29.58
Precipitation (in)	0.015	0.024	0.000	0.000	0.000	0.000

(Low values have green text, average values have black text, and high values have red text.)

Table 2-5: PM Peak Period Cluster Descriptions

Cluster	Percentage of Year in Cluster	Description
1	13%	Low Demand, Rain (2 days, 0.73 inches total), Sundays
2	4%	Low Demand, Low TT, Low Incident Severity, Rain (1 day, 0.39 inches total)
3	32%	High Demand, Weekdays
4	14%	Medium Demand, Saturdays
5	21%	High Demand, High EB TT, Weekdays
6	15%	Medium Demand, High EB TT, Fridays

The cluster analysis resulted in three operational conditions in the Pasadena Testbed area, which were selected from the PM peak period cluster results in Table 2-4 and Table 2-5:

- #1: High demand, low to medium incident frequency/severity, medium corridor travel times; accounting for 115 days (or 32% of the analysis horizon) represented by Cluster #3.
- #2: Medium to high demand, high incident frequency/severity, medium or low corridor travel times; accounting for 51 days (or 14% of the analysis horizon) represented by Cluster #4.
- #3: High demand, medium incident frequency/severity, high corridor travel times; accounting for 132 days (or 36% of the analysis horizon) represented by Cluster #5 and #6.

Please note that the original analysis plan for Operational Condition #2 was to use an AM peak cluster. However, due to extensive efforts used to develop the calibrated traffic simulation model for Operation Condition #1 for PM peak, the AM peak cluster that was originally considered for the original operational conditions as previously discussed and recommended in the AMS Analysis Plan for the Pasadena Testbed was infeasible. The differences in traffic patterns between AM and PM peak periods are too dissimilar. Accommodating for coding efforts on existing signal timing plans and traffic patterns for the AM peak period is unduly time consuming and infeasible.

A PM peak hour cluster with similar description to the original Operational Condition #2 recommendation was selected. A weekday representation of Cluster #4 shown in Table 2-4 was selected to substitute the original recommendation. Shown in Table 2-5 details Cluster #4 is a Saturday, but for the purpose of this testbed, the Operational Condition #2 simulation models were calibrated to a weekday representation of Cluster #4 to assess a better representation of the strategies' performances under typical traffic and better answer the research questions.

Further details on the cluster analysis process and results are provided in the AMS Analysis Plan for the Pasadena Testbed. Per the cluster analysis guide, customizing the model to reflect specific operational conditions involves identifying the data point that is closest to the centroid of the corresponding data cluster. Note that the data attributes had been normalized across the overall dataset, that is, each attribute is a scalar computed as follows:

$$Att_i = \frac{Att_{i,raw} - Att_{min,raw}}{Att_{max,raw} - Att_{min,raw}}$$

where $Att_{i,raw}$ is the raw data attribute (e.g., VMT_EB for AM or PM), $Att_{min,raw}$ and $Att_{max,raw}$ are the min and max values in the entire dataset, respectively, and Att_i is the data element in the whole data vector. Consequently, computation of the representative data point is completed by a simple three-step process to compare the Euclidean distances and identify the representative day, as defined below:

- Step 1: compute the centroid of the data cluster, by averaging over each data element within the cluster;
- Step 2: compute the Euclidean distance from each data point to the centroid from the above step:

$$d_j = \sqrt{\sum_{i=1}^{9} \left(Att_{j,i} - Att_{j,i}^{(c)} \right)}$$

where d_j is the distance for data point j, $Att_{j,i}$ is the attribute I of data point j, and $Att_{j,i}^{(c)}$is the value for centroid attribute i.

- Find the smallest $d_{j,min}$, and its corresponding data point.

A Python script was developed to implement the above steps, and run for the clusters that correspond to each of the operational conditions. The following representative days are selected:

1. December 18, 2013
2. January 6, 2014
3. November 14, 2013.

Figure 2-5 shows the cluster analysis heat-map of all clusters, and the identified date. Each cluster identification numbers are color coded by their respective cluster groups as shown in the heat scale on the right of Figure 2-5.

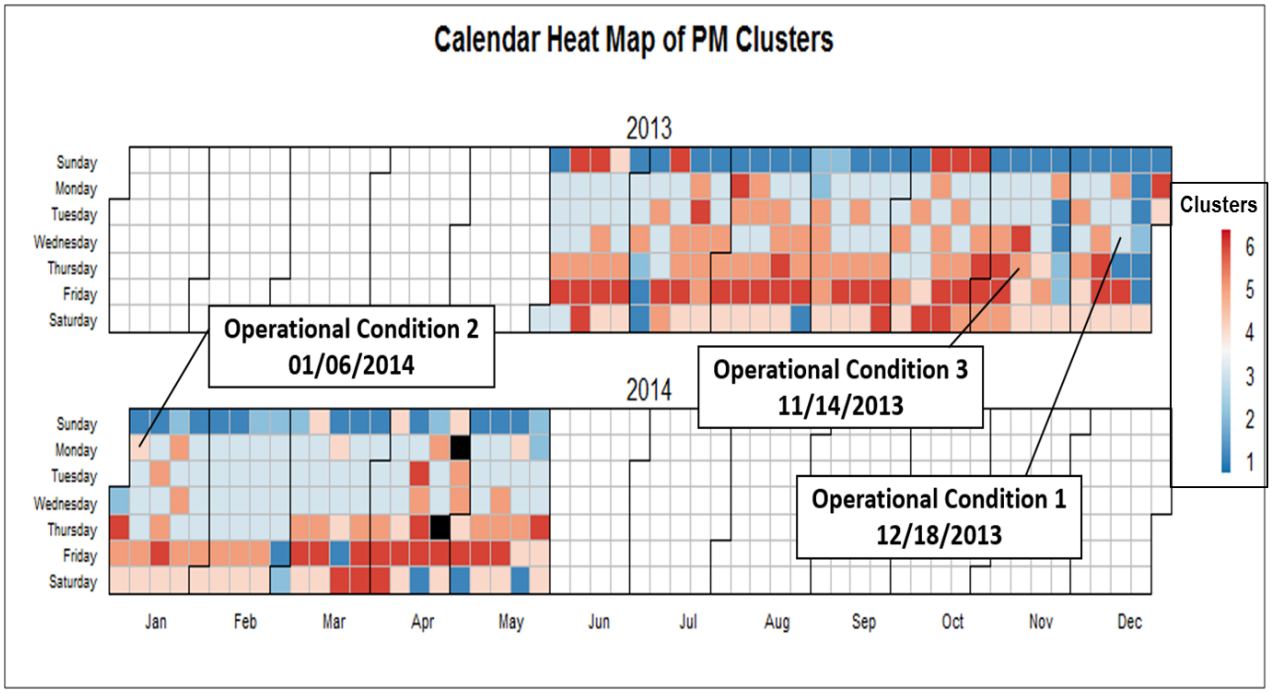


Figure 2-5: Cluster Analysis Results (PM) and Identified Representative Days. [Source: HBA]

2.2.2 Preparing the Traffic Operational Data for the Representative Day

Once the representative days are identified, the operational data for that day were collected and their modeling impact were analyzed. This effort involved interpreting the traffic impact of incidents. For each of the selected representative days, the team identified traffic incidents that were modeled into the system.

For Operational Condition #1, three incidents were reported for during the PM peak period (3-7PM) within the testbed area. Their locations were plotted on the testbed model network, and descriptions listed, as shown in Figure 2-6. Similarly, for operational conditions #2 and #3, the team analyzed the vehicle detector station data to identify the lane closures, slowdowns, and similar incidents that were modeled into the network. Figure 2-7 and Figure 2-8 shows the location of these incidents.

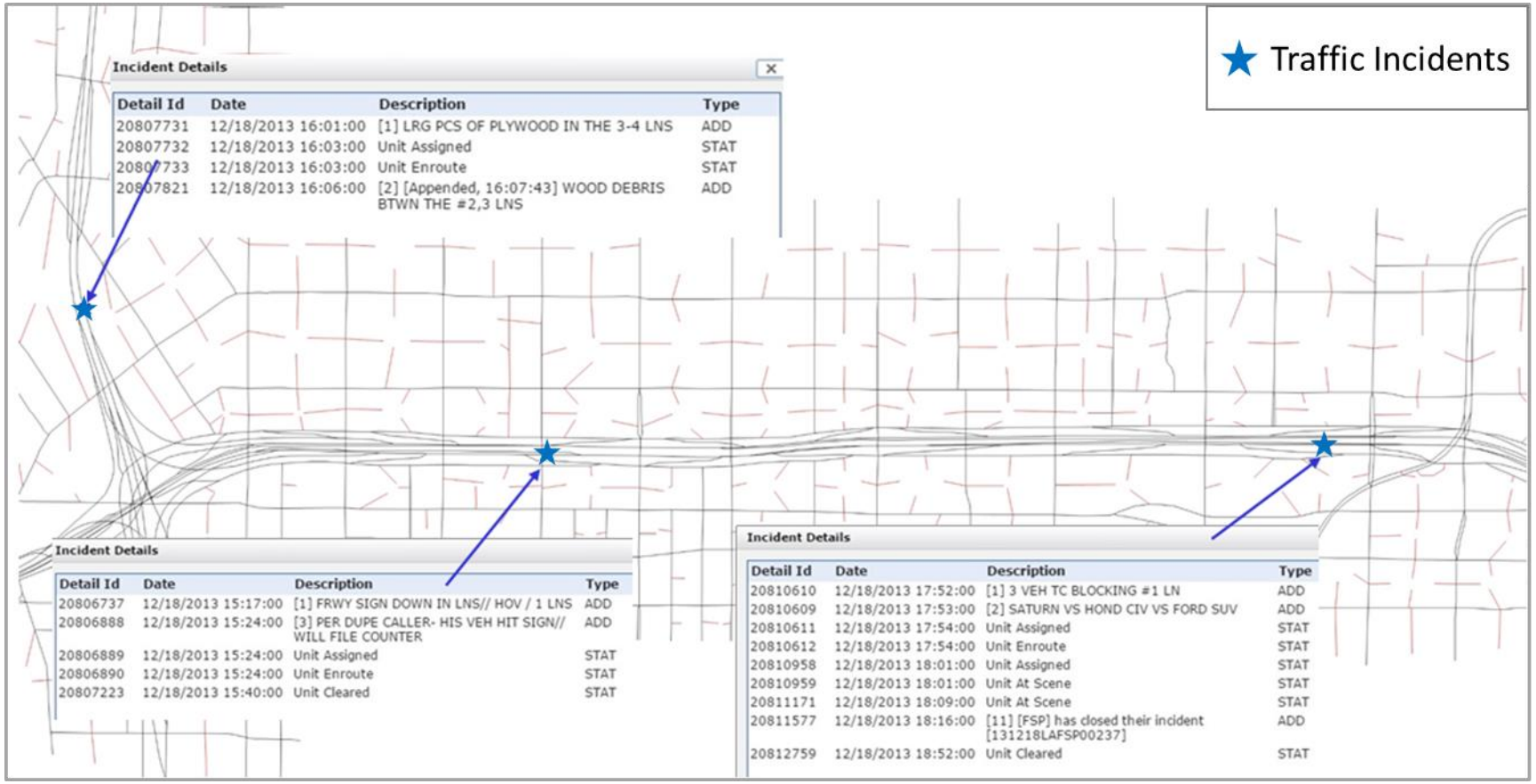


Figure 2-6: Locations and Descriptions of Traffic Incidents for Operational Condition #1 [Source: HBA]

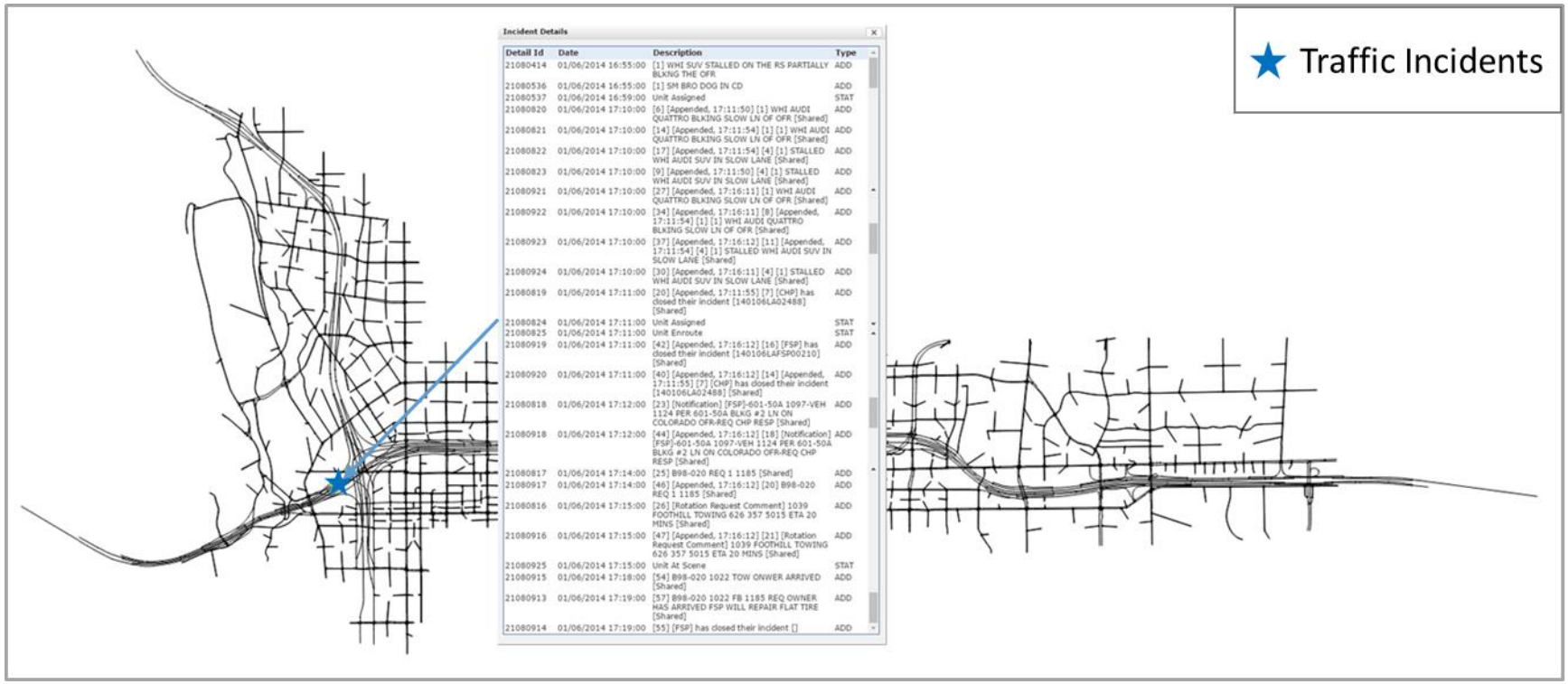
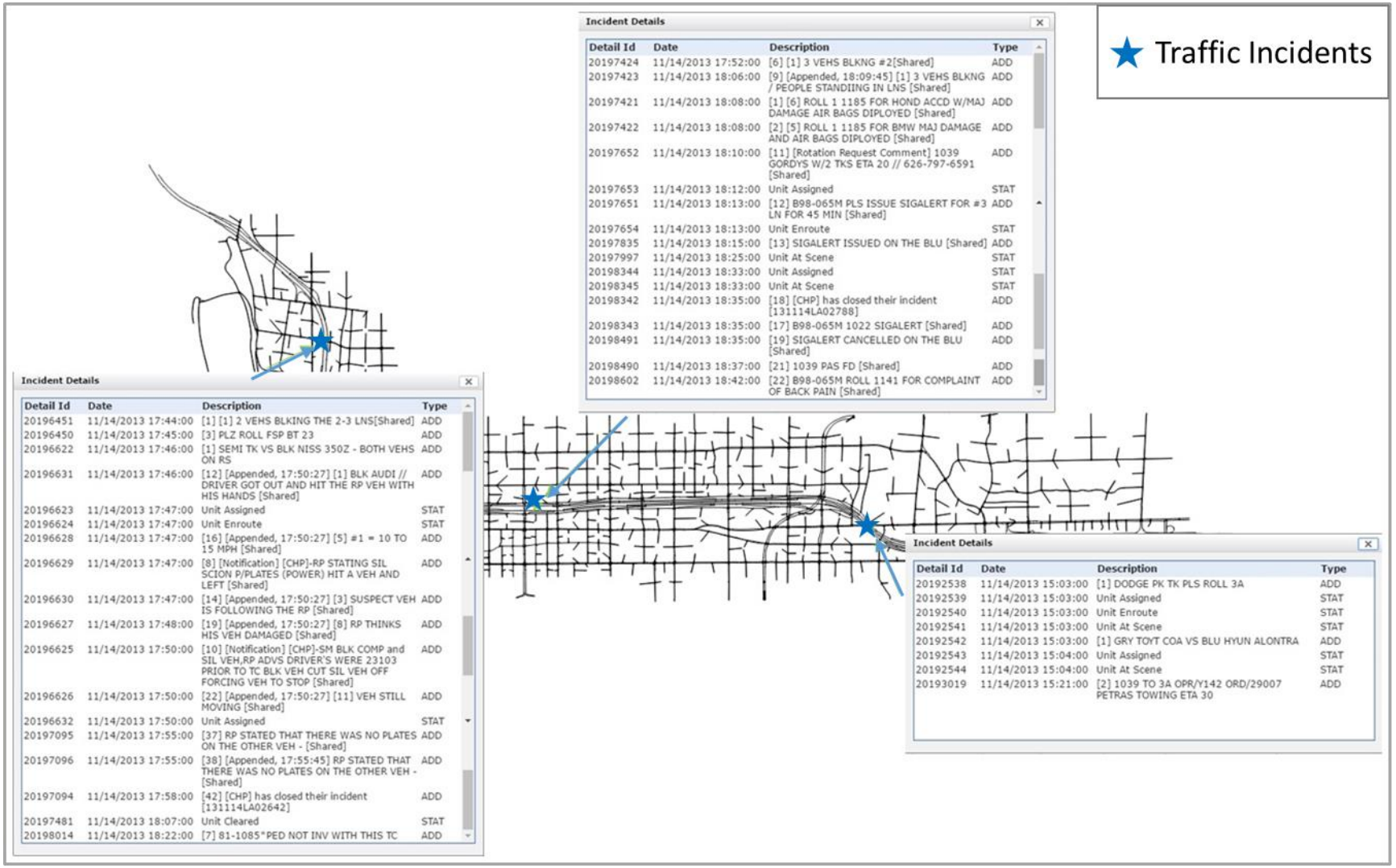


Figure 2-7: Locations and Descriptions of Incidents for Operational Condition #2 [Source: HBA]



Incident Details

Detail Id	Date	Description	Type
20196451	11/14/2013 17:44:00	[1] [1] 2 VEHS BLKING THE 2-3 LNS[Shared]	ADD
20196450	11/14/2013 17:45:00	[3] PLZ ROLL FSP BT 23	ADD
20196622	11/14/2013 17:46:00	[1] SEMI TK VS BLK NISS 350Z - BOTH VEHS ON RS	ADD
20196631	11/14/2013 17:46:00	[12] [Appended, 17:50:27] [1] BLK AUDI // DRIVER GOT OUT AND HIT THE RP VEH WITH HIS HANDS [Shared]	ADD
20196623	11/14/2013 17:47:00	Unit Assigned	STAT
20196624	11/14/2013 17:47:00	Unit Enroute	STAT
20196628	11/14/2013 17:47:00	[16] [Appended, 17:50:27] [5] #1 = 10 TO 15 MPH [Shared]	ADD
20196629	11/14/2013 17:47:00	[8] [Notification] [CHP]-RP STATING SIL SCION P/PLATES (POWER) HIT A VEH AND LEFT [Shared]	ADD
20196630	11/14/2013 17:47:00	[14] [Appended, 17:50:27] [3] SUSPECT VEH IS FOLLOWING THE RP [Shared]	ADD
20196627	11/14/2013 17:48:00	[19] [Appended, 17:50:27] [8] RP THINKS HIS VEH DAMAGED [Shared]	ADD
20196625	11/14/2013 17:50:00	[10] [Notification] [CHP]-SM BLK COMP and SIL VEH,RP ADVS DRIVER'S WERE 23103 PRIOR TO TC BLK VEH CUT SIL VEH OFF FORCING VEH TO STOP [Shared]	ADD
20196626	11/14/2013 17:50:00	[22] [Appended, 17:50:27] [11] VEH STILL MOVING [Shared]	ADD
20196632	11/14/2013 17:50:00	Unit Assigned	STAT
20197095	11/14/2013 17:55:00	[37] RP STATED THAT THERE WAS NO PLATES ON THE OTHER VEH - [Shared]	ADD
20197096	11/14/2013 17:55:00	[38] [Appended, 17:55:45] RP STATED THAT THERE WAS NO PLATES ON THE OTHER VEH - [Shared]	ADD
20197094	11/14/2013 17:58:00	[42] [CHP] has closed their incident [131114LA02642]	ADD
20197481	11/14/2013 18:07:00	Unit Cleared	STAT
20198014	11/14/2013 18:22:00	[7] 81-1085*PED NOT INV WITH THIS TC	ADD

Incident Details

Detail Id	Date	Description	Type
20197424	11/14/2013 17:52:00	[6] [1] 3 VEHS BLKNG #2[Shared]	ADD
20197423	11/14/2013 18:06:00	[9] [Appended, 18:09:45] [1] 3 VEHS BLKNG / PEOPLE STANDIING IN LNS [Shared]	ADD
20197421	11/14/2013 18:08:00	[1] [6] ROLL 1 1185 FOR HOND ACCD W/MAJ DAMAGE AIR BAGS DIPLOYED [Shared]	ADD
20197422	11/14/2013 18:08:00	[2] [5] ROLL 1 1185 FOR BMW MAJ DAMAGE AND AIR BAGS DIPLOYED [Shared]	ADD
20197652	11/14/2013 18:10:00	[11] [Rotation Request Comment] 1039 GORDYS W/2 TKS ETA 20 // 626-797-6591 [Shared]	ADD
20197653	11/14/2013 18:12:00	Unit Assigned	STAT
20197651	11/14/2013 18:13:00	[12] B98-065M PLS ISSUE SIGALERT FOR #3 LN FOR 45 MIN [Shared]	ADD
20197654	11/14/2013 18:13:00	Unit Enroute	STAT
20197835	11/14/2013 18:15:00	[13] SIGALERT ISSUED ON THE BLU [Shared]	ADD
20197997	11/14/2013 18:25:00	Unit At Scene	STAT
20198344	11/14/2013 18:33:00	Unit Assigned	STAT
20198345	11/14/2013 18:33:00	Unit At Scene	STAT
20198342	11/14/2013 18:35:00	[18] [CHP] has closed their incident [131114LA02788]	ADD
20198343	11/14/2013 18:35:00	[17] B98-065M 1022 SIGALERT [Shared]	ADD
20198491	11/14/2013 18:35:00	[19] SIGALERT CANCELLED ON THE BLU [Shared]	ADD
20198490	11/14/2013 18:37:00	[21] 1039 PAS FD [Shared]	ADD
20198602	11/14/2013 18:42:00	[22] B98-065M ROLL 1141 FOR COMPLAINT OF BACK PAIN [Shared]	ADD

Incident Details

Detail Id	Date	Description	Type
20192538	11/14/2013 15:03:00	[1] DODGE PK TK PLS ROLL 3A	ADD
20192539	11/14/2013 15:03:00	Unit Assigned	STAT
20192540	11/14/2013 15:03:00	Unit Enroute	STAT
20192541	11/14/2013 15:03:00	Unit At Scene	STAT
20192542	11/14/2013 15:03:00	[1] GRY TOYT COA VS BLU HYUN ALONTRA	ADD
20192543	11/14/2013 15:04:00	Unit Assigned	STAT
20192544	11/14/2013 15:04:00	Unit At Scene	STAT
20193019	11/14/2013 15:21:00	[2] 1039 TO 3A OPR/Y142 ORD/29007 PETRAS TOWING ETA 30	ADD

Figure 2-8: Locations and Descriptions of Incidents for Operational Condition #3 [Source: HBA]

Chapter 3. Pasadena Testbed Multi-Resolution Model Calibration

3.1 Overall Calibration Approach

Calibrating the baseline microscopic simulation model for the Pasadena Testbed took the multi-resolution modeling (MRM) approach. Figure 3-1 provides a high-level overview of this approach. It separates the macro/meso level modeling in VISUM from the micro level modeling in VISSIM, each being responsible for various calibration aspects of the MRM. This approach had proved its success in both productivity and accuracy in model calibrations in many other studies. The orange box shows the process specific to comparing with field data while the blue box shows the individual simulation process at the macro/meso and microscopic levels.

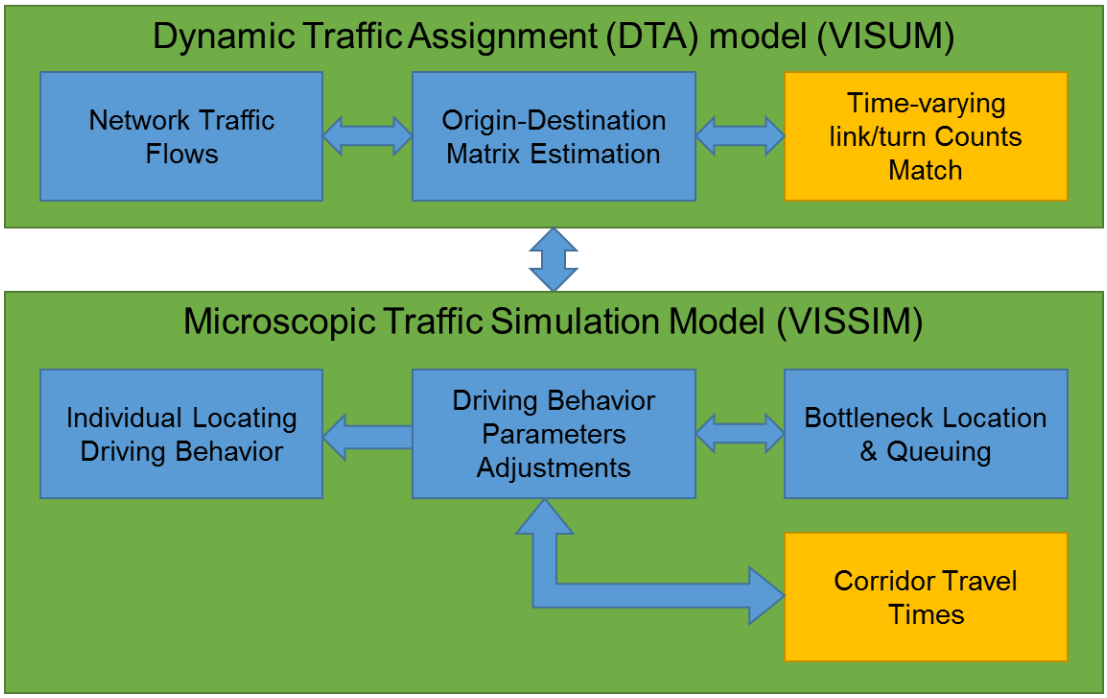


Figure 3-1: Overview of Multi-Resolution Modeling and Calibration Process for the Pasadena Testbed [Source: HBA]

The dynamic traffic assignment (DTA) model and the microscopic simulation model have different roles:

- The DTA model is responsible for ensuring the network flow patterns meeting the calibration targets, time-varying traffic counts. Consisting of time-dependent OD and path flows, the network flow patterns will be completely transferred to the microsimulation model to be simulated. From a broader view, the DTA model also serves the platform to study different testing scenarios, for example, the network flow pattern changes from certain active transportation demand management (ATDM) strategies.

- As the final product from the calibration process, the micro simulation model is expected to satisfy calibration guidelines such that the model can reflect the local traffic operations. At this level, the calibration target is the corridor travel times meeting the criteria. At the same time, bottleneck location and queuing must also meet the analysts' visual checking.

Note that the calibration process is not a sequential process that go only one-way from macro model (VISUM) to micro model (VISSIM); rather this is an iterative process where the micro simulation model also provides feedback of local queuing to the macro model. For example, unrealistic local gridlocks in the micro model can tell the inconsistency between two models. As such, the macro model must be adjusted at corresponding links and turns for the next iterative adjustments. The next section discussed some specific calibration aspects during the model development and calibration process.

3.2 Critical Model Calibration Steps and Solutions

3.2.1 DTA Model Calibration: Link/Turn Capacity Adjustments and OD Matrix Corrections

The testbed DTA model took the following settings from the citywide DTA model:

- Network topology (geometric data and turn restrictions) and basic link attributes including lengths, number of lanes, and speed limits.
- Link and turn capacity settings, and other fundamental diagram related parameters (shockwave speeds and jam density/vehicle lengths).

From the sub-network generation process, the cellular phone data based hourly OD matrices were also taken into the testbed model, with external-internal (X-I), internal-external (I-X) and external-external (X-X) sub-matrices generated from the path flows in the city wide DTA model. These hourly matrices were then corrected via the origin-destination matrix estimation (ODME) technique. In Visum, this ODME module is termed TFlowFuzzy, a fuzzy logic based program that solves the ODME problem with the base matrix and link counts/turn counts input. Commonly, ODME process is completed via a traffic assignment-ODME loop; in the Pasadena Testbed model, it was completed on an hour-by-hour basis (3-4PM, 4-5PM, 5-6PM and 6-7PM).

Note that ODME process could easily fall into the trap of 'over-fitting' if done in excessive iterations. To avoid this over-fitting trap, the Pasadena Testbed ODME process was carried out only once with the synthetic traffic counts input and the base matrices. Additionally, the TFlowFuzzy module also has the advantage of correcting both HOV and SOV matrices at the same time; this feature further reduced the over-fitting possibility compared to assignment-ODME loops in separate HOV and SOV user classes.

In addition to the turn capacities and link level parameters, calibrating the dynamic traffic assignment model also requires the adjustment of both network wide parameters and algorithmic parameters at the global level. In the Pasadena Testbed DTA model, the following global model parameters are applied as shown in Figure 3-2 and Figure 3-3.

These algorithmic parameters are generally adjusted so that the DUE model can converge to a stable solution for the baseline testbed network.

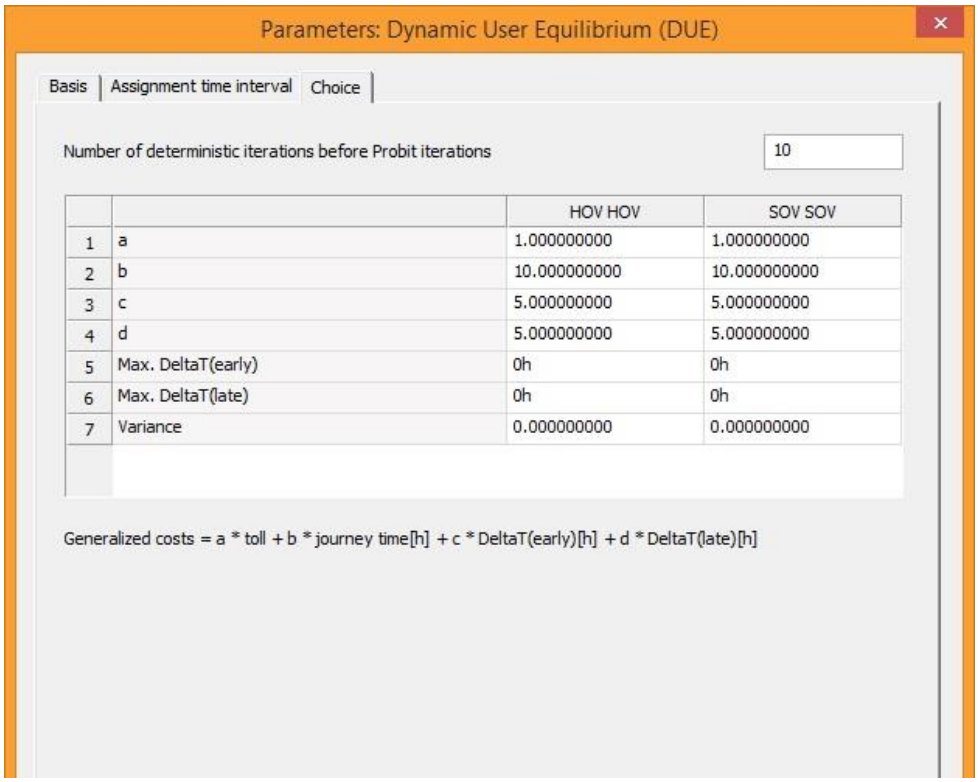


Figure 3-2: DUE Assignment Parameters: Generalized Cost in Path Choice [Source: HBA]

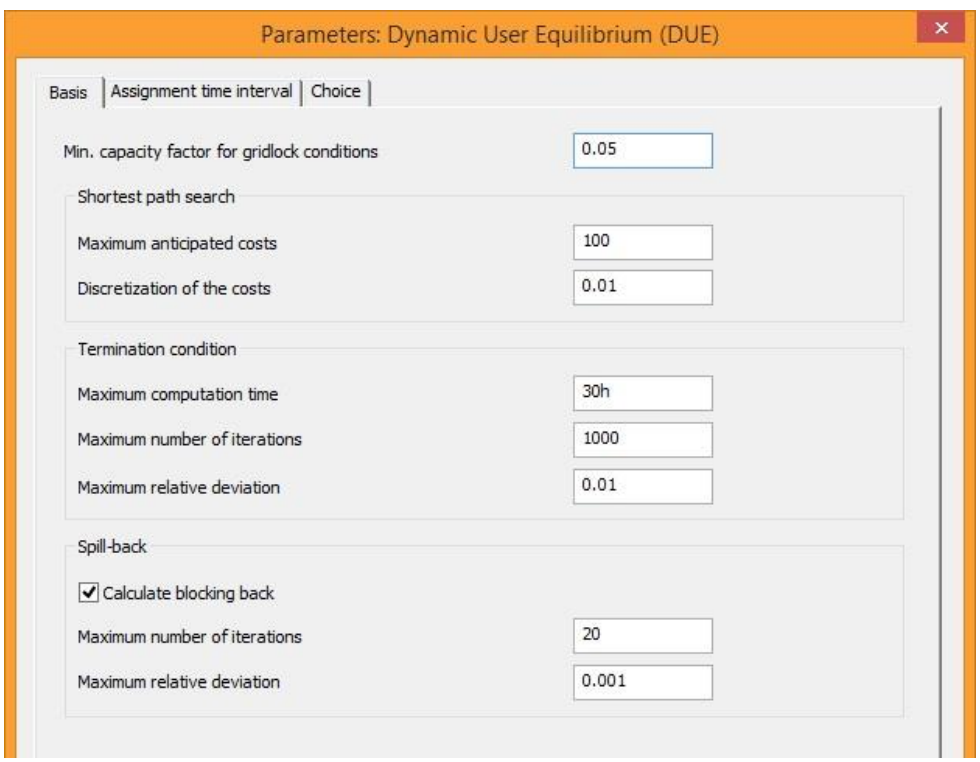


Figure 3-3: Dynamic User Equilibrium (DUE) Assignment: Algorithmic Control Parameters [Source: HBA]

3.2.2 VISSIM Model Initialization by Macro-Micro Data Transfers

Once the testbed DTA model was calibrated, its results were then ready to be export to VISSIM simulation through the module of Abstract Network Model (ANM). The Abstract Network Model (ANM), the VISUM-VISSIM integration module, allows users to work on the same study network in both the VISUM travel demand forecast and the VISSIM micro simulation. The DTA model network was then exported into the ANM data format, which was then imported directly into VISSIM to set up the initial simulation network. This way the transportation system modeling data are carried over to the simulation model. This includes:

- Network hierarchy (freeway or urban streets) geometries and corresponding speed limits; in VISSIM, these become various driving behavior parameters (freeway versus urban streets) and desired speed decision points;
- Travel demand and vehicle routing; in VISSIM, these can be either dynamic assignment (matrices + routes) or static routing (vehicle inputs + static routes).
- Traffic controls (signal groups, timing plans, right-of-way allocation at stop or yield signs); both VISUM and VISSIM use the same ring-barrier-controller (RBC) emulation files.

The initial model setup also included ensuring the model runs are like the local driving environment. The software vendor of VISSIM / VISUM suggested a vehicle fleet that more reflects vehicle compositions in North America based on the Protocol for VISSIM Simulation[1]; this vehicle fleet was then taken to replace the default European vehicle fleet in the model initialization.

3.2.3 Micro Simulation Model Calibration: Error-Checking and Driving Behavior Parameter Adjustments

Calibration of the VISSIM micro simulation model takes a few general steps, including model error-checking, adjustments of global or general driving behavior parameters, adjustments of local or site-specific driving behavior parameters, and demand and routing adjustments. As the demand routing has been fixed and calibrated in the DTA model and it is completely transferred to the VISSIM model, it is expected that when the VISSIM model can run through the model period, the modeled link and turn flows will match the traffic counts. Therefore, the remaining calibration process thus focused on error-checking and driving behavior parameter adjustments.

Model error-checking included going over the model elements to ensure the network coding is correct. For example, one important task was to ensure detectors were correctly referenced by the signal controller and corresponding signal groups and phases. In addition, link speed limits (desired speed limits in VISSIM model) were also further checked to both match field conditions.

Driving behavior parameter adjustments is by nature an iterative process. Following some closely related literature[2] [3], driving behavior parameters, specifically car following and lane change behavior models were adjusted for selected set of sites in the model area, including both freeway sections and main arterial sections. The changes are listed as follows:

[1] *Protocol for VISSIM Simulation*. Oregon Department of Transportation. https://www.oregon.gov/ODOT/TD/TP/APM/Add15A.pdf
[2] Gomes, Gabriel, A. May, R. Horowitz, 2004. *Calibration of VISSIM for a Congested Freeway*, California PATH Research Report, UCB-ITS-PRR-2004-4, Berkeley, CA
[3] Yu, L., et al., Calibration of VISSIM for Bus Rapid Transit systems in Beijing using GPS data, Journal of Public Transportation, 2006 BRT Special Edition, pp 239-257.

Car Following Model

- Additive part of Safety Distance: 1 to 3
- Multiplicative part of Safety Distance: 2 to 4
- Look ahead distance (Observed Vehicles): 2 to 6
- Stand Still Distance: 7.5 to 17.5 feet
- Headway Time: 1 to 1.32 seconds
- Following Variation: 3 to 15 feet

Lane Change Model

- Minimum headway: 1.6 to 2.2 feet
- Safety distance reduction factor: 0.2 to 0.6
- Maximum Deceleration for Cooperative Braking: -6.84 to -11 feet/second^2.

Some calibration techniques were applied to speed up the calibration process[4]. For example, considering the size of the network, initializing the simulation could take up to 30 minutes on different server computers. This became a huge computing overhead in iterative parameter adjustments. Therefore, some small local networks containing the target sites were generated, and their driving parameters were adjusted iteratively until a satisfactory set is obtained. The adjusted parameters were then carried back to the main model.

To fine-tune the model, separate driving behavior parameter sets were set up to model various bottleneck segments (e.g., merges, diverges, and heavy weaving sections).

3.3 VISSIM Calibration Results

3.3.1 Calibration Targets and Criteria

Several calibration guidelines exist for either travel demand modeling or microscopic traffic simulation modeling efforts, but no well-acknowledged guidelines exist for large-scale multi-resolution modeling work. In general, modeling complexity increases when: the model considers network flow temporal variations (dynamic modeling); and network sizes get larger or modeling horizon spans longer. As the Pasadena Testbed model considers a four-hour afternoon peak at both macro and micro level, and covers an urban network of both freeway and arterials, it is considered a medium-large scale traffic model.

In the Pasadena Testbed study, the team selected the NCHRP 255 standard[5], which specifies an error band for different flow levels (Table 3-1). By the standard, the minimum percentage of measurements that must be within the specified range is 85% (Min-Percent-In statistic). That is, at least for 85% of cases for links with measurements, they must be within the specified error range. This criterion should apply to any hours of the modeling period. In addition, the coefficient of determination (R squared) from linear regression must be over 0.88.

For corridor travel time measurements, the FHWA Traffic Analysis Toolbox Volume III[6] listed the Wisconsin DOT freeway model calibration criteria, which specifies that each model output for network wide

[4] Zhang, M., J. Ma, H. Dong, 2008. *Developing Calibration Tools for Microscopic Traffic Simulation Final Report Part II: Calibration Framework and Calibration of Local/Global Driving Behavior and Departure/Route Choice Model Parameters*. California PATH Research Report UCB-ITS-PRR-2008-7.
[5] Pedersen, N., Samdahl, D. 1982. *Highway Traffic Data for Urbanized Area Project Planning and Design*. Transportation Research Board – National Research Council Washington DC
[6] Dowling, R., Skabardonis A., Alexiadis A. 2004. *Traffic Analysis Toolbox Volume III: Guidelines for Applying Traffic Microsimulation Modeling Software*. FHWA-HRT-04-040

measurement (corridors) must be within 15% of measurement (or 1 min if higher); 85% of cases must be within this error range. These criteria are also taken for all freeway and arterial corridors in the Pasadena Testbed model. Meanwhile, bottleneck locations and queuing must also satisfy the analysts' visual checking.

Table 3-1: Calibration Target Statistics of Min-Percent-In Error Band at Different Flow Levels[7]

Observed Value (veh/hr)	Tolerance
100	100.0%
200	100.0%
300	54.0%
400	51.0%
500	48.0%
600	45.0%
700	42.0%
800	40.0%
1000	38.0%
1100	36.0%
1200	35.0%
1300	34.0%
1500	32.0%
1700	30.0%
2000	28.0%
2200	27.0%
2400	26.0%
2600	25.0%
3000	24.2%
3500	23.2%
4000	22.2%
4500	21.2%
5000	21.0%
5500	19.2%
6000	18.2%
6500	17.2%
7000	16.2%
7500	15.2%
8000	14.2%

[7] Pedersen, N., Samdahl, D. 1982. Highway Traffic Data for Urbanized Area Project Planning and Design. Transportation Research Board – National Research Council Washington DC

3.3.2 Operational Condition #1

The charts in Figure 3-4 shows traffic counts comparisons of different hours, and the Table 2 summarizes the Min-Percent-In statistics for each hour under NCHRP 255 standard. R^2 values of all hours are well above the specified target value 0.88, indicating an overall match of the simulated traffic flows with the field measurements.

Table 2 listed the Min-Percent-In statistics for each model hour. Note that freeway sections were examined separately from urban arterials. This separate comparison ensures that both freeways and urban arterials must be simulated to its close match with the field; the underlying reason was that Pasadena Testbed evaluations largely focus on ATM strategies freeway operations and as such, freeway traffic must be modeled accurately. Table 2 clearly showed that both freeways and urban arterials are well within the Min-Percent-In statistics criteria.

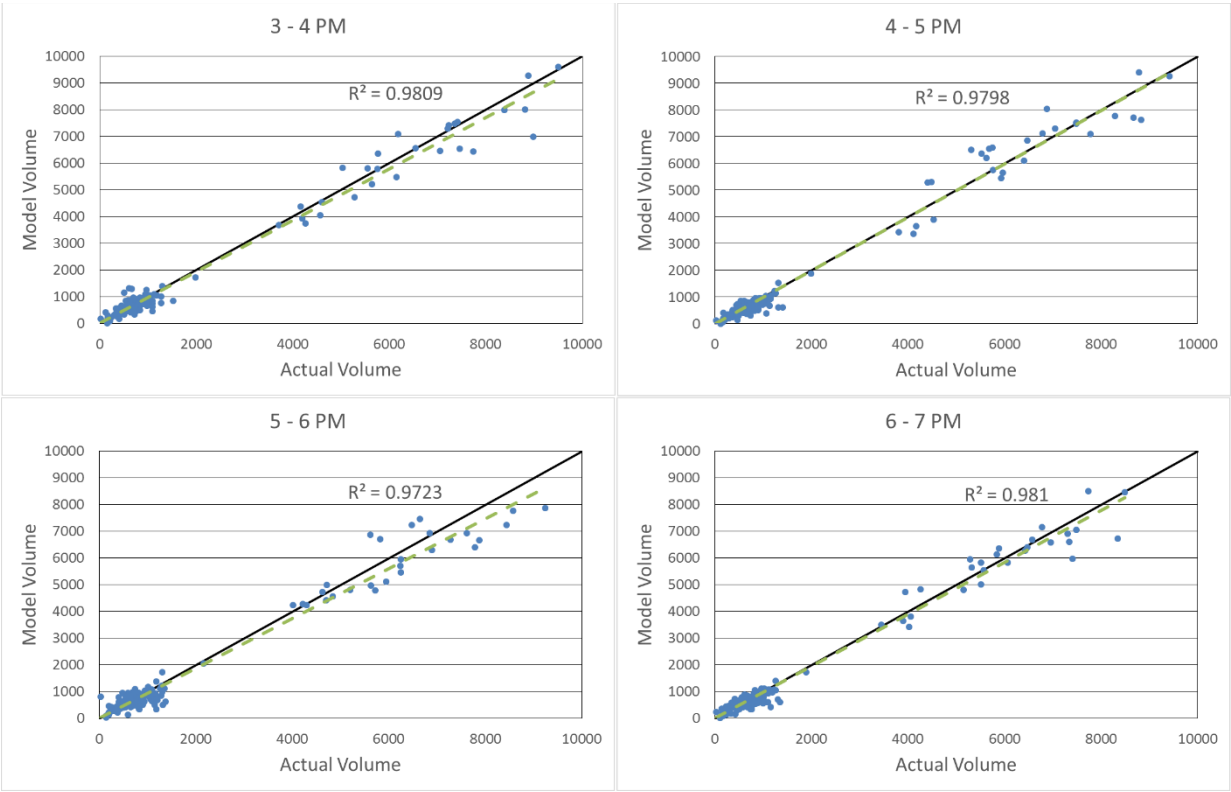


Figure 3-4: Modeled Hourly Volumes versus Traffic Counts in Pasadena Testbed Area, Coefficient of Determination (R-Squared) All Exceeding the Criterion – OC#1 [Source: HBA]

Table 3-2: Pasadena Calibration Statistics for Traffic Volume: Percent in NCHRP 255 Error Range and R-Squared (OC #1)

Target	Time Period	Current within Tolerances		
		All	Urban	Freeway
>85% of cases	3 – 4 PM	90%	89%	93%
	4 – 5 PM	91%	90%	96%
	5 – 6 PM	87%	88%	86%
	6 – 7 PM	91%	91%	93%

Both freeway and arterial corridor travel times were compared between model output and measurements. Freeway speed profile data were collected from a series of loop detectors located along the freeway corridor for the specific time period were accessed via the California PeMS website before they were converted to travel times. Freeway travel times were aggregated over each hour, as shown in the following charts (Figure 3-5 and Figure 3-6). In each of the charts, the shaded green band represents the threshold values specified in the FHWA TAT Vol. III guideline (i.e., 15% of the measured travel times). For both directions, freeway travel times are within the threshold values for all hours. Furthermore, the travel time fluctuations across the peaking time also follow the trend observed from the measurement.

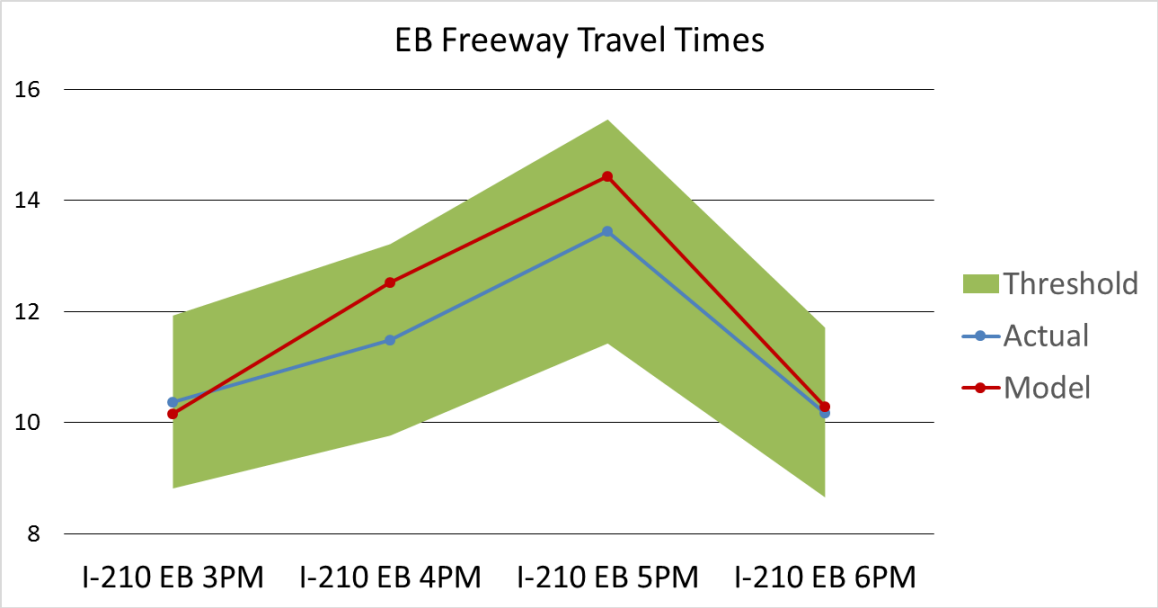


Figure 3-5: EB Freeway Arterial Corridor Travel Time Comparison: Model Output versus Measurement – OC#1 [Source: HBA]

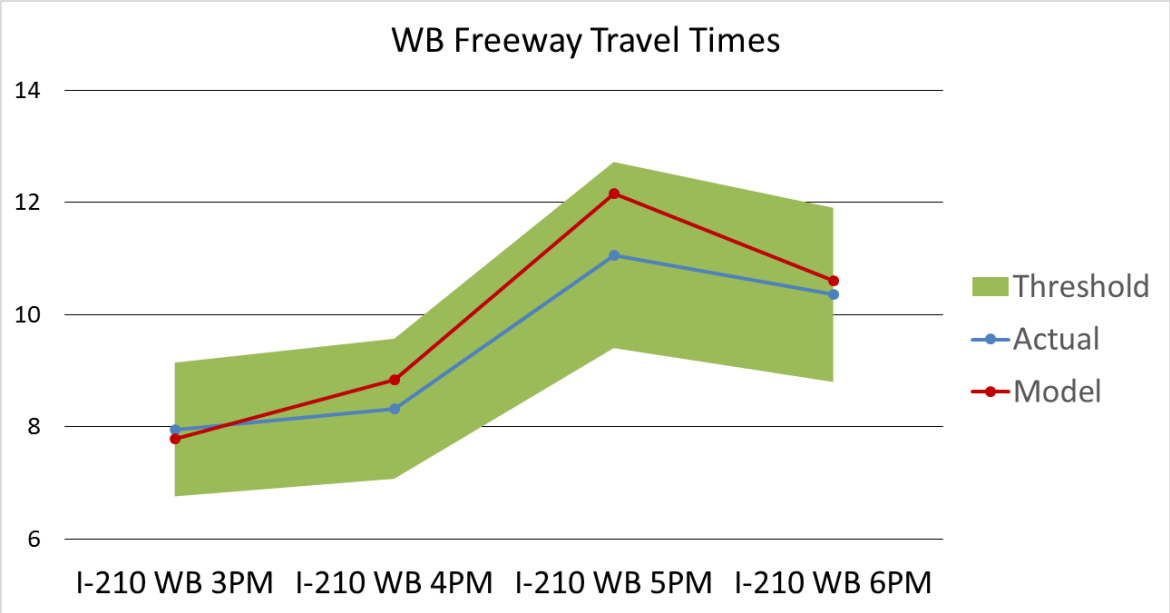


Figure 3-6: WB Freeway Arterial Corridor Travel Time Comparison: Model Output versus Measurement – OC#1 [Source: HBA]

The arterial travel times were obtained from a DTA model developed for the City of Pasadena's Transportation Report Card (TRC)[8] and aggregated the model period as in the measurement data. Figure 3-7 also includes the shaded green band that specifies the threshold values for each of the arterials. In total, 91% percent of all arterial travel time cases are within the threshold values, meeting the calibration target (>85%).

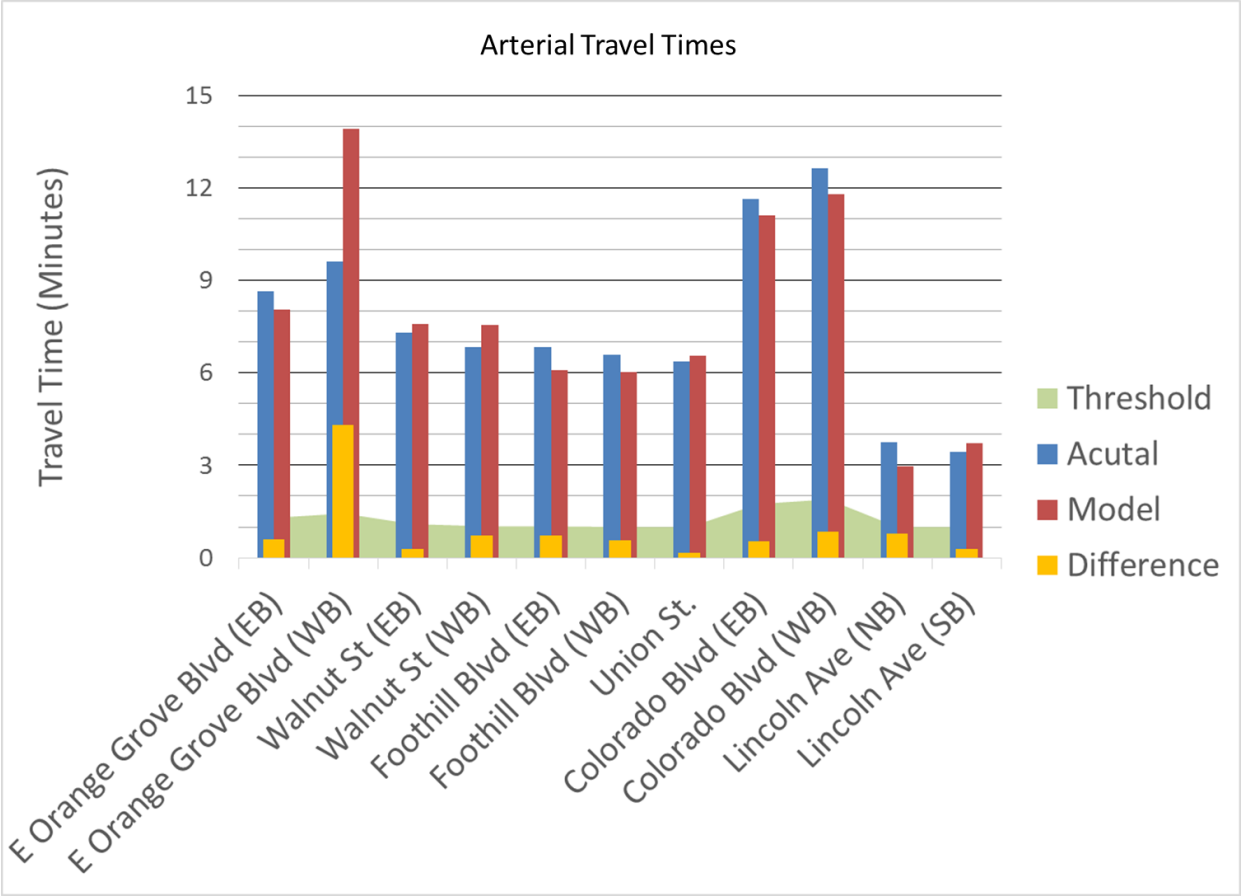


Figure 3-7: Arterial Travel Time Comparison: Model Output versus Measurement – OC#1 [Source: HBA]

Visual checking of bottleneck locations and congestion durations was assisted by the so-called *speed profiles, speed contour map or speed heat-maps.* This visual checking tool is constructed for the main freeway corridor I-210, based on the Caltrans PeMS VDS stations available for each direction of travel. The following tables showed the final model output versus the observed speed at each corresponding VDS cross section location, denoted by the closest cross street names at each corresponding interchange.

From speed profiles of both directions, one can note that bottleneck locations were well captured, and the starting time and duration are all modeled correctly. This is especially true for Eastbound, the peaking direction of travel in the model period. In conjunction with the travel time measurements, we can conclude that the simulated freeway travels well reflect the field congestion formations and dissipations.

[8] Ta-Chavez, A. City of Pasadena Department of Transportation, *Annual Transportation Report Card*: http://ww2.cityofpasadena.net/trans/TAC%20REPORTS/2013/062713/Item%205A%20Presentation.pdf

Table 3-3: Speed Profile for the I-210 EB: Model Output versus Observed – OC#1

	Observed (mph)				Model (mph)			
Locations	3 PM	4 PM	5 PM	6 PM	3 PM	4 PM	5 PM	6 PM
Arroyo Blvd	62.8	62.8	62.7	62.9	65.7	65.7	65.5	65.8
Lincoln Ave	65.7	66.0	66.1	65.1	65.6	65.6	65.4	65.7
Hammond St	66.7	65.3	64.1	62.6	65.2	65.4	65.0	65.4
Winona Way	63.5	63.8	63.2	53.3	59.5	55.9	57.2	57.7
I-210 SB to I-210 EB	60.2	59.8	61.3	58.4	57.1	58.0	56.3	59.3
Marengo Ave	50.8	59.6	56.1	44.3	64.1	64.4	64.7	64.7
Lake Ave	52.8	62.7	54.2	39.2	59.9	53.1	60.3	50.5
Hill Ave	54.6	60.6	49.9	39.3	61.9	61.1	63.4	34.2
Allen Ave	52.4	53.9	47.9	42.3	64.0	62.9	59.6	29.8
Sierra Madre Blvd	43.1	37.4	33.3	63.6	57.2	25.0	21.6	49.1
Sierra Madre Villa Ave	24.3	21.4	18.6	60.5	23.1	21.5	19.0	41.7
Rosemead Blvd	39.5	34.5	27.7	52.4	57.5	25.4	19.9	41.8
Michillinda Ave	38.5	30.0	22.5	48.9	53.0	40.9	25.0	55.7
Baldwin Ave	46.7	26.9	19.5	30.6	26.1	23.3	17.0	44.8

0 mph **35 mph** **70 mph**

Table 3-4: Speed Profile for I-210 WB: Model Output versus Observed – OC#1

	Observed (mph)				Model (mph)			
Locations	3 PM	4 PM	5 PM	6 PM	3 PM	4 PM	5 PM	6 PM
Arroyo Blvd	61.5	61.8	61.4	60.0	65.3	65.1	65.3	65.2
Lincoln Ave	61.4	62.1	62.3	60.5	65.2	65.1	65.3	65.2
Hammond St	63.6	64.3	62.8	61.6	64.6	64.1	63.8	62.9
Mountain St	64.4	63.6	64.4	63.5	65.6	65.4	65.5	65.6
I-210 WB to I-210 NB	66.0	65.4	65.1	66.1	65.7	65.6	65.6	65.7
Marengo Ave	62.3	57.3	56.7	57.0	56.1	55.5	55.8	57.0
Lake Ave	59.0	51.8	49.3	49.6	63.3	24.1	18.8	36.3
Hill Ave	65.8	56.4	35.8	37.2	64.9	55.5	21.1	44.2
Sierra Madre Blvd	63.6	61.9	26.3	31.3	60.5	60.6	30.1	23.0
Sierra Madre Villa Ave	66.0	64.8	44.1	52.1	65.0	64.9	58.1	52.3
Rosemead Blvd	64.4	58.6	43.4	38.2	62.7	62.2	63.3	62.6
Michillinda Ave	62.0	58.8	50.9	54.0	64.7	64.4	64.1	64.7
Baldwin Ave	58.6	55.0	42.6	46.9	64.4	64.1	63.9	64.4

0 mph **35 mph** **70 mph**

3.3.3 Operational Condition #2

Similarly, for operational condition #2, the same calibration procedure was used to calibrate the freeway flows for the I-210 freeway. Three parameters were calibrated – hourly volumes, observed average speed, and observed travel times. A comparison of these variables in terms of model output versus field

observed values are provided in Table 3-5 and Table 3-6 show comparison for speed while Table 3-7 and Table 3-8 below show the comparison between the observed versus the modeled vehicle flow rate at each defined roadway segment both the eastbound and westbound directions. Following the thresholds defined in Table 3-1, the results show for operational condition 2 in Figure 3-7 and Figure 3-8, the eastbound direction has a compliance of approximately 91% total cases between the observed versus simulated, while the westbound direction has approximately 88% total cases compliance.

Speed profiles shown in Table 3-5 and Table 3-6 were converted to travel times and the results were summarized to Figure 3-8 and Figure 3-9.

Table 3-5: Speed Profile for I-210 EB: Model versus Observed – OC#2

	Observed (mph)				Modeled (mph)			
Locations	3 PM	4 PM	5 PM	6 PM	3 PM	4 PM	5 PM	6 PM
Arroyo Blvd	61.9	62.1	63.5	61.9	65.5	65.5	65	65.6
Lincoln Ave	64.0	63.5	65.4	64.1	65.5	65.5	65.2	65.4
Hammond St	62.9	64.2	64.1	64.6	65.3	65.3	64.5	62.3
Winona Way	61.9	64.2	65.1	64.3	28.6	31.0	28.2	32.2
I-210 SB to I-210 EB	58.6	60.5	58.1	58.5	52.6	51.9	53	53.3
Marengo Ave	62.6	65.3	61.7	62.9	64.2	64.2	64.7	64.6
Lake Ave	65.0	66.8	62.2	63.7	63.2	61.6	63.6	61.1
Hill Ave	65.3	65.0	63.6	64.2	63.2	61.9	62.7	63.1
Allen Ave	65.5	66.8	62.1	63	61.1	61.5	60.7	60.1
Sierra Madre Blvd	52.6	47.2	58.9	64.3	47.4	24.2	64.1	57.7
Sierra Madre Villa Ave	23.4	25.1	32.7	29.8	15.9	25.7	26.4	14.8
Rosemead Blvd	35.3	34.5	37.9	39.9	60.6	60.3	61.5	60.5
Michillinda Ave	30.9	29.3	31.3	35.0	60.7	60.5	54.8	64.3
Baldwin Ave	47.7	55.0	21.0	31.9	61.2	59.4	40.5	58.8

0 mph **35 mph** **70 mph**

Table 3-6: Speed Profile for I-210 WB Model versus Observed – OC#2

	Observed (mph)				Modeled (mph)			
Locations	3 PM	4 PM	5 PM	6 PM	3 PM	4 PM	5 PM	6 PM
Arroyo Blvd	62.8	64.2	65.3	63.6	65.4	64.9	65.3	65.3
Lincoln Ave	61.6	62.8	63.7	63.1	65.4	65	65.3	65.3
Hammond St	65.3	66.5	62.6	63.3	62.7	61.7	61.3	60.8
Mountain St	63.7	64.9	65.3	63.7	65.2	64.9	64.9	65.3
Winona Way	62.6	64.1	64.2	64.6	65.7	65.6	65.5	65.6
I-210 WB to I-210 NB	63.6	63.7	63.8	64.8	65.6	65.6	65.6	65.6
Marengo Ave	67.3	67.2	67.8	69.4	38.6	35.1	35.1	47.8
Lake Ave	58.1	59.9	51.1	57.3	64.5	64.2	64.1	64.3
Hill Ave	66.6	67.3	61.6	57.9	65.4	65.3	65.5	65.6
Sierra Madre Blvd	61.7	63	58.3	61.6	56.7	56.8	54.7	57.6
Sierra Madre Villa Ave	63.6	64.6	61.1	63.2	58.8	60.8	61.5	62
Rosemead Blvd	67.4	67.9	66.3	67.3	65.1	64.9	65.1	65.1
Michillinda Ave	66.5	65.3	65.1	67.1	55.3	55.6	60.5	55.2
Baldwin Ave	63.6	65.2	60.7	64.1	60.3	62.1	59.8	61.8

0 mph **35 mph** **70 mph**

Table 3-7: Hourly Volumes for I-210 EB: Model output versus Observed – OC#2

	Observed (veh/hr)				Modeled (veh/hr)			
Locations	3 PM	4 PM	5 PM	6 PM	3 PM	4 PM	5 PM	6 PM
Arroyo Blvd	3366	3331	3447	2873	3677	3291	4296	3420
Lincoln Ave	3507	3358	3627	2906	3707	3346	4352	3677
Hammond St	3353	3278	3435	2906	3896	3648	4386	3738
Winona Way	3977	3946	4169	3423	3913	3759	4003	3737
I-210 SB to I-210 EB	4406	4352	4449	3763	3043	2872	2745	2753
Marengo Ave	8519	8282	8552	7869	8809	8763	8073	8245
Lake Ave	8494	8118	8498	7883	8458	9011	8209	8211
Hill Ave	8000	7543	8169	7378	7386	7453	7413	7062
Allen Ave	8307	7922	8414	7813	7803	7852	7839	7686
Sierra Madre Blvd	7963	7550	7698	6999	7233	7602	7004	7063
Sierra Madre Villa Ave	6926	6499	6708	6260	6839	7000	6818	6796
Rosemead Blvd	5797	5574	5358	5504	6490	6513	6077	6558
Michillinda Ave	6703	6426	5983	6059	6977	6975	6537	6593
Baldwin Ave	6066	5873	4661	5598	6371	6119	6161	6486

Table 3-8: Hourly Volumes for I-210 WB: Model output versus Observed – OC#2

	Observed (veh/hr)				Modeled (veh/hr)			
Locations	3 PM	4 PM	5 PM	6 PM	3 PM	4 PM	5 PM	6 PM
Arroyo Blvd	4060	4405	4941	4029	3858	5183	4043	3841
Lincoln Ave	4241	4561	5134	4224	4102	5187	4203	4055
Hammond St	4128	4085	4212	3544	4594	5721	5183	4657
Mountain St	4891	5283	5890	5039	4288	5231	4737	4095
Winona Way	3838	4009	4392	3754	4630	5533	5178	4412
I-210 WB to I-210 NB	3450	3672	4070	3325	1417	1651	1793	1161
Marengo Ave	6848	6842	7436	6366	7006	6994	7200	5601
Lake Ave	6733	6757	7086	6068	7677	7609	7835	6512
Hill Ave	7106	6998	7363	6161	6486	6473	6509	5294
Sierra Madre Blvd	7010	6937	7244	6139	6490	6698	6388	5659
Sierra Madre Villa Ave	6584	6617	6775	5852	6215	6486	6334	5551
Rosemead Blvd	6927	6870	7069	6144	6041	6162	5967	5587
Michillinda Ave	5273	5365	5569	4524	5456	5554	5732	4978
Baldwin Ave	6930	6757	6965	6106	5519	5600	6035	5229

Table 3-9 shows the percentage within tolerance for the defined segments for vehicle flowrates by hours from 3 PM to 7 PM in both eastbound and westbound directions. The results show the calibrated OC 2 model is within the acceptable threshold of error for vehicle counts.

Table 3-9: Pasadena Freeway Volume Calibration within Threshold for OC#2

Target	Time Period	Current within Tolerances
		Freeway
>85% of cases	3 – 4 PM	93%
	4 – 5 PM	86%
	5 – 6 PM	86%
	6 – 7 PM	86%

The following Figure 3-8 and Figure 3-9 shows the travel times for the simulation model compared to the field observation with acceptable threshold boundary. The results show the model reasonably replicates travel time for the freeway corridor in both EB and WB directions.

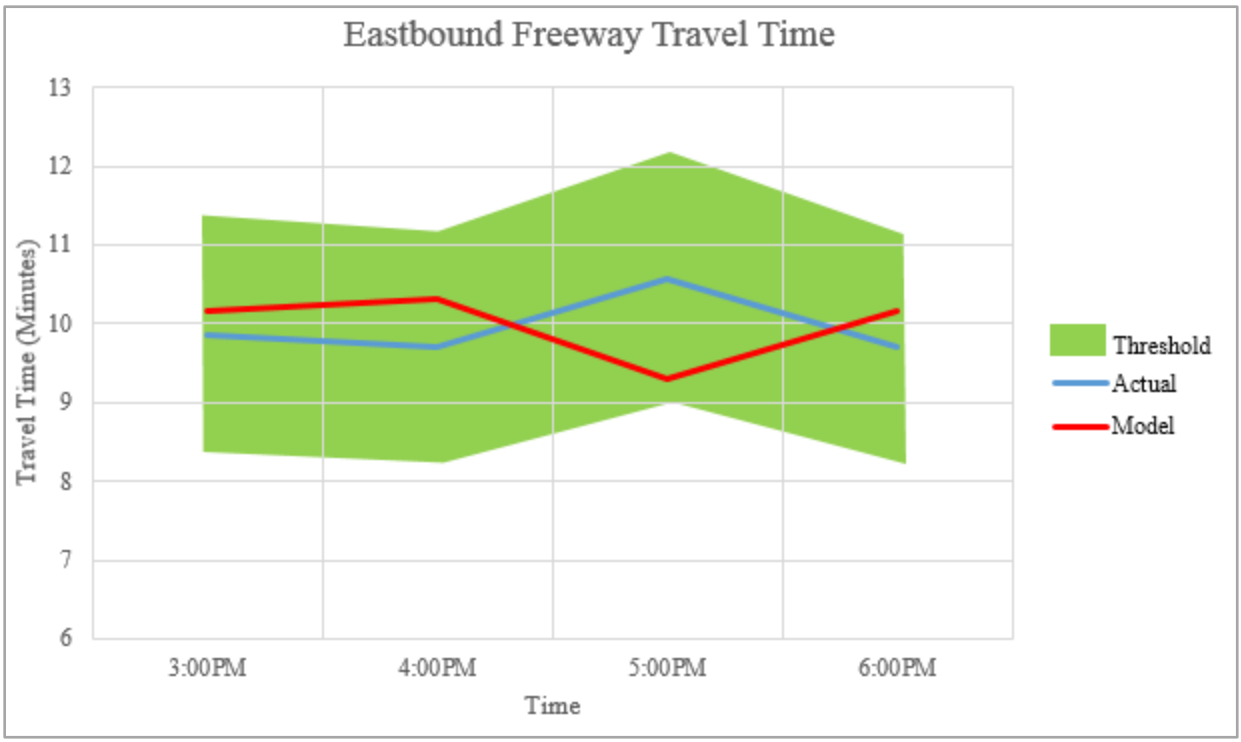


Figure 3-8: Freeway Corridor EB Travel Time Comparison: Model Output versus Measurement – OC#2 [Source: Booz Allen Hamilton]

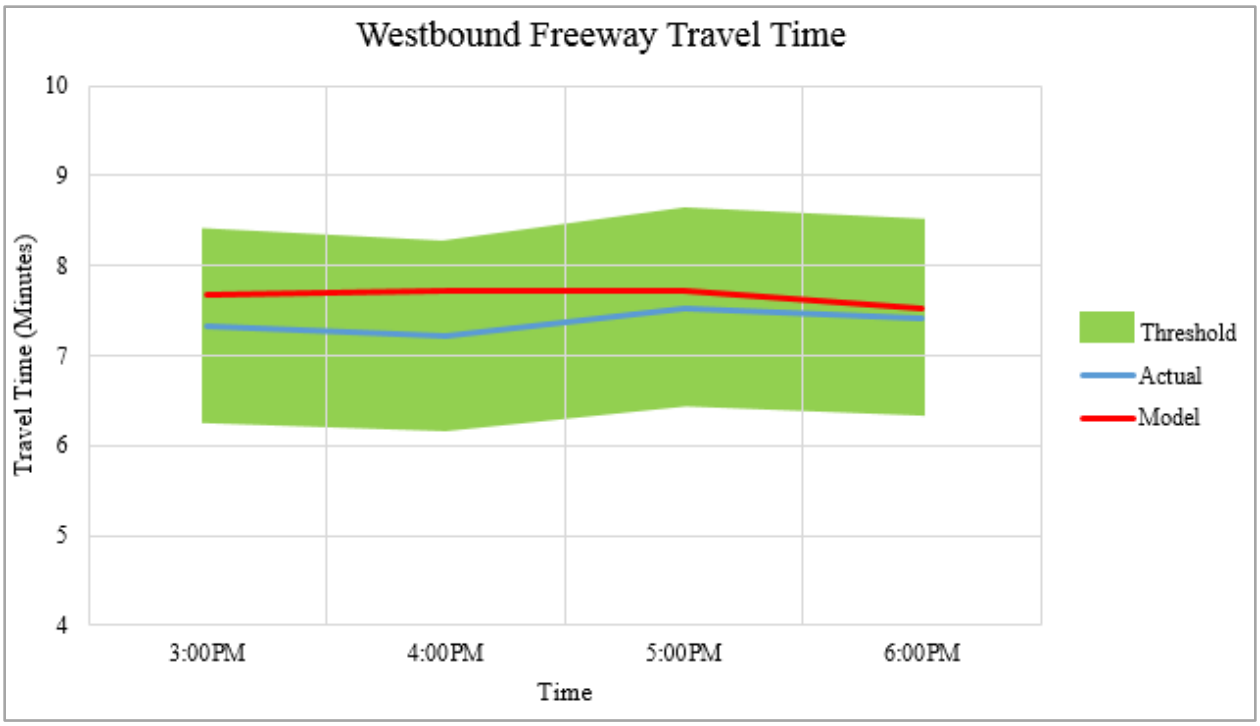


Figure 3-9: Freeway Corridor WB Travel Time Comparison: Model Output versus Measurement – OC#2 [Source: Booz Allen Hamilton]

3.3.4 Operational Condition #3

For operational condition #3, the same calibration procedure to calibrate the freeway flows for the I-210 freeway and calibrated them for three parameters – hourly volumes, observed average speed, and observed travel times. A comparison of these variables in terms of model output versus field observed values are provided in

	Observed (mph)				Modeled (mph)			
Locations	3 PM	4 PM	5 PM	6 PM	3 PM	4 PM	5 PM	6 PM
Arroyo Blvd	66.4	65.7	65.7	66.7	65.5	65.2	65.5	65.5
Lincoln Ave	63.3	64.3	64.1	64.3	65.3	64.9	65.2	65.3
Hammond St	62.5	62.4	62.3	62.7	62.7	61.6	61.1	60.8
Mountain St	64.4	65.5	64.5	65.4	65.3	65	65	65.2
Winona Way	61.3	62.5	63.2	64.5	65.6	65.5	65.6	65.6
I-210 WB to I-210 NB	63.6	64.3	64.8	66.2	65.8	65.5	65.6	65.4
Marengo Ave	65.6	66.1	65.3	65.4	46.7	46.2	46.1	53.4
Lake Ave	46.6	45.1	43	48	63.9	64.4	62.8	63.3
Hill Ave	32.9	27.4	24.1	44.3	61.5	64.9	63.4	65.3
Sierra Madre Blvd	25.9	37.8	23	22.6	20.8	18.5	15.1	14.9
Sierra Madre Villa Ave	43.6	63.3	37.5	29.5	25.3	25.1	11.6	16.3
Rosemead Blvd	52.8	60.5	43.9	37.1	64.7	65.1	37.3	21.7
Michillinda Ave	47.9	53.5	44.1	36.4	50.7	54.9	59.9	55

	Observed (mph)				Modeled (mph)			
Locations	3 PM	4 PM	5 PM	6 PM	3 PM	4 PM	5 PM	6 PM
Baldwin Ave	43.7	32.1	34.6	32.6	57.1	62.4	59.7	61.4

0 mph **35 mph** **70 mph**

Table 3-12 and Table 3-13.

	Observed (mph)				Modeled (mph)			
Locations	3 PM	4 PM	5 PM	6 PM	3 PM	4 PM	5 PM	6 PM
Arroyo Blvd	66.4	65.7	65.7	66.7	65.5	65.2	65.5	65.5
Lincoln Ave	63.3	64.3	64.1	64.3	65.3	64.9	65.2	65.3
Hammond St	62.5	62.4	62.3	62.7	62.7	61.6	61.1	60.8
Mountain St	64.4	65.5	64.5	65.4	65.3	65	65	65.2
Winona Way	61.3	62.5	63.2	64.5	65.6	65.5	65.6	65.6
I-210 WB to I-210 NB	63.6	64.3	64.8	66.2	65.8	65.5	65.6	65.4
Marengo Ave	65.6	66.1	65.3	65.4	46.7	46.2	46.1	53.4
Lake Ave	46.6	45.1	43	48	63.9	64.4	62.8	63.3
Hill Ave	32.9	27.4	24.1	44.3	61.5	64.9	63.4	65.3
Sierra Madre Blvd	25.9	37.8	23	22.6	20.8	18.5	15.1	14.9
Sierra Madre Villa Ave	43.6	63.3	37.5	29.5	25.3	25.1	11.6	16.3
Rosemead Blvd	52.8	60.5	43.9	37.1	64.7	65.1	37.3	21.7
Michillinda Ave	47.9	53.5	44.1	36.4	50.7	54.9	59.9	55
Baldwin Ave	43.7	32.1	34.6	32.6	57.1	62.4	59.7	61.4

0 mph **35 mph** **70 mph**

Table 3-12 and Table 3-13 below show the comparison between the observed versus the modeled vehicle flow rate at each defined roadway segment both the eastbound and westbound directions. Following the thresholds defined in Table 3-1, the results show for operational condition 2 in Table 3-12 and Table 3-13, the eastbound direction has a compliance of approximately 93% total cases between the observed versus simulated, while the westbound direction has approximately 88% total cases compliance.

Speed profiles shown in Table 3-10 and Table 3-11 were converted to travel times and the results were summarized to Figure 3-10 and Figure 3-11.

Table 3-10: Hourly Speed Profile for I-210 EB: Model Output versus Observed – OC#3

	Observed (mph)				Modeled (mph)			
Locations	3 PM	4 PM	5 PM	6 PM	3 PM	4 PM	5 PM	6 PM
Arroyo Blvd	67.2	65.4	67.4	66.7	65.5	65.5	65	65.6

	Observed (mph)				Modeled (mph)			
Locations	3 PM	4 PM	5 PM	6 PM	3 PM	4 PM	5 PM	6 PM
Lincoln Ave	63.6	63.7	65.3	63.9	63.4	65.6	65.2	65.4
Hammond St	43.9	60.4	61.9	61.7	60.3	65.3	64.9	63.4
Winona Way	33.9	62.5	64	61.7	28.8	26.5	28.6	30.7
I-210 SB to I-210 EB	54.6	61.9	62.3	61.4	52.6	52.2	52.4	53.4
Marengo Ave	30.3	50.2	57.4	59.3	58.1	64.2	64.3	64.3
Lake Ave	31.7	42.7	50.8	61.6	49.7	52.4	63.1	61.1
Hill Ave	24.5	30	38.3	63.7	42.8	47.3	64	63.5
Allen Ave	30.9	35.6	44.2	63.7	31.6	44.7	62.4	60.4
Sierra Madre Blvd	20.9	24.1	24.5	57.1	22.4	18.8	32	63.9
Sierra Madre Villa Ave	16.4	15.7	15.2	25	14.1	15.1	9.7	51.6
Rosemead Blvd	20.3	17.1	17.2	24.6	18.8	17.8	9.6	31.8
Michillinda Ave	22.1	17.8	18	26	23.5	23.1	11.1	35.5
Baldwin Ave	24.7	17.8	16.1	22.3	24.1	11.6	32	25.3

0 mph **35 mph** **70 mph**

Table 3-11: Hourly Speed for I-210 WB: Model Output versus Observed – OC#3

	Observed (mph)				Modeled (mph)			
Locations	3 PM	4 PM	5 PM	6 PM	3 PM	4 PM	5 PM	6 PM
Arroyo Blvd	66.4	65.7	65.7	66.7	65.5	65.2	65.5	65.5
Lincoln Ave	63.3	64.3	64.1	64.3	65.3	64.9	65.2	65.3
Hammond St	62.5	62.4	62.3	62.7	62.7	61.6	61.1	60.8
Mountain St	64.4	65.5	64.5	65.4	65.3	65	65	65.2
Winona Way	61.3	62.5	63.2	64.5	65.6	65.5	65.6	65.6
I-210 WB to I-210 NB	63.6	64.3	64.8	66.2	65.8	65.5	65.6	65.4
Marengo Ave	65.6	66.1	65.3	65.4	46.7	46.2	46.1	53.4
Lake Ave	46.6	45.1	43	48	63.9	64.4	62.8	63.3
Hill Ave	32.9	27.4	24.1	44.3	61.5	64.9	63.4	65.3
Sierra Madre Blvd	25.9	37.8	23	22.6	20.8	18.5	15.1	14.9
Sierra Madre Villa Ave	43.6	63.3	37.5	29.5	25.3	25.1	11.6	16.3
Rosemead Blvd	52.8	60.5	43.9	37.1	64.7	65.1	37.3	21.7
Michillinda Ave	47.9	53.5	44.1	36.4	50.7	54.9	59.9	55
Baldwin Ave	43.7	32.1	34.6	32.6	57.1	62.4	59.7	61.4

0 mph **35 mph** **70 mph**

Table 3-12: Hourly Volumes for I-210 EB: Model Output versus Observed – OC#3

	Observed (veh/hr)				Modeled (veh/hr)			
Locations	3 PM	4 PM	5 PM	6 PM	3 PM	4 PM	5 PM	6 PM
Arroyo Blvd	4639	4524	4469	4375	3677	3291	4296	3420
Lincoln Ave	3687	3661	3620	3517	3707	3340	4355	3673
Hammond St	3554	3203	3218	3230	3900	3702	4380	3826
Winona Way	3914	4486	4452	4549	3901	3750	3996	3829
I-210 SB to I-210 EB	4478	4885	4648	4379	3041	2942	2722	2847
Marengo Ave	8054	8690	8701	8861	9517	7521	7090	8139
Lake Ave	7516	7933	8352	8317	9154	7719	7057	8171
Hill Ave	6844	6935	7400	7786	7715	6616	6299	7092
Allen Ave	7242	7264	7827	8014	7920	7223	6720	7681
Sierra Madre Blvd	7474	7486	7630	7383	6719	7557	5923	6917
Sierra Madre Villa Ave	5885	5575	5633	6574	6356	6735	5194	6613
Rosemead Blvd	5321	4679	4831	5540	6028	6002	4231	6461
Michillinda Ave	5863	5169	5322	6082	6451	6395	4539	6648
Baldwin Ave	4952	4576	4490	5262	5525	3921	5943	7023

Table 3-13: Hourly Volumes for I-210 WB: Model Output versus Observed – OC#3

	Observed (veh/hr)				Modeled (veh/hr)			
Locations	3 PM	4 PM	5 PM	6 PM	3 PM	4 PM	5 PM	6 PM
Arroyo Blvd	4818	5389	5378	4351	3807	5042	4012	3935
Lincoln Ave	4957	5520	5538	4520	4022	5092	4409	4189
Hammond St	4606	4885	4933	4304	4521	5619	5374	4794
Mountain St	5648	6150	6319	5246	4209	5142	4830	4249
Winona Way	3275	3615	3721	3053	4519	5476	5263	4553
I-210 WB to I-210 NB	2129	2339	2479	2030	1273	1658	1752	1151
Marengo Ave	7237	7378	7776	7009	7103	6666	6513	5665
Lake Ave	8336	8522	8255	7831	7893	7255	7114	6556
Hill Ave	7781	7843	7491	7285	6596	6087	5663	5251
Sierra Madre Blvd	7744	7770	6921	6626	7561	7298	6795	6789
Sierra Madre Villa Ave	6940	7187	6308	5979	7023	6361	6002	5923
Rosemead Blvd	7091	6858	6766	5980	7292	6028	6399	5948
Michillinda Ave	7013	6676	6667	5952	7095	5727	6169	5647
Baldwin Ave	5982	5661	5776	5277	6509	5117	5902	5041

Table 3-14 shows the percentage within tolerance for the defined segments for vehicle flowrates by hours from 3 PM to 7 PM in both eastbound and westbound directions. The results show the calibrated OC 3 model is within the acceptable threshold of error for vehicle counts.

Table 3-14: Pasadena Freeway Volume Calibration within Threshold for OC#2

Target	Time Period	Current within Tolerances
		Freeway
>85% of cases	3 – 4 PM	93%
	4 – 5 PM	86%
	5 – 6 PM	86%
	6 – 7 PM	86%

The following Figure 3-10 and Figure 3-11 shows the travel times for the simulation model compared to the field observation with acceptable threshold boundary. The results show the model reasonably replicates travel time for the freeway corridor in both EB and WB directions.

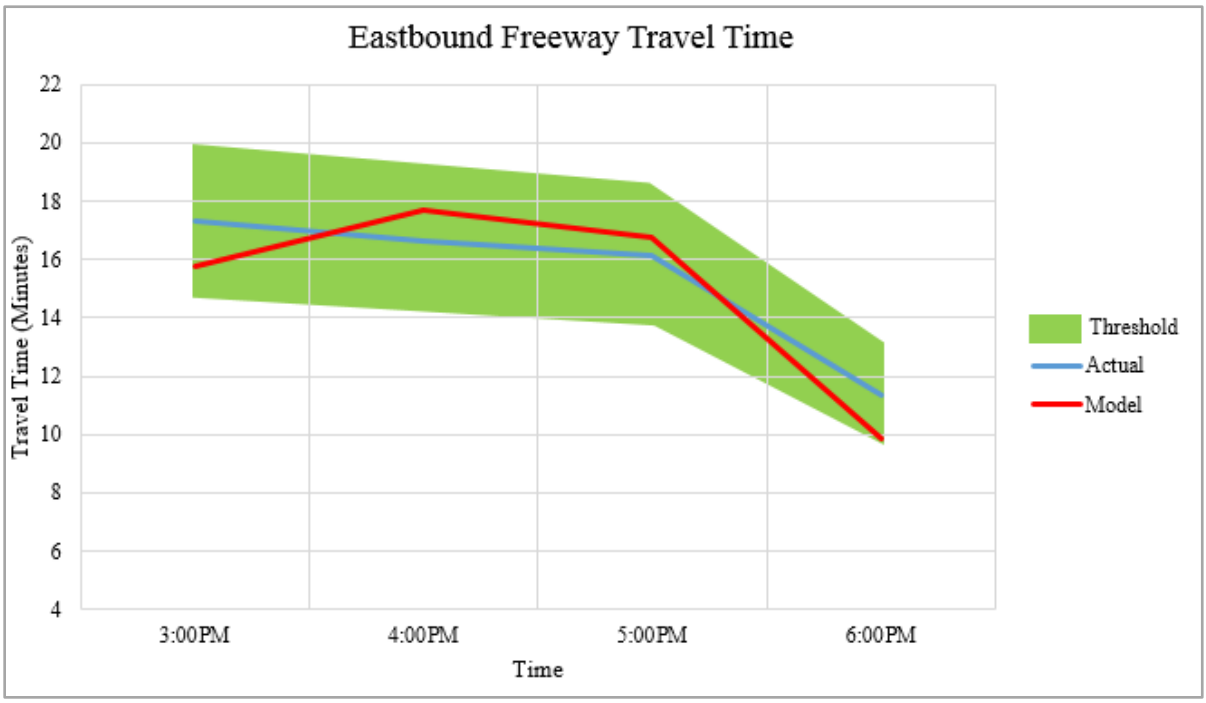


Figure 3-10: Freeway Corridor EB Travel Time Comparison: Model Output versus Measurement – OC#3 [Source: Booz Allen Hamilton]

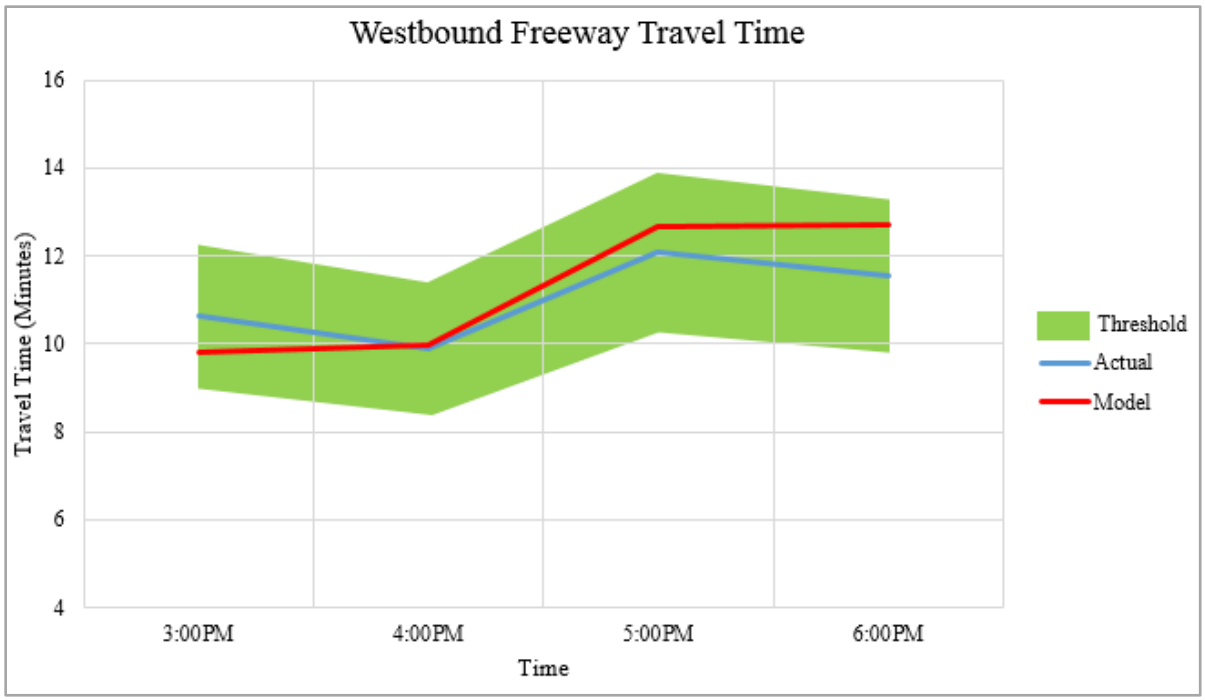


Figure 3-11: Freeway Corridor WB Travel Time Comparison: Model Output versus Measurement – OC#3 [Source: Booz Allen Hamilton]

Chapter 4. TRANSIMS Calibration

4.1 Calibration Approach and Target

For this AMS project, VISSIM represents the real-world conditions of the Pasadena network and TRANSIMS predicts how these conditions are expected to change when various ATDM strategies are implemented at a specific time of day. TRANSIMS receives speed and volume data from VISSIM every 5 to 10 minutes and estimates the benefits over the next 30 to 60 minutes of implementing up to three possible ATDM strategies versus doing nothing. TRANSIMS recommends the best performing strategy for VISSIM to implement in the next 5 minutes. In this case, the System Manager executes four applications of the TRANSIMS Simulator in parallel for up to 60 minutes into the future, summarizes the results, and returns the best strategy to VISSIM in less than 5 minutes of clock time thereby approximating the level of information that could be available at a real-world traffic control center.

In order for TRANSIMS to predict the impacts of a given ATDM strategy effectively, it needs to replicate the expected impact of each strategy. VISSIM runs with and without each strategy were used to quantify the impacts of the strategies on network performance. The TRANSIMS calibration effort attempted to replicate the impacts estimated by VISSIM by adjusting various simulation parameters. These adjustments were added to the interactive VISSIM-TRANSIMS application for predicting the likely impact of various strategy combinations.

TRANSIMS v7.0 was used for this testbed. A TRANSIMS program called VissimXML was developed to read the XML data used as input to VISSIM, create the TRANSIMS network, and travel plan file. From both the network and demand perspective, this created a number of challenges.

4.1.1 Network Conversion

TRANSIMS uses links between nodes for the primary network structure. Merge and turn lanes are defined using pocket lane records. The connections between lanes at nodes are defined using lane connectivity records. Traffic controls include timing and phasing plans based on lane connections at nodes. VISSIM on the other hand uses connector links between lane groups. Each change in the numbers of lanes includes two links and a link connector. Some of these transition sections were extremely short (e.g., less than one meter) in the Pasadena network. VISSIM also includes nodes, but these nodes are not necessarily used for link connections at intersections.

The initial TRANSIMS conversion converted all VISSIM links to TRANSIMS links and replaced VISSIM connectors with a node and lane connectivity record. Unfortunately, this caused havoc with the TRANSIMS Simulator. The TRANSIMS Simulator breaks links and lanes into car-size cells and moves vehicles between cells during each time step. In many cases, the size of the links and the complexity of moving between links at nodes made the TRANSIMS methods ineffective.

As a result, software tools were developed to translate the VISSIM network coding to links, nodes, pocket lanes, and lane connections that TRANSIMS could more effectively simulate. At the same time, the translation needed to maintain as much link information as possible in order to facilitate the integration of the VISSIM volume-speed data with the TRANSIMS network. This tool identified VISSIM connections near intersection and consolidated the location into a single intersection node and reattached each

approach and departure link to this node. It also replaced connections that changed the number of lanes between intersections with a single link and a pocket lane to represent the lane add or lane drop.

Figure 4-1 and Figure 4-2 show an example of how the VISSIM link centerlines were converted to TRANSIMS network coding at a few intersections.

Another complication was that the VISSIM network used RBC files for traffic signal controllers. Unfortunately, the team was not able to identify the data structures within an RBC file so it was not possible for the TRANSIMS conversion tools to extract the signal timing and phasing plans from the VISSIM network. As an alternative, the signal locations and intersection turning movements were fed into the TRANSIMS IntControl program to synthetically generate signal timing and phasing plans for each signalized intersection.

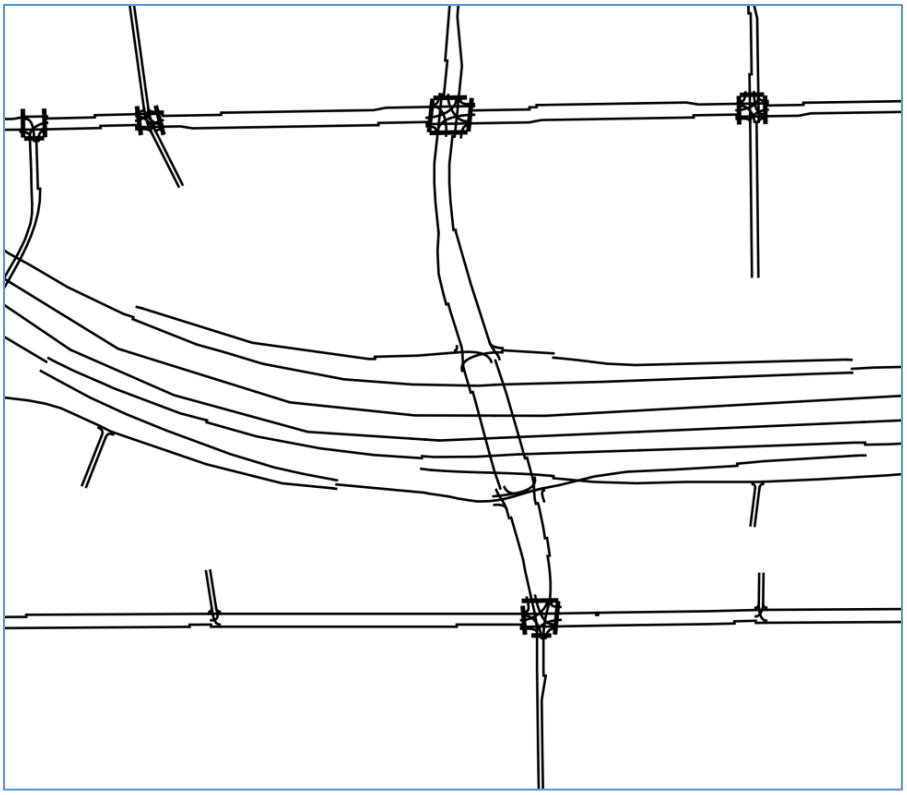


Figure 4-1: VISSIM Link Centerlines [Source: AECOM]

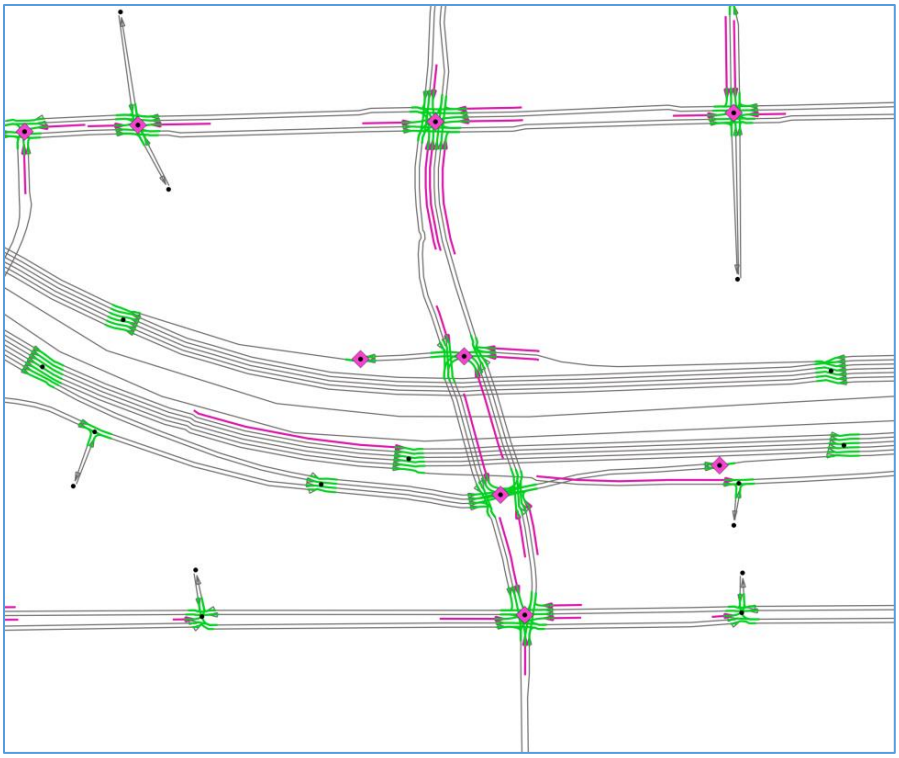


Figure 4-2: TRANSIMS Network Coding [Source: AECOM]

4.1.2 Demand Conversion

Demand conversion was also complicated. The objective was to use the paths from the VISSIM simulation for the TRANSIMS simulation. The VISSIM XML file stores several path options between origin and destination locations and then provides hourly O-D demand totals and path fractions. The coding is a bit odd in that it provides a path fraction for the first 5 minutes and assumes that fraction continues until it changes. The trip fractions on a given O-D pair appear to be truncated to integers and converted to individual trips through a random probability function. The start time of the trip within the 5 minute time period appears to be uniform. It took considerable time to deconstruct the VISSIM process and determine the best way to replicate it within TRANSIMS.

The TRANSIMS travel plans include a separate path with a specific start time for each individual trip. The conversion tool created the number of trips for each 5 minute time period for each VISSIM path based on a close approximation of the VISSIM logic and then randomly assigned each of the trips to a specific start time within the 5 minute period. Since the TRANSIMS network includes fewer links than the VISSIM network, the paths also needed to be reconfigured accordingly. The resulting plan file includes approximately 320,000 trips during the four-hour simulation period (15:00 -19:00).

Due to the random nature of the process, the VISSIM and TRANSIMS trips are not exactly the same. Comparisons were made between the volumes reported from the VISSIM simulation and the TRANSIMS link demand by time of day using the VISSIM link speeds. Figure 4-3 shows an example of the differences in approach and departure volumes for an intersection with ramps on and off the freeway.

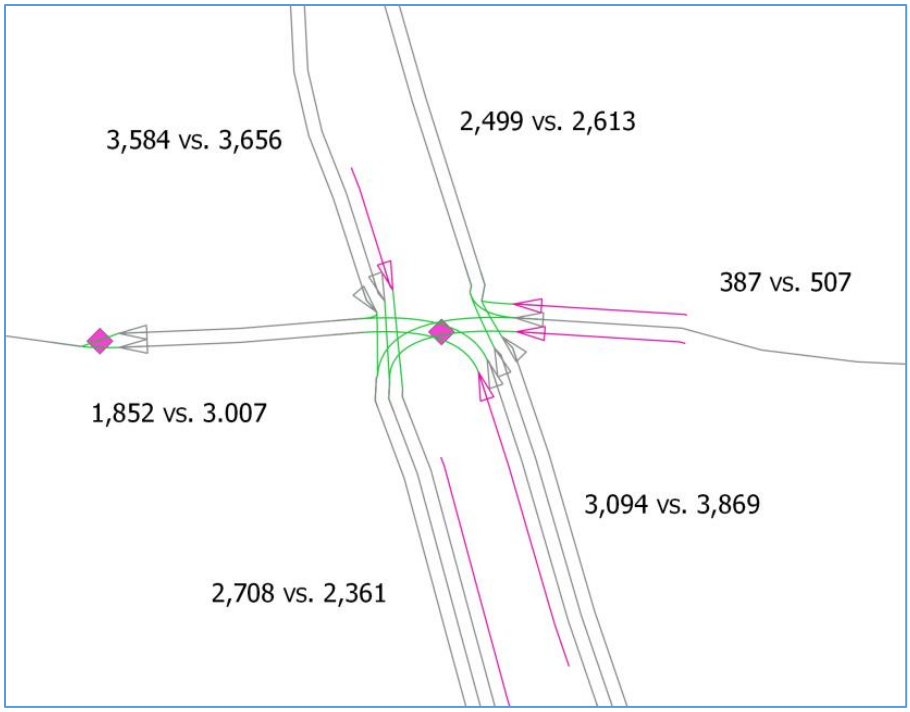


Figure 4-3: TRANSIMS Volumes versus VISSIM Volumes [Source: AECOM]

Table 4-1 summarizes the differences between the peak period link volumes generated by the TRANSIMS conversion process and the volumes generated by the VISSIM simulation. The TRANSIMS paths include about 6.5 percent more traffic on freeway links than VISSIM predicts. TRANSIMS has less volume on arterials.

Table 4-1: Difference Between TRANSIMS Path Volumes and VISSIM Simulation Hourly Volumes

Facility Type	Num. Obs.	Volume		Difference		Absolute Error		Std. Dev.	% RMSE	R^2
		TRANSIMS	VISSIM	Volume	%	Average.	%			
Freeway	436	2310306	2168721	141585	6.5	563	11.3	479	14.8	0.931
Major	1256	697349	769467	-72118	-9.4	93	15.1	75	19.5	0.825
Minor	2972	1266137	1331733	-65596	-4.9	75	16.8	83	25.0	0.871
Collector	2704	361630	421678	-60048	-14.2	35	22.3	55	42.0	0.909
Local	3620	243380	258505	-15125	-5.9	13	17.9	25	38.7	0.934
Ramp	420	202573	220052	-17479	-7.9	123	23.4	116	32.2	0.876
Total	11408	5170156	5170156	-88781	-1.7	68	15.0	153	36.9	0.981

4.1.3 TRANSIMS Calibration

The TRANSIMS calibration focused on comparing the volumes and speeds provided by VISSIM for each link every 5 minutes to TRANSIMS simulated volumes and speeds. A mesoscopic simulation method was used in calibration to provide the VISSIM-TRANSIMS interface with different accuracy levels. Mesoscopic simulations use traffic controls, many more vehicle interaction considerations (e.g., lane-changing, path lane alignment, look ahead, speed gaps), and one second time steps to load the trips to the network. Vehicle snapshots at various time points during the simulation were used to identify and address unexpected queues and slow speeds at intersections and junctions. Refinements to the link connections or signal timing and phasing plans were made to improve the results.

In addition, the maximum link volumes and speeds from the VISSIM results were used to refine the TRANSIMS link capacity and maximum speed values. Capacity factors have very little impact on a mesoscopic simulation. For this method, the speed gap function was the primary calibration tool. This function controls the speed-density relationship and acceleration-deceleration decisions. The function was calibrated to approximate the link vehicle densities implied by the VISSIM volume and speed data in 5-minute increments. A polynomial function was selected with the following values

$$\text{Gap (meters)} = 5.7961 - 0.0277 * \text{speed} + 0.0716 * \text{speed}^2 - 0.0011 * \text{speed}^3$$

where speed is in meters per second. The resulting gap-speed relationship is shown in Figure 4-4.

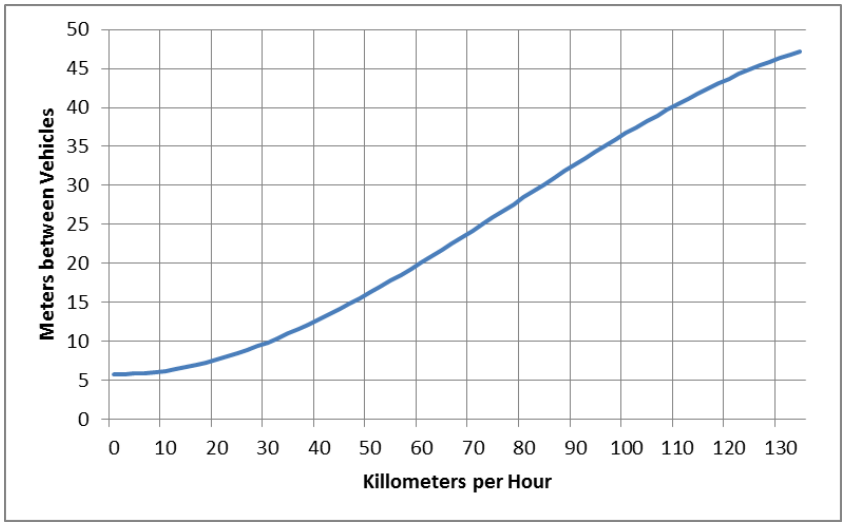


Figure 4-4: TRANSIMS Speed-Gap Function [Source: AECOM]

4.1.4 Strategy Impacts

The impacts of a given ATDM strategy on the TRANSIMS network configuration and performance or the travel plans was estimated using the VISSIM volume-speed data from a strategy application with each strategy activated at the start of the simulation period. Runs with and without the incident were provided to capture the impacts of various strategies. Impacts to the base scenario were used to calibrate TRANSIMS parameters for each strategy. The volumes and speeds in 5-minute time periods were compared to identify the magnitude and extent of the impacts. The tables below are the overall impacts simulated by VISSIM. The “Without” volumes in the tables represent the Base scenario. Each strategy was compared to the base scenario to quantify the overall impact of the strategy.

Table 4-2 shows the aggregate volume difference between VISSIM volume-speed files for the base scenario with and without the incident. Table 4-3 shows the impact of Dynamic Route Guidance plan number 6 with the incident to the base conditions without the incident. The AMS Testbed Action Plan defines the combination of actions that are included in each analysis scenario. DRG Plan 6 includes three alternate routes that would be recommended to travelers during an incident. Table 4-4 shows the impact of Hard Shoulder Running plan number 2 to the base conditions. HSR Plan 2 as defined in the Action Plan includes additional shoulder lanes for most freeway segments. The percent hourly link volume differences are generally less than 0.5 percent because the total trips and trip schedules do not change. The Dynamic Route Guidance strategy is the only strategy that changes any of the paths and this change adds only 1.1 percent to the major arterial volumes.

Table 4-2: VISSIM Base Simulation With and Without an Incident

Facility Type	Num. Obs.	Volume		Difference		Absolute Error		Std. Dev.	% RMSE	R^2
		With	Without	Volume	%	Average	%			
Freeway	440	2174777	2169971	4806	0.2	68	1.4	66	1.9	0.998
Major	1256	766495	769467	-2972	-0.4	29	4.7	28	6.5	0.969
Minor	3004	1335043	1331793	3250	0.2	19	4.3	18	6.0	0.991
Collector	2888	422534	422327	207	0.0	9	6.0	12	10.3	0.994
Local	3880	260812	259802	1010	0.4	4	6.4	7	12.7	0.992
Ramp	420	221066	220052	1014	0.5	24	4.6	26	6.7	0.992
Total	11888	5180727	5173412	7315	0.1	15	3.4	24	6.5	0.999

Table 4-3: VISSIM Dynamic Route Guidance with Incident and Base Volumes without Incident

Facility Type	Num. Obs.	Volume		Difference		Absolute Error		Std. Dev.	% RMSE	R^2
		DRG #6	Without	Volume	%	Average	%			
Freeway	440	2160935	2169971	-9036	-0.4	74	1.5	73	2.1	0.998
Major	1256	777792	769467	8325	1.1	34	5.6	38	8.4	0.952
Minor	3004	1341020	1331793	9227	0.7	22	4.9	32	8.8	0.982
Collector	2888	420864	422327	-1463	-0.3	9	6.1	13	10.9	0.993
Local	3880	259820	259802	18	0.0	5	7.0	9	14.7	0.989
Ramp	420	220629	220052	577	0.3	30	5.7	45	10.3	0.982
Total	11888	5181060	5173412	7648	0.1	17	3.8	31	8.1	0.999

Table 4-4: VISSIM Hard Shoulder Running and Base Volumes without Incident

Facility Type	Num. Obs.	Volume		Difference		Absolute Error		Std. Dev.	% RMSE	R^2
		HSR 2	Base	Volume	%	Average.	%			
Freeway	436	2138851	2168721	-29870	-1.4	178	3.6	648	13.5	0.919
Major	1256	751949	769467	-17518	-2.3	49	8.0	66	13.5	0.878
Minor	3004	1312360	1331793	-19433	-1.5	25	5.7	41	11.0	0.972
Collector	2888	421313	422327	-1014	-0.2	14	9.7	27	20.9	0.976
Local	3880	257094	259802	-2708	-1.0	6	9.3	17	27.4	0.962
Ramp	420	217649	220052	-2403	-1.1	36	6.8	48	11.5	0.977
Total	11884	5099216	5172162	-72946	-1.4	25	5.7	133	31.1	0.983

The methods of implementing the ATDM strategies within TRANSIMS also require special consideration. TRANSIMS uses lane-use records to modify lane restrictions or performance attributes by time of day. The incident, for example, is modeled as a lane-use record that prohibits all vehicle types from using a link lane offset and length between a start and end time. Hard shoulder running uses lane-use records to prohibit use of the shoulder lane when it is not enabled. Dynamic junction control is implemented by changing the lane connectivity records at one intersection. Dynamic route guidance is implemented by scanning the plan file for a specified sequence of links and if this sequence is found and the conformity probability selects the trip, the plan is updated with the new route. Dynamic signal control and adaptive ramp metering are implemented within VISSIM using new signal timing plans. Since the VISSIM RBC files could not be read by TRANSIMS, these strategies were implement using lane use files with capacity and speed adjustment factors for the affected links.

4.2 TRANSIMS Calibration Results

Using the approach mentioned in the previous section, the TRANSIMS calibration results for three sample scenarios are presented below.

4.2.1 Base Without Incident Scenario

The charts in Figure 4-5 show the TRANSIMS Simulator volumes comparison with VISSIM volumes in various time periods for the 'base without incident' scenario. The R^2 values for all time periods are within the accepted range, indicating an overall match between the TRANSIMS volumes and the VISSIM volumes. TRANSIMS tends to overestimate the volumes on high capacity roadways, but this is consistent with the differences in demand generated by the demand conversion process. The AMS testbed includes an incident during the 3rd hour of the simulation to mimic real world traffic performances based on historic traffic incident data as part of the operational condition. Since TRANSIMS is predicting as much as one hour into the future, it does not know about the incident before it occurs. As a result, TRANSIMS needs to model the future without the incident in order to properly capture the inaccuracies of the prediction prior to the incident. The TRANSIMS predictions start with different input data after the incident takes place.

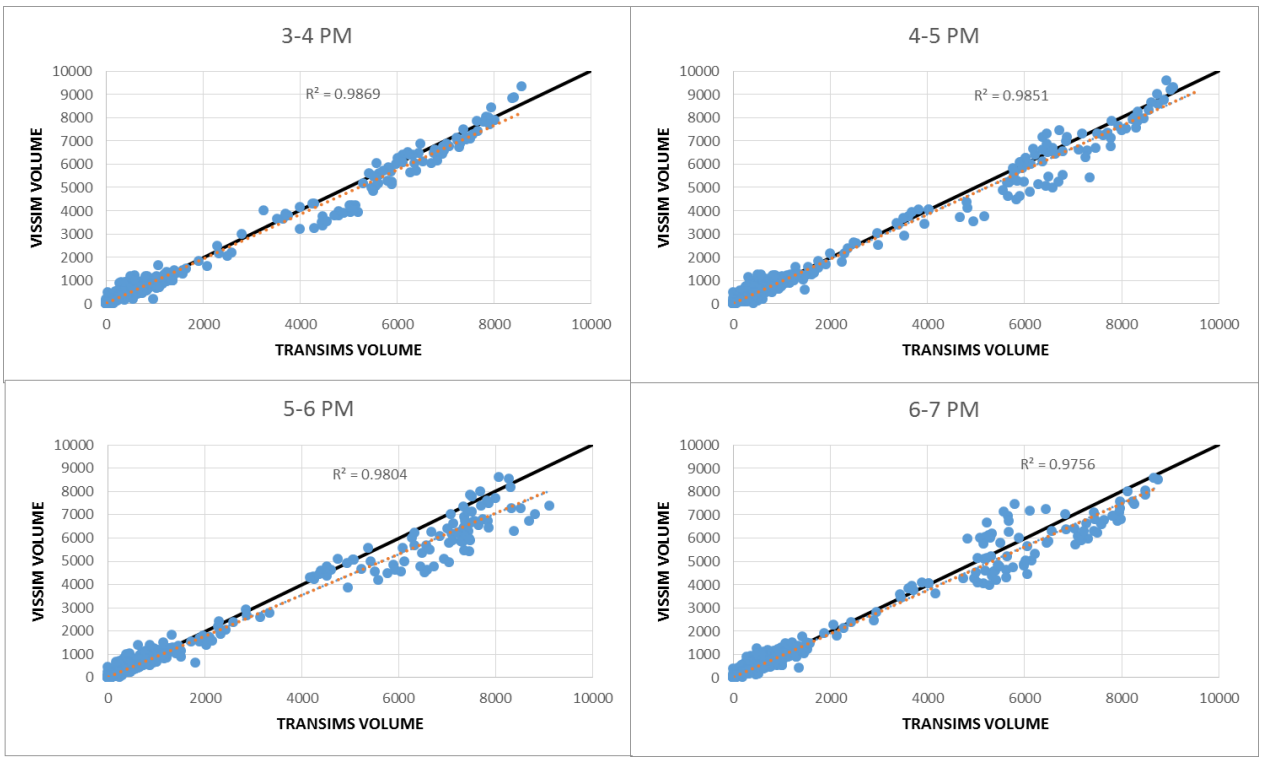


Figure 4-5: Hourly VISSIM Link Volumes versus TRANSIMS Simulated Link Volumes for the Base Scenario without an Incident [Source: AECOM]

Table 4-5 summarizes the validation statistics for the TRANSIMS simulation by facility type for the 'base without incident' scenario. VISSIM speeds and volumes at 5-minute time increments were used to calibrate the model. TRANSIMS calibration attempts to replicate VISSIM volume, speed and VHT results. Greater emphasis was placed on freeway links and facilities closer to the freeway. The overall difference in the TRANSIMS vehicle hours of travel is less than 13 percent and the freeway VHT is 3.6 percent low. Only being able to approximate the travel paths generated dynamically by VISSIM complicated this process (i.e., the total link volumes summarized by the VISSIM run did not always equal the total peak

period volumes included in the paths generated for TRANSIMS using the VISSIM input file). This issue/concern was greater for arterials than it was for the freeways in general. As a result, more emphasis was placed on replicating time of day patterns and changes than specific numbers.

Table 4-5: Vehicle Hours Difference for the Base Strategy

Facility Type	Num. Obs.	Vehicle Hours Traveled		Difference	
		TRANSIMS	VISSIM	Volume	%
Freeway	1744	13809	14329	-520	-3.6
Major	5024	3116	3913	-797	-20.4
Minor	11888	4750	5904	-1154	-19.5
Collector	10848	1482	2250	-767	-34.1
Local	14512	1507	1658	-151	-9.1
Ramp	1680	991	1404	-413	-29.4
Total	45696	25655	29458	-3802	-12.9

Several comparisons of volume and speed profiles for selected links are shown below. Figure 4-6 and Figure 4-7 show two freeway links. The first has relatively little speed impact while the second has a major speed reduction. Figure 4-8 and Figure 4-9 show two arterial links. The first is a mid-block link while the second is between two signalized intersections. The TRANSIMS signals are not coordinated as effectively as the VISSIM signals.

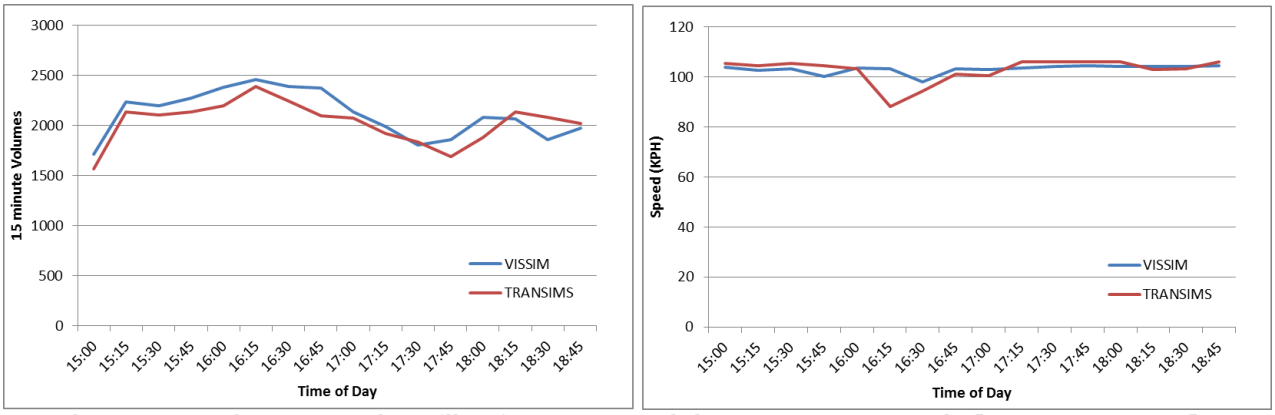


Figure 4-6: Volume-Speed Profiles for Freeway Link 3156 Base Scenario [Source: AECOM]

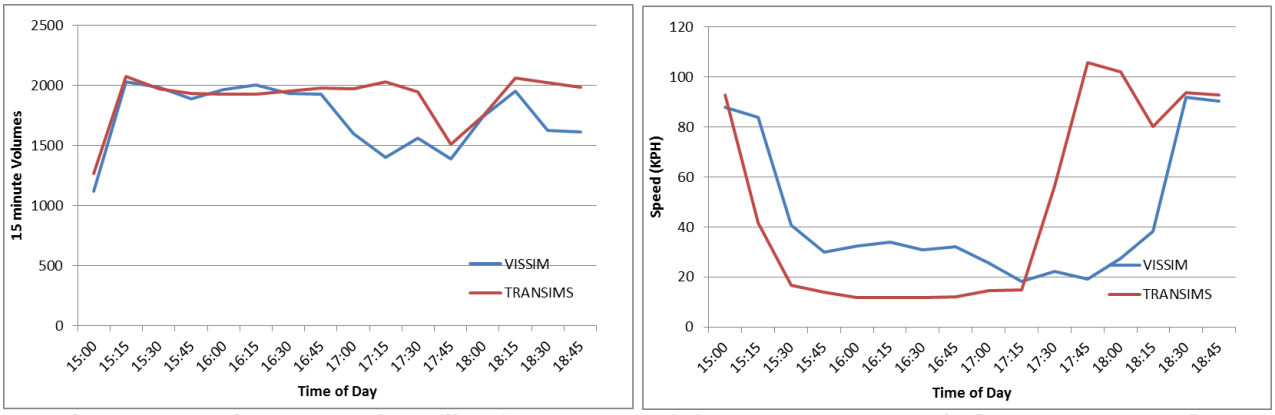


Figure 4-7: Volume-Speed Profiles for Freeway Link 5306 Base Scenario [Source: AECOM]

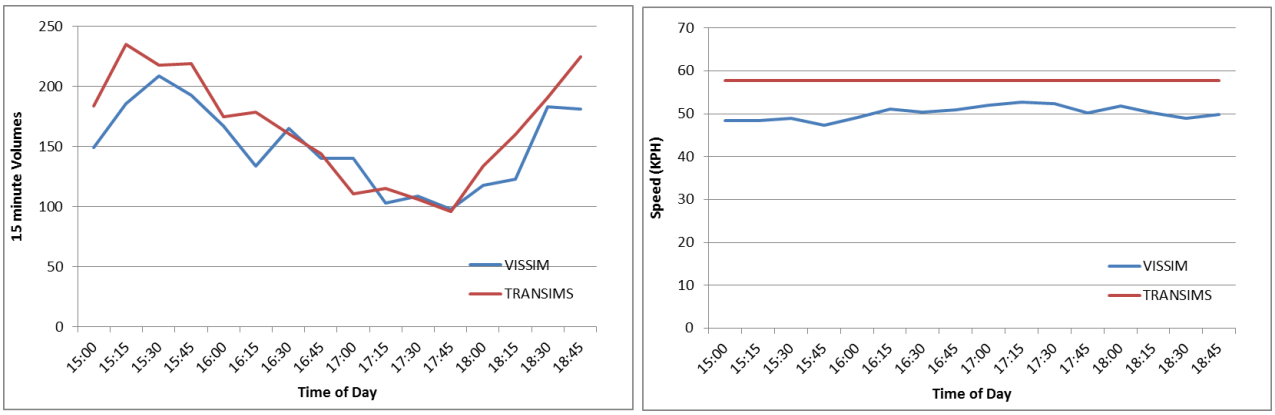


Figure 4-8: Volume-Speed Profiles for Arterial Link 3352 Base Scenario [Source: AECOM]

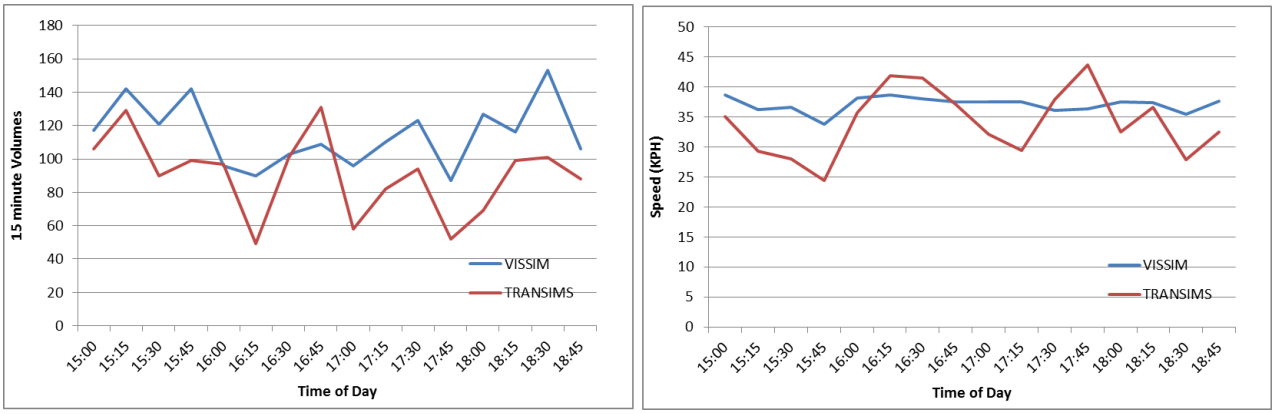


Figure 4-9: Volume-Speed Profiles for Arterial Link 743 Base Scenario [Source: AECOM]

Figure 4-10 shows the overall speed differences between TRANSIMS and VISSIM during the peak hour (17:00-18:00). The speeds are comparable to VISSIM speeds in major facilities like freeway links and ramps.

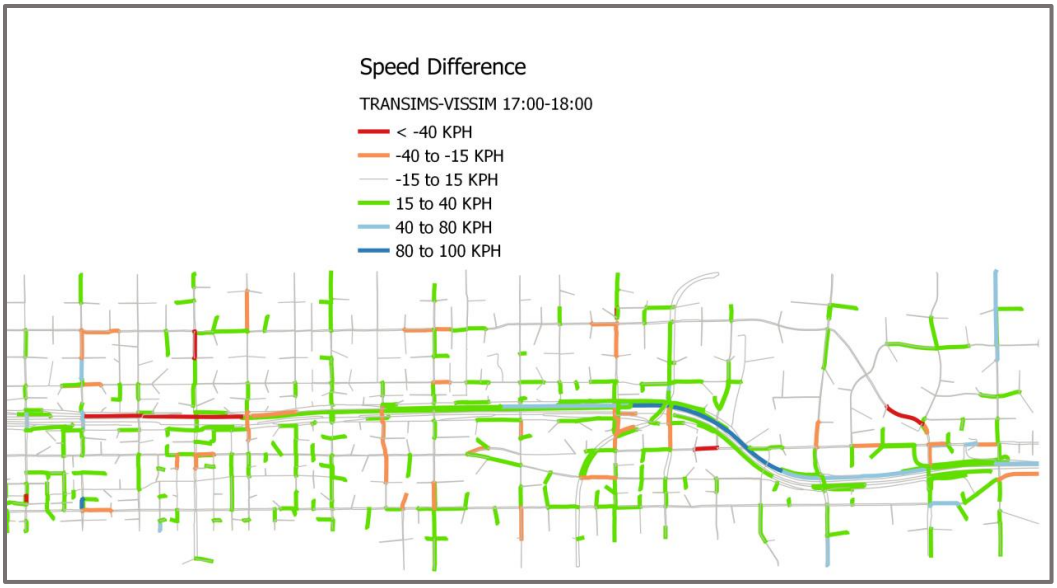


Figure 4-10: Speed Differences for the Base Scenario without an Incident [Source: AECOM]

4.2.2 Dynamic Route Guidance (DRG) Strategy

The DRG strategy was calibrated using the VISSIM volume and speed data. The charts in Figure 4-11 show the TRANSIMS Simulator volumes comparison with VISSIM volumes in various periods for the 'base without incident' scenario. The R^2 values for all periods are within the accepted range, indicating an overall match between the TRANSIMS volumes and the VISSIM volumes. TRANSIMS tends to overestimate the volumes on high capacity roadways, but this is consistent with the differences in demand generated by the demand conversion process.

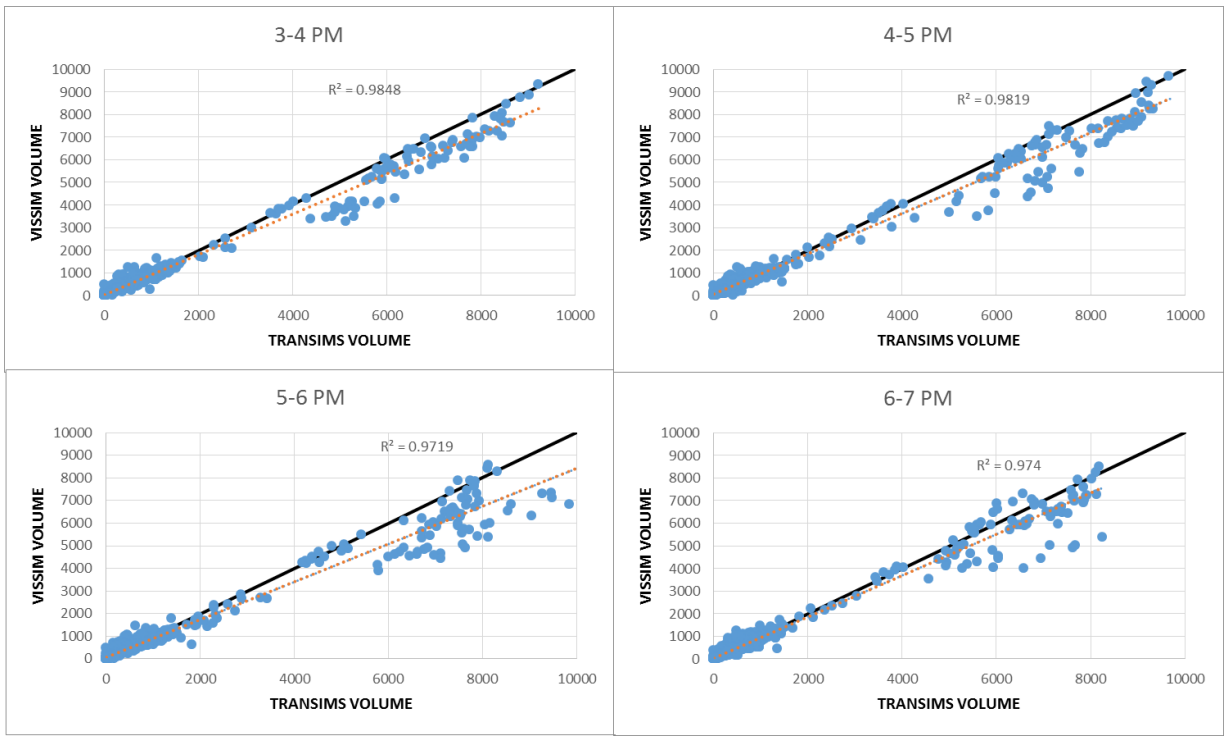


Figure 4-11: Hourly Link Volume Comparisons for the DRG Strategy [Source: AECOM]

Table 4-6 summarizes the validation statistics for the TRANSIMS simulation by facility type for the 'base without incident' scenario. VISSIM speeds and volumes at 15-minute time increments were used to calibrate the model. The overall difference in the TRANSIMS vehicle hours of travel is less than 12 percent and the freeway VHT is 1.7 percent low.

Table 4-6: Vehicle Hours Difference for DRG Strategy

Facility Type	Num. Obs.	Vehicle Hours Traveled		Difference	
		TRANSIMS	VISSIM	VHT	%
Freeway	1744	14478	14727	-250	-1.7
Major	5024	3185	3971	-787	-19.8
Minor	11888	4855	5876	-1021	-17.4
Collector	10848	1509	2256	-747	-33.1
Local	14480	1518	1774	-256	-14.4
Ramp	1680	967	1413	-446	-31.6
Total	45696	26512	30018	-3507	-11.7

Several comparisons of volume and speed profiles for selected links are shown below. Figure 4-12 and Figure 4-13 show two freeway links. The first has relatively little speed impact while the second has a major speed reduction. Figure 4-14 and Figure 4-15 show two arterial links. The first is a mid-block link while the second is between two signalized intersections. The TRANSIMS signals are not coordinated as effectively as the VISSIM signals.

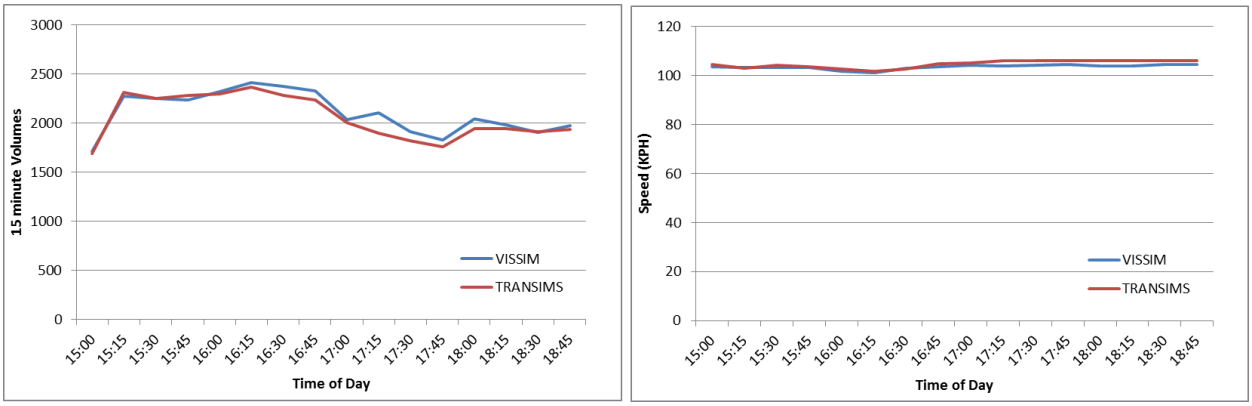


Figure 4-12: Volume-Speed Profiles for Freeway Link 3156 for DRG Strategy [Source: AECOM]

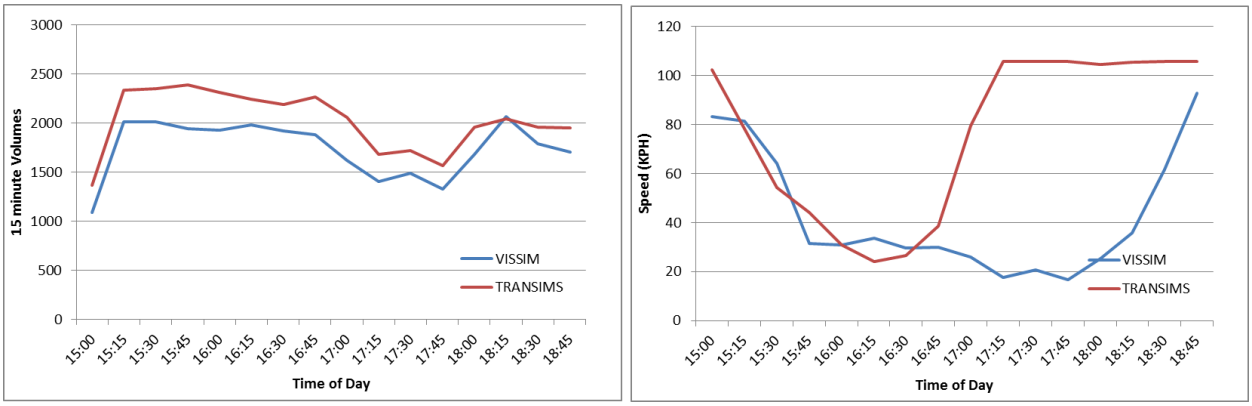


Figure 4-13: Volume-Speed Profiles for Freeway Link 5306 for DRG Strategy [Source: AECOM]

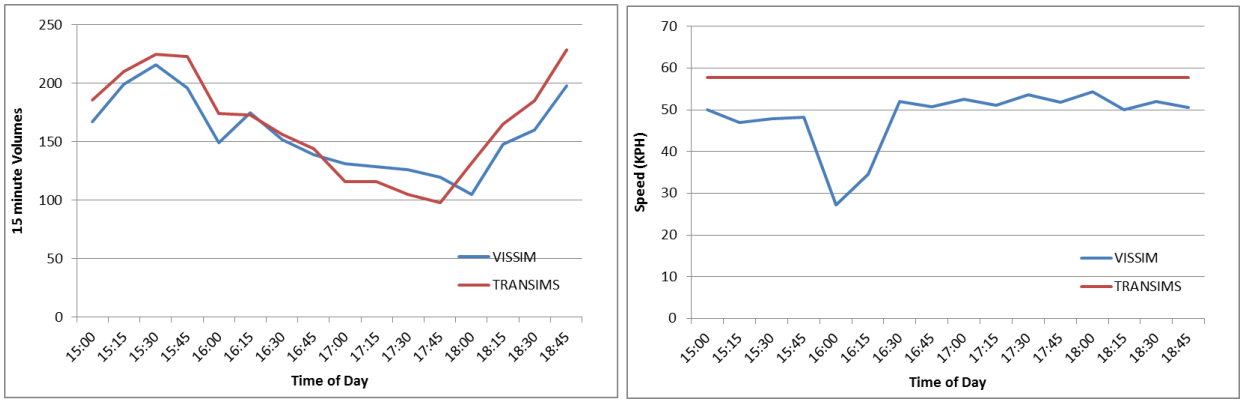


Figure 4-14: Volume-Speed Profiles for Arterial Link 3352 for DRG Strategy [Source: AECOM]

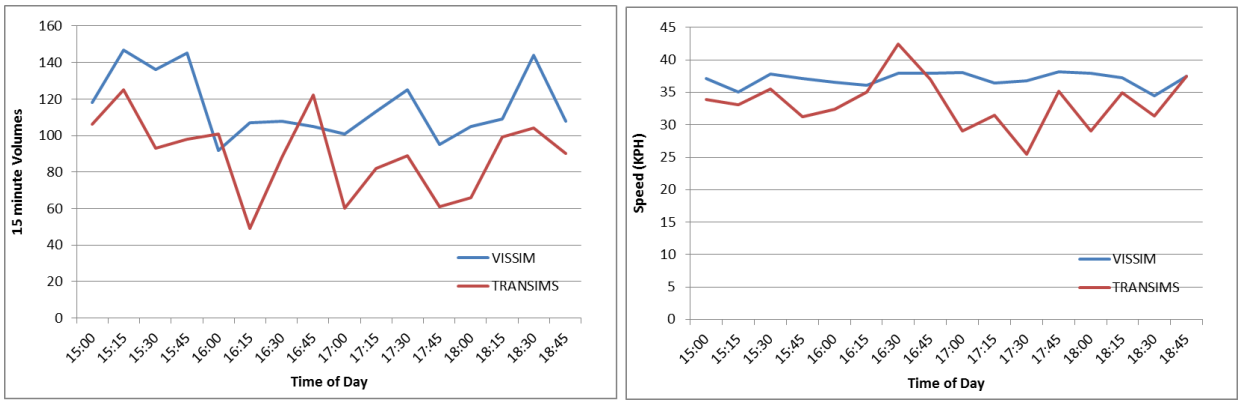


Figure 4-15: Volume-Speed Profiles for Arterial Link 743 for DRG Strategy [Source: AECOM]

Figure 4-16 shows the overall speed differences between TRANSIMS and VISSIM during the peak hour (17:00-18:00). In general, the TRANSIMS speeds tend to be higher than the VISSIM speeds.

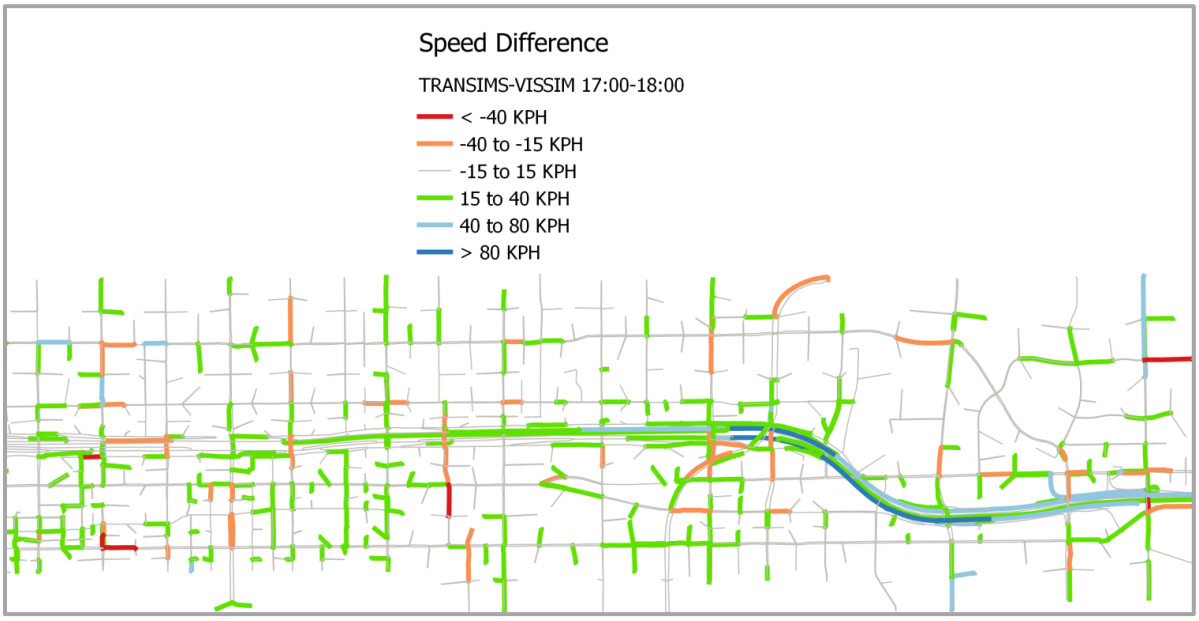


Figure 4-16: Speed Differences for the DRG Strategy [Source: AECOM]

4.2.3 Hard Shoulder Running (HSR) Strategy

The HSR strategy was calibrated using the VISSIM volume and speed data. The charts in Figure 4-17 show the TRANSIMS simulated volumes plotted against the VISSIM volumes in various time periods. The R^2 values for all time periods are well within the accepted range criteria, indicating an overall match between the TRANSIMS volumes with the VISSIM volumes.

Table 4-5 summarizes the validation statistics for the TRANSIMS simulation by facility type.

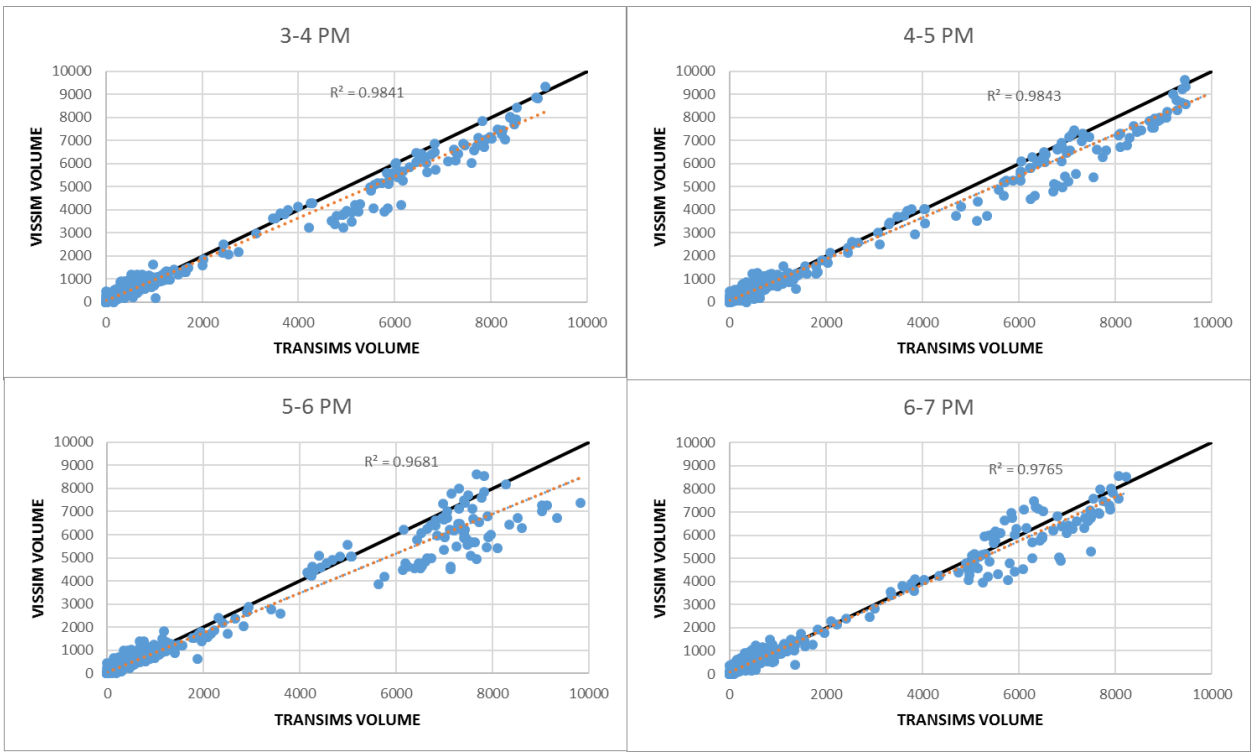


Figure 4-17: Hourly VISSIM Link Volumes versus TRANSIMS Link Volumes for the HSR Strategy [Source: AECOM]

Table 4-7 summarizes the validation statistics for the TRANSIMS simulation by facility type for the 'base without incident' scenario. VISSIM speeds and volumes at 15-minute time increments were used to calibrate the model. The overall difference in the TRANSIMS vehicle hours of travel is 13 percent low and the freeway VHT is 1.8 percent high.

Table 4-7: Vehicle Hours Difference for the HSR Strategy

Facility Type	Num. Obs.	Vehicle Hours Traveled		Difference	
		TRANSIMS	VISSIM	VHT	%
Freeway	1744	14371	14117	255	1.8
Major	5088	3195	4155	-960	-23.1
Minor	11936	4870	6418	-1548	-24.1
Collector	10864	1506	2380	-873	-36.7
Local	14496	1520	1745	-224	-12.9
Ramp	1680	962	1559	-597	-38.3
Total	45760	26424	30374	-3947	-13.0

Several comparisons of volume and speed profiles for selected links are shown below. Figure 4-18 and Figure 4-19 show two freeway links. The first has relatively little speed impact while the second has a major speed reduction. Figure 4-20 and Figure 4-21 show two arterial links. The first is a mid-block link while the second is between two signalized intersections. The TRANSIMS signals are not coordinated as effectively as the VISSIM signals.

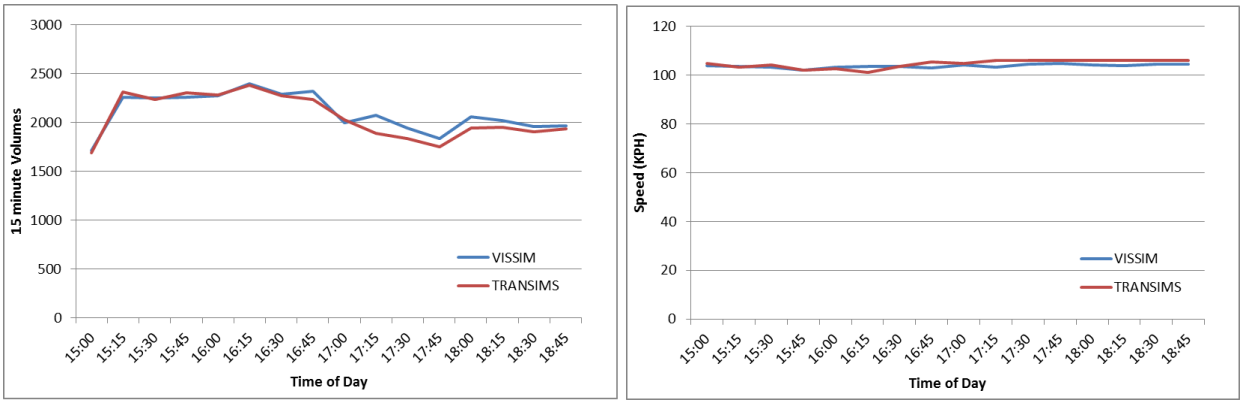


Figure 4-18: Volume-Speed Profiles for Freeway Link 3156 for the HSR Strategy [Source: AECOM]

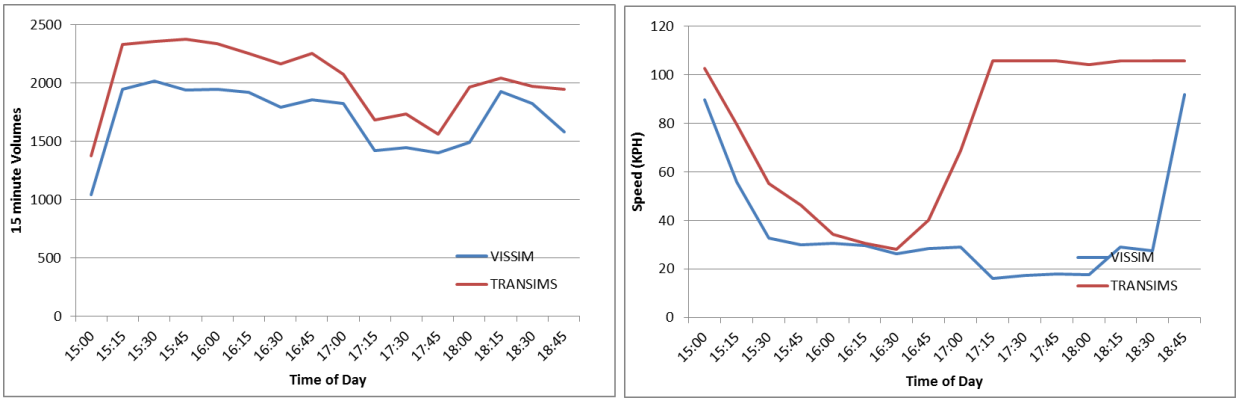


Figure 4-19: Volume-Speed Profiles for Freeway Link 5306 for the HSR Strategy [Source: AECOM]

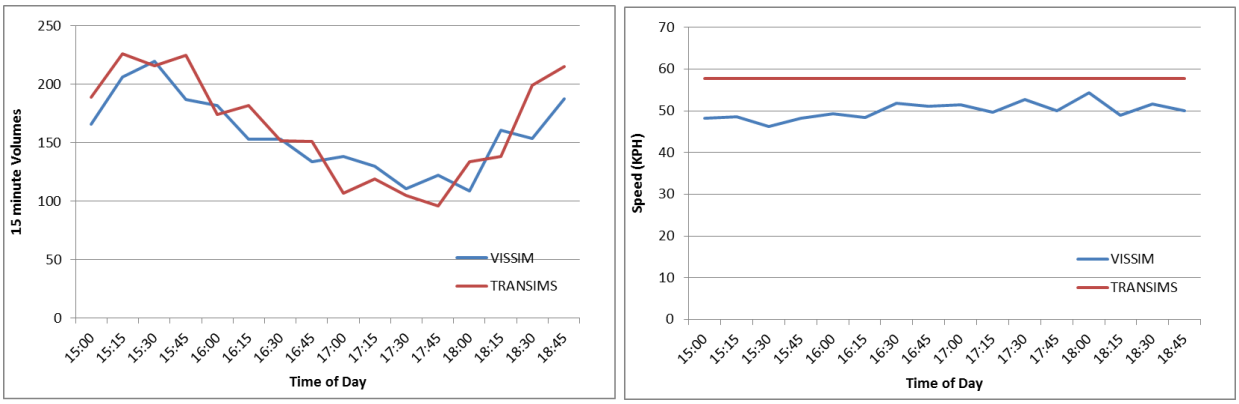


Figure 4-20: Volume-Speed Profiles for Arterial Link 3352 for the HSR Strategy [Source: AECOM]

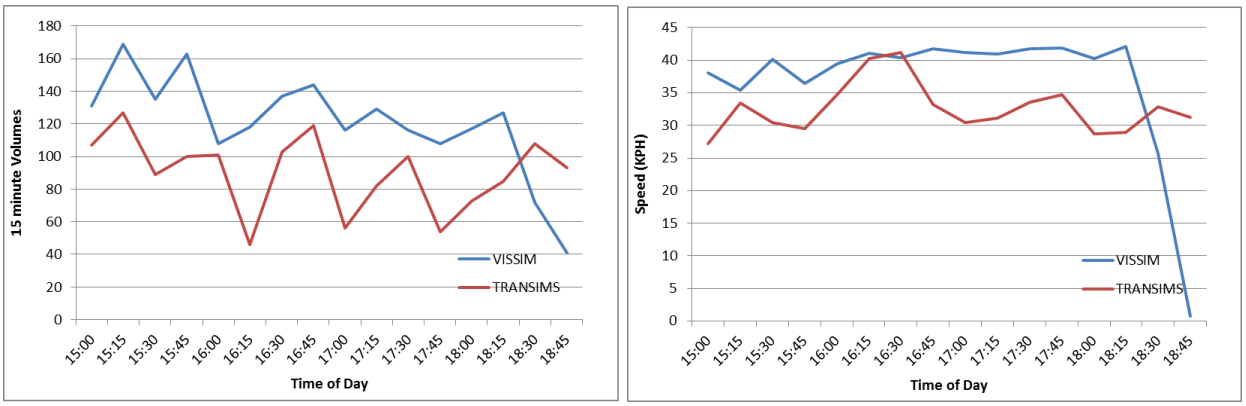


Figure 4-21: Volume-Speed Profiles for Arterial Link 743 for the HSR Strategy [Source: AECOM]

Figure 4-22 shows the overall speed differences between TRANSIMS and VISSIM during the peak hour (17:00-18:00). In general, the TRANSIMS speeds tend to be higher than the VISSIM speeds.

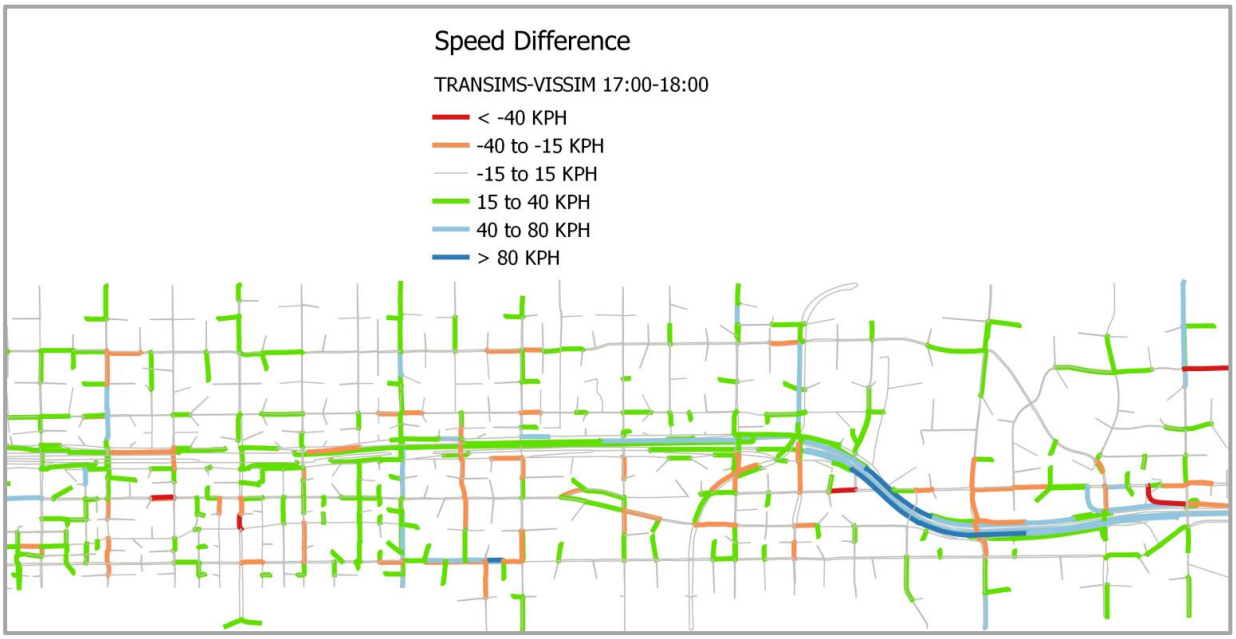


Figure 4-22: Speed Differences from the Hard Shoulder Run Strategy [Source: AECOM]

Chapter 5. Simulation Integration

One particular requirement of Pasadena Testbed models is to ensure consistent path choices between the prediction modeling environment (TRANSIMS) and virtual reality (VISSIM). It then requires that the path choice set within the baseline model need to remain the same for both TRANSIMS and VISSIM modeling. The Pasadena Testbed team took the following approach to build that path choice set in anticipation of various ATDM strategies to be evaluated (Figure 5-1).

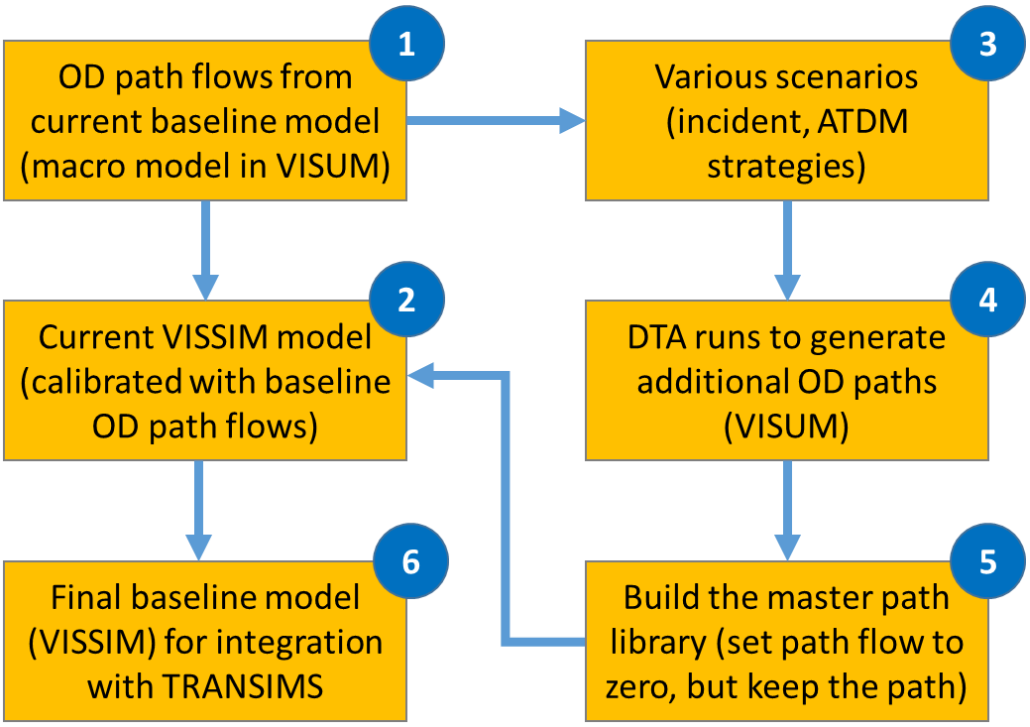


Figure 5-1: Workflow to enhance Pasadena Testbed Model for Integration with TRANSIMS [Source: HBA]

In Figure 5-1, the existing baseline model development and calibration took the steps 1 and 2. In Step 3, various model run scenarios were designed, based on the Pasadena Testbed Evaluation plans. These include:

1. Model run with no incident
2. Model run with Incident
3. Model run with capacity increase on ramp links (Adaptive Ramp Metering)
4. Model run with capacity increase on freeway links (Queue warning)
5. Model run with capacity increase on freeway links with Dynamic Speed Limit signs
6. Model run with capacity increase on urban arterials with Dynamic Signal Control
7. Model run with capacity increase on sections with Dynamic Shoulder Lane and Dynamic Junction Control

8. Model run with capacity increase on sections with Dynamic Shoulder Lane by time or location (sub-scenarios, i.e., 8a, 8b)
9. Model run with capacity increase on sections with Dynamic Junction Control by time or location (sub-scenarios, i.e., 9a, 9b)

Note that the goal of these models is to develop a comprehensive path choice set instead of evaluation of exact flow pattern changes; it is therefore of less importance to specify the exact model parameter adjustments under different scenarios. Rather, it is to use a reasonable set of parameter estimates, run the model (Step 4 in Figure 5-1) and discover the additional path choice from each different scenario, and add to the complete path set (Step 5 in Figure 5-1).

Nevertheless, literature review was conducted to determine the most reasonable model parameter adjustments under different scenarios. For example, a recent study on capacities of Hard Shoulder Running (HSR)/Dynamic Shoulder Lanes suggested a capacity range of 1,250 vphpl to 1,700 vphpl depending on the length and quality of HSR lanes[9]. Other past ITS Virtual Lab studies[10] suggested travelers' compliance rates under different VMS display text settings. For other ATDM or DMA applications with little or no empirical studies, a 10% capacity increase for concerned links was applied.

A custom program was developed to track the base path choice set and the newly discovered paths from each scenario runs (Step 5 in Figure 5-1). After each above scenario dynamic user equilibrium (DUE) model was completed, this program was run and the new paths were then added to the *master* path file. It was found that each scenario would generate about 3~5% new paths, and the margin diminished in the last few scenarios. This implied that a comprehensive yet reasonable path choice set is obtained.

The master path set was then reassembled in VISUM, with the time-dependent path volumes set to zero for the new paths flagged from different scenarios. The master path was then generated through the same ANM process (Step 6 in Figure 5-1). This becomes the final baseline model for use in TRANSIMS.

[9] Margiotta, R., M. Xyntarakis, A. Skabardonis, W. Huang, M. Mcgurrin (2014). Development of Modeling Capacities for Shoulders Using Part-Time Travel Lanes. FHWA-HOP-14-017.
[10] Martin, P.T., M. Zlatkovic, P. Chaudhuri, I. Tasic (2011). PTV Traffic Platform, Appendix: Utah Traffic Lab and Utah DOT Traffic Operations Center Staff Training Simulator, Administrator and Trainee Manual. University of Utah.

Chapter 6. Conclusion

The Pasadena Testbed modeling work benefited from existing datasets generated by past USDOT projects and local planning efforts. Through a multi-resolution modeling approach, the testbed model was developed and calibrated in a productive way. The model was enhanced by building a comprehensive path choice set for integration with TRANSIMS. The multi-resolution model is ready to be deployed as the basis for further testbed development.

Compared against representative traffic data for Operational Condition #1, the calibrated model well exceeded all calibration criteria. Operational Condition #2 and #3 had few cases that did not meet the designated calibration thresholds for margin of error due to the immense size of the network and limitation in resources available. However, given the extensive calibration efforts made to achieve a model that closely resembles field observations, the current Operational Condition #2 and #3 models are expected to have valid basis for assessing the planned strategies.

For the TRANSIMS model, emphasis was placed on replicating time of day patterns and changes instead of specific numbers. No specific calibration thresholds were used to the TRANSIMS calibration targets.

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