I-15 San Diego, California, Model Validation and Calibration Report

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16. Abstract

The Integrated Corridor Management (ICM) initiative requires the calibration and validation of simulation models used in the Analysis, Modeling, and Simulation of Pioneer Site proposed integrated corridors. This report summarizes the results and process for the calibration of microsimulation network for the I-15 Corridor in San Diego, California. As one of the Pioneer Sites for the ICM project, the I-15 Corridor was simulated in TransModeler microsimulation. Various versions of TransModeler were utilized as additional capabilities became available. The work was conducted by Cambridge Systematics, Inc. (CS), in partnership with San Diego Association of Governments (SANDAG). The eventual model was satisfactorily calibrated according to the guidelines set forth in the Experimental Plan.

The report is organized into two major parts. The first part provides the final calibration results, and provides a quick summary of the model calibration criteria and comparison against real data. The second section provides further insights into the calibration process, including details on the software used, challenges faced, and key lessons that can be carried forward in future projects.

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Chapter 1　　Introduction

The Integrated Corridor Management (ICM) initiative requires the calibration and validation of simulation models used in the Analysis, Modeling, and Simulation of Pioneer Site proposed integrated corridors. This report summarizes the results and process for the calibration of microsimulation network for the I-15 Corridor in San Diego, California.

As one of the Pioneer Sites for the ICM project, the I-15 Corridor was simulated in TransModeler microsimulation. Various versions of TransModeler were utilized as additional capabilities became available. The final base simulation network as well as future baseline and alternative analysis was conducted in version 1055. While the driver behavior parameters between version 1005 and 1055 remained virtually unchanged, the version included significant enhancements in the routing model for HOT lanes. Consequently, the base year calibrated model was run in versions 960, 1005 and 1040 to ensure that the calibration was consistent across versions, and consistency was confirmed.

The work was conducted by Cambridge Systematics, Inc. (CS), in partnership with San Diego Association of Governments (SANDAG). The eventual model was satisfactorily calibrated according to the guidelines set forth in the Experimental Plan.

1.1　Project Team

The project team includes representatives from the following:

- CS;
- United States Department of Transportation (DOT);
- Noblis; and
- SANDAG.

1.2　Organization of Report

The report is organized into two major parts. The first part provides the final calibration results, and provides a quick summary of the model calibration criteria and comparison against real data. The second section provides further insights into the calibration process, including details on the software used, challenges faced, and key lessons that can be carried forward in future projects. This document is organized as follows:

- This section, **Chapter 1**, outlines the context of this report; and introduces the project team, project study area, and data sources.
- **Chapter 2** details the model calibration statistics and their comparison with data collected. Most of the detailed locational information has been moved to the appendices.

- **Appendix A** presents the model calibration process, explaining both the necessity of the process and the results of this study's calibration efforts.
- **Appendix B** presents detailed output reports from the simulation calibration process.

1.3 Project Study Area

The Pioneer Site identified for this analysis is the Interstate 15 corridor in San Diego, California. The corridor extends from the interchange with State Road (SR) 163 in the south to the interchange with SR 78 in the north, a freeway stretch of approximately 20 miles. Also included in the study area are the following roadways:

- Centre City Parkway;
- Pomerado Road;
- Rancho Bernardo Road;
- Camino Del Norte Road;
- Ted Williams Parkway;
- Black Mountain Road; and
- Scripps Parkway.

Figure 1-1 illustrates the Pioneer Corridor and the roadways included in the study area. I-15 is an 8- to 10-lane freeway section in San Diego, providing an important connection between San Diego and cities like Poway, Mira Mesa, and Escondido, and destinations to the northeast. Figure 1-2 indicates the geographic location of the corridor, along with the extents of the mainline study area.

The year 2003 configuration on I-15 includes two center-median lanes that run along eight miles of I-15 between SR 163 in the south and Ted William Parkway (SR 56) in the north. These center-median lanes are reversible high-occupancy vehicle (HOV) lanes that operate in the southbound direction in the a.m. peak period and in the northbound direction during the p.m. peak period (not being simulated).

The I-15 corridor is one of three primary north-south transportation corridors in San Diego County, and is the primary north-south highway in inland San Diego County, serving local, regional, and interregional travel. The corridor is a heavily utilized regional commuter route connecting communities in northern San Diego County with major regional employment centers. The corridor is situated within a major interregional goods movement corridor, connecting Mexico with Riverside and San Bernardino Counties, as well as Las Vegas, Nevada.

Figure 1-1. Study Area – I-15 Corridor in San Diego, California
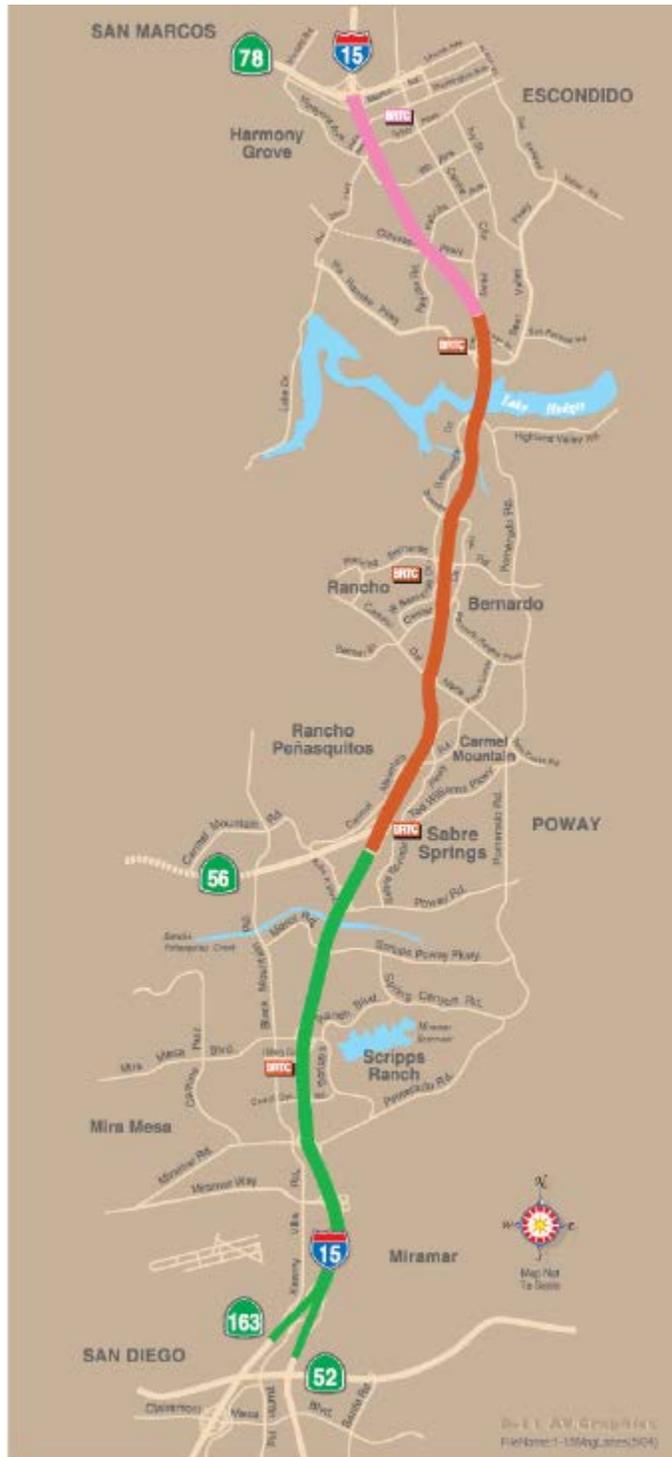
[Source: AV Graphics.]

Figure 1-2. Location and Geographic Boundaries of Corridor
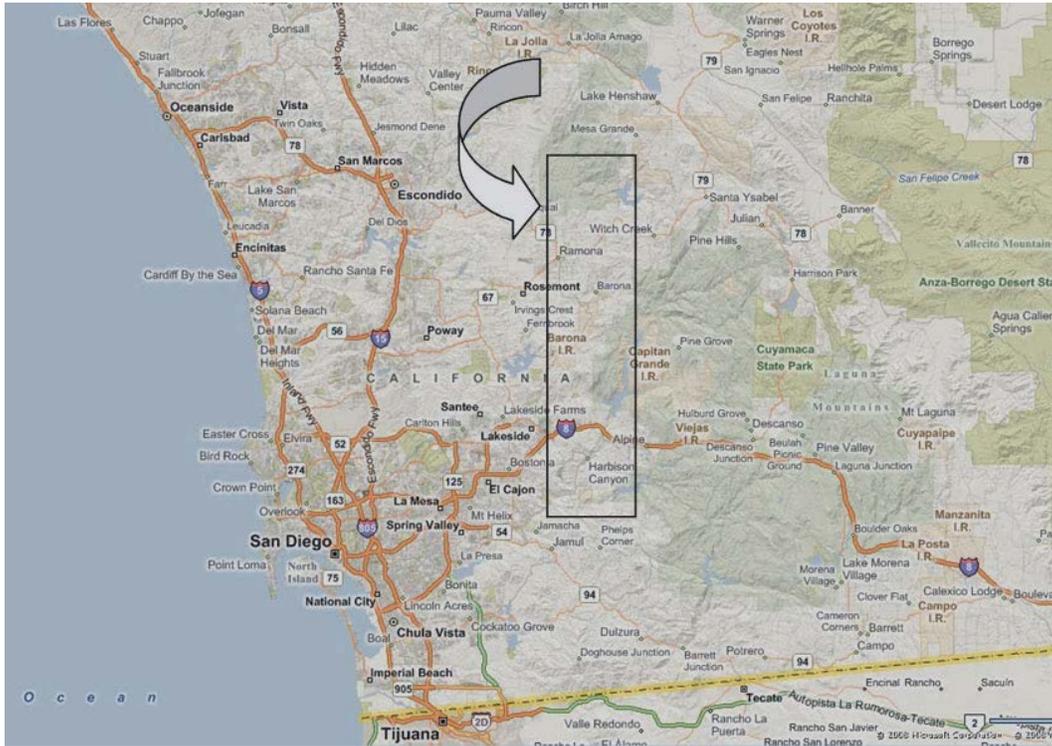
[Source: ©Microsoft Corporation ©NAVTEC ©AND.]

Baseline Network Timeframe Definition

For the simulation modeling, a peak period had to be identified for the model. For the base year (2003), this peak period is defined for the a.m. and p.m. peak periods, to correspond to the time of day when the traffic levels are elevated. Resource constraints allowed the team to model only one peak period – the a.m. Peak, as discussed in the I-15 Analysis Plan. The time period of 6:00-9:00 a.m. was chosen as the a.m. peak period as it showed the highest levels of travel demand during the a.m. period for the entire network. Also, this period corresponded to the peak period defined in the regional model, which provides significant input into the simulation. Additionally, a 30-minute warm-up period also was utilized, making the simulation run from 5:30 a.m. to 9:00 a.m. period for the base year. The warm-up period allows for traffic to appear on the network before the peak traffic starts appearing within the simulation.

For the future alternative analysis, there would be an additional period of one to two hours added as required at the end of the simulation, to allow for traffic to clear out. Although, this period will appear as needed, traffic generated will still be based on the regional travel demand patterns identified in the base and future analysis years.

1.4   Modeling Framework

The modeling framework for the simulation network usually follows a set pattern wherein certain information is collected and prepared outside of the simulation model, and incorporated within the models to ensure that the outputs from the simulation match real-world conditions. A similar framework was utilized for the I-15 simulation model development. The three key inputs into the simulation model were:

1. Network characteristics;
2. Travel demand; and
3. Field data for validation.

Each of these inputs is discussed in detail in this section. For a detailed discussion on the different aspects of calibration within the simulation itself, please refer to Appendix A.

Network Characteristics

The key network characteristics that need to be captured and input for the simulation network include: detailed geometric information (travel lanes, pavement markings, horizontal and vertical alignment, etc.), traffic control data (signal timings and phasings, and ramp metering information), and network restrictions (speed limits, lane-restrictions, etc.).

This information was extracted from various data sources which are identified in Appendix B. Since the network was built from scratch, utilizing only the base GIS files from the regional travel demand model, there was a need to identify specific information on all aspects of the network. The simulation network was reviewed by SANDAG and Caltrans staff that was familiar with the network, especially the 2003 characteristics.

Travel Demand

The release of vehicles in the simulation models, from trip origins towards their destinations is dependent upon the regional travel demand patterns that can either be identified via survey or by using a validated travel demand model for the region. San Diego has its own travel demand model that provides this input by vehicle type and was utilized to create origin-destination matrices for the simulation model. The origin-destination matrices for the simulation were based on a refined zone structure that disaggregated the travel demand model's Traffic Analysis Zones (TAZ) into smaller subzones, and distributed the base traffic pattern spatially and temporally. The details of the process are documented in the I-15 Analysis Plan under Section 2.3.

Field Data

The primary source of field data for validation purposes was the PeMS system. Details on PeMS data assembly and cleanup, and field data collection efforts are provided in Section 1.5.

All this information was utilized in an integrated set-up, and the calibration methodology followed the framework presented in Figure 1-3. As the figure shows, any change to the input origin-destination matrices impact the calibration and validation effort. As such, model calibration efforts followed this top-down process, to represent major changes in traffic patterns at the travel demand disaggregated zonal level. Also, smaller changes in the simulation, as detailed in Appendix A, were often made at local levels so as to represent local congestion effects utilizing the consistent set of origin-destination matrices.

Figure 1-3. San Diego ICM Modeling Framework
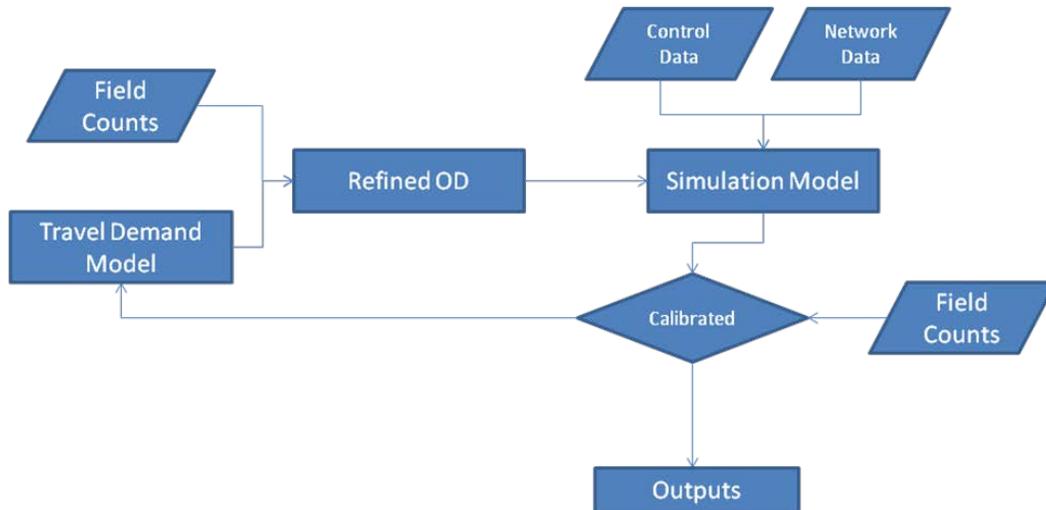
1.5 Data Sources

The main source of data that was utilized was the automatic detection on the freeway available through the PeMS database maintained by Caltrans. Year 2003 has been chosen as the base year for model calibration, since the period from 2003 to 2009 has seen a lot of construction activity; making it impossible to gather consistent data due to evolving geometrical configurations.

SANDAG collected turning movement count and travel time data off the freeway sections in order to help create hybrid data sets for the model calibration and validation processes. The primary data created utilized these multiple sources were volumes at freeway mainline and ramp locations, and speed contours from PeMS for year 2003.

The PeMS database was utilized to extract a typical month for the simulation, characterized by the period between September 16 and October 15, 2003. A "typical day" was developed using data from all eligible weekdays (Tuesdays, Wednesdays, and Thursdays), which were averaged for different parameters. PeMS data also were used to develop an "incident day" – that is a day with a major freeway incident. Tables 1-1 and 1-2 show the speed contours over the average month typical day and an incident day.

The sources of data and complete listing of locations where the calibration data is available are listed in Appendix A of the experimental plan. A summary of these data sources is available in Table B-1 in Appendix B.

Table 1-1. Typical Day Speed Profile

Month Weighted Average

Southbound I-15 PeMS Speed Contours at 5-Minute Intervals																	
PeMS Detector Stations																	
Segment	Miramar Way	WB Pomerado Rd	Carrol Canyon Rd**	WB Mira Mesa Blvd	Mercy Rd	WB Rancho	Ted Williams Pkwy	Carmel Mountain Rd	Camino Del Norte	Bernardo Center Dr	Rancho Bernardo	Pomerado/Highland	Via Rancho Pkwy	Center City Pkwy	Citracado Pkway	9th Ave	Valley Pkwy
Detector	1108607	1108495		1108491	1108450	1108489	1108429	1108427	1108425	1108519	1108538	1108541	1108543	1108545	1108516	1108558	1108556
Time Period (a.m.)	13.35	14.61		16.23	17.39	18.49	19.03	20.68	22.05	23.05	24.00	26.10	27.03	27.70	28.88	30.22	30.93
6:00-6:05	69.0	68.4	-	67.1	66.3	64.4	65.9	61.9	67.4	65.5	66.0	54.8	27.6	17.1	22.3	20.6	15.1
6:05-6:10	68.5	67.7	-	66.2	65.5	64.0	65.9	60.6	67.1	63.9	65.1	55.2	28.2	17.5	20.8	16.3	12.9
6:10-6:15	68.3	67.2	-	64.9	64.8	63.7	66.2	58.7	66.4	64.1	64.6	54.9	28.1	18.2	19.9	14.0	11.0
6:15-6:20	68.1	67.4	-	64.8	64.3	63.5	65.8	56.2	66.4	64.3	65.2	54.7	27.3	17.0	19.8	12.4	9.9
6:20-6:25	68.3	67.1	-	64.2	63.5	63.8	66.3	55.6	64.2	64.2	65.1	56.7	27.0	15.2	18.9	12.9	8.9
6:25-6:30	68.3	67.3	-	64.1	63.3	64.4	66.3	54.6	60.3	64.5	65.1	56.7	27.5	15.0	16.5	12.3	9.0
6:30-6:35	68.0	66.9	-	63.5	61.1	65.1	66.7	53.2	56.6	64.2	65.6	56.8	27.8	15.0	16.8	10.9	8.4
6:35-6:40	68.0	66.8	-	62.5	57.8	65.4	67.2	52.6	53.5	63.4	66.1	56.2	27.4	15.1	16.8	11.1	7.6
6:40-6:45	68.8	67.0	-	61.4	55.4	63.0	67.8	51.7	48.5	61.2	65.6	54.8	29.0	15.4	16.6	11.1	7.7
6:45-6:50	69.2	67.0	-	60.2	51.8	61.2	66.2	51.7	44.1	57.7	65.0	54.0	26.5	17.1	16.4	11.1	7.5
6:50-6:55	69.5	67.2	-	58.2	49.9	58.6	64.3	50.8	41.7	54.4	63.6	55.5	27.0	16.1	19.1	10.8	7.4
6:55-7:00	69.0	66.6	-	57.2	45.9	55.6	61.6	49.4	38.4	53.9	62.0	57.6	26.6	17.2	16.6	12.3	7.6
7:00-7:05	68.8	66.9	-	55.8	42.9	52.2	59.6	48.0	37.2	51.3	60.0	56.8	26.9	16.9	18.9	11.2	8.0
7:05-7:10	68.2	66.5	-	56.3	40.4	47.6	55.8	47.4	34.7	49.6	57.6	55.0	28.2	16.9	18.8	11.4	7.7
7:10-7:15	67.9	65.9	-	55.7	37.8	41.9	50.7	46.9	33.9	47.0	53.8	54.7	28.3	16.4	18.7	11.7	8.0
7:15-7:20	68.2	66.2	-	55.6	36.2	35.0	44.1	46.8	32.0	45.0	51.7	54.8	27.7	16.4	18.3	12.4	8.3
7:20-7:25	67.5	65.7	-	54.8	34.6	28.9	34.9	44.3	30.5	43.1	50.8	51.6	25.6	16.7	18.4	12.3	8.3
7:25-7:30	66.8	64.0	-	54.5	34.9	25.5	29.0	41.3	27.7	45.0	52.2	54.3	25.0	15.6	18.4	12.8	8.2
7:30-7:35	66.5	64.7	-	54.5	33.7	22.5	26.1	37.3	27.1	40.5	53.8	54.1	25.7	16.6	17.7	12.1	8.4
7:35-7:40	66.8	64.6	-	52.4	33.3	22.1	23.6	34.4	24.7	40.7	53.3	57.4	26.8	17.0	19.6	12.4	8.2
7:40-7:45	66.5	63.9	-	53.9	31.4	22.3	22.6	30.7	23.9	41.0	54.3	58.3	25.7	16.8	20.1	13.0	8.2
7:45-7:50	66.7	63.9	-	54.2	31.1	19.9	20.7	28.0	23.1	43.9	52.8	55.1	25.0	16.0	19.1	13.7	8.9
7:50-7:55	66.5	64.5	-	53.1	32.5	19.9	17.9	28.4	23.7	45.3	51.9	56.1	25.7	15.9	18.9	13.6	9.3
7:55-8:00	66.2	65.2	-	52.9	34.9	20.2	18.7	28.4	25.3	43.6	52.6	55.6	25.7	16.1	18.9	13.7	9.1
8:00-8:05	66.4	66.0	-	52.9	34.6	20.7	19.1	31.4	26.7	42.5	52.1	54.8	25.6	17.5	18.9	13.2	9.8
8:05-8:10	66.5	65.7	-	53.1	33.2	21.8	18.7	30.2	29.7	42.2	50.3	54.9	26.0	16.8	20.6	13.9	9.6
8:10-8:15	66.3	65.6	-	52.7	34.2	21.6	19.6	34.2	29.4	42.0	48.2	53.0	25.0	17.2	21.2	17.0	10.1
8:15-8:20	66.0	65.3	-	52.7	35.9	23.0	19.3	32.3	29.8	41.0	47.6	54.9	25.4	17.0	21.5	17.7	11.4
8:20-8:25	66.2	65.7	-	53.1	36.2	23.7	20.6	32.2	30.6	44.4	48.5	53.9	25.5	17.9	20.5	17.8	14.0
8:25-8:30	66.1	65.8	-	52.6	37.7	25.1	22.0	32.1	30.6	43.3	50.7	53.3	24.5	17.8	21.2	17.7	15.8
8:30-8:35	66.3	65.5	-	52.7	38.3	28.3	24.5	36.2	29.9	43.7	51.4	54.4	24.5	16.7	23.5	19.6	18.6
8:35-8:40	66.0	65.5	-	53.4	38.7	29.2	26.8	39.6	32.8	45.0	51.9	55.1	25.4	16.4	22.4	22.9	22.4
8:40-8:45	66.3	65.9	-	52.7	35.0	32.7	28.0	41.3	38.9	46.3	52.9	55.0	25.1	18.1	20.8	24.9	26.2
8:45-8:50	66.0	65.6	-	52.3	36.4	30.8	32.5	42.0	44.1	50.1	53.9	54.5	24.4	19.3	26.0	26.9	30.5
8:50-8:55	65.8	65.4	-	52.2	39.4	31.6	32.3	44.6	46.5	54.7	56.0	54.5	24.6	19.7	30.2	31.1	37.7
8:55-9:00	66.0	65.4	-	52.4	40.7	36.7	35.9	45.1	48.4	57.6	58.6	54.2	26.3	24.3	30.6	33.0	46.6

Table 1-2. Incident Day Speed Profile

Segment	Miramar Way	WB Pomerado Rd	WB Mira Mesa Blvd	Mercy Rd	WB Rancho	Ted Williams Pkwy	Carmel Mountain Rd	Camino Del Norte	Bernardo Center Dr	Rancho Bernardo	Pomerado/ Highland	Via Rancho Pkwy	Center City Pkwy	Citracado Pkway	9th Ave	Valley Pkwy
Detector	1108607	1108495	1108491	1108450	1108489	1108429	1108427	1108425	1108519	1108538	1108541	1108543	1108545	1108516	1108558	1108556
Segment Ids	37332	14407	37344	789	14660	570	37338	13664	13653	37022	8810	722	562	12946	12944	36530
Time Period (a.m.)	28.66	27.07	26.81	25.79	24.85	24.18	22.26	19.71	18.45	16.29	15.79	13.83	13.11	12.27	11.35	10.21
6:00	68.3	68.1	61.2	64.5	62.2	66.0	61.2	66.8	61.3	63.1	59.4	25.0	16.6	23.7	25.7	24.8
6:05	69.0	69.0	62.6	65.5	63.5	65.7	60.6	68.6	62.4	65.4	60.3	25.1	14.4	19.7	20.1	17.7
6:10	69.6	68.1	55.9	57.9	65.9	67.4	61.7	68.6	64.5	66.0	59.1	24.2	16.1	17.7	15.7	13.9
6:15	70.3	69.1	58.7	57.7	64.9	66.5	62.3	67.9	64.7	66.3	59.8	27.3	15.1	25.6	12.4	12.4
6:20	69.9	68.7	58.9	61.6	63.9	65.3	59.4	68.5	67.0	67.3	58.1	27.7	15.7	21.0	17.2	9.8
6:25	69.2	67.5	58.9	65.3	64.7	67.7	61.5	69.4	67.3	67.4	45.9	29.6	14.9	20.5	13.7	11.8
6:30	70.0	69.2	62.0	66.4	65.8	68.2	63.6	69.4	65.6	66.5	57.1	27.6	14.0	16.4	12.3	9.3
6:35	70.2	69.3	52.3	51.4	66.7	69.4	63.5	69.6	59.4	60.8	60.8	33.9	15.8	15.3	11.2	10.4
6:40	71.9	70.7	49.0	30.7	48.3	69.3	62.7	68.0	60.0	59.9	61.8	35.9	16.4	16.1	10.6	8.6
6:45	73.3	71.1	48.4	21.6	28.3	40.1	54.8	67.9	65.0	65.1	62.1	34.0	18.0	22.0	12.6	7.7
6:50	73.7	71.6	50.1	17.2	21.1	24.5	53.3	69.0	67.5	67.1	62.0	37.3	18.2	20.4	13.8	7.7
6:55	73.3	70.9	51.0	16.3	15.6	17.3	40.2	68.4	68.3	68.5	63.9	29.3	17.0	21.3	12.6	10.2
7:00	71.4	68.2	50.5	20.8	13.1	13.0	26.7	64.8	69.3	68.1	63.2	26.9	19.7	17.7	12.7	9.9
7:05	69.3	68.2	47.6	31.4	15.8	12.3	20.8	38.2	67.0	65.7	60.6	33.6	20.1	25.6	11.5	9.1
7:10	69.3	67.6	48.6	38.3	20.6	17.8	17.1	24.9	39.4	55.6	63.4	36.3	20.9	23.3	15.2	8.2
7:15	69.7	68.4	51.4	39.9	22.7	20.6	20.4	17.4	25.6	37.7	61.9	30.6	22.8	21.3	13.2	9.0
7:20	71.3	69.2	50.9	29.6	26.0	20.1	24.9	15.9	17.7	27.4	63.4	27.5	17.1	24.7	12.7	10.7
7:25	70.2	67.4	50.4	36.7	19.9	20.3	40.6	14.4	17.5	24.0	62.8	27.4	22.0	18.8	18.4	9.2
7:30	70.5	67.6	47.5	43.5	25.4	16.4	44.2	21.0	14.9	20.9	38.3	25.5	16.7	20.2	13.4	10.3
7:35	70.7	69.9	44.7	35.0	26.3	25.6	32.9	26.1	30.0	20.8	25.5	18.3	14.9	16.2	15.1	9.9
7:40	69.5	68.4	48.5	37.7	20.8	22.3	29.1	19.6	43.3	28.8	31.4	14.5	11.4	14.7	12.8	9.2
7:45	68.8	68.4	48.9	34.7	23.6	19.3	41.6	17.3	28.7	43.2	30.2	15.5	9.4	12.2	10.6	8.4
7:50	69.9	68.8	48.5	30.5	24.1	19.0	30.3	25.9	22.3	41.2	32.0	20.8	10.0	10.1	9.1	7.3
7:55	69.9	67.6	51.2	31.4	21.9	18.0	30.9	22.1	40.1	39.4	46.6	26.0	12.3	11.3	7.4	6.5
8:00	68.9	67.6	51.3	31.5	20.0	17.9	34.4	17.2	37.4	51.9	40.2	29.8	13.5	13.8	7.7	5.8
8:05	68.4	67.7	51.8	36.5	19.4	16.0	32.0	18.6	27.6	59.3	52.6	26.3	16.4	19.6	8.5	6.7
8:10	68.8	68.9	50.6	35.4	21.6	14.5	28.2	17.6	28.6	57.3	60.1	25.8	15.3	18.5	10.8	6.4
8:15	68.2	68.7	50.4	29.0	23.6	21.6	36.8	15.5	25.7	62.5	61.2	26.8	17.7	17.6	11.6	8.6
8:20	69.3	69.7	52.3	24.8	19.3	24.2	29.6	21.9	21.0	63.0	60.5	28.5	16.8	20.9	11.6	10.3
8:25	68.2	69.7	47.8	23.5	15.6	20.2	42.3	17.0	29.9	54.9	60.2	24.5	15.2	19.8	12.8	9.3
8:30	68.5	69.3	51.0	29.6	16.1	17.6	40.9	23.0	25.2	54.8	59.6	28.0	13.7	18.8	17.9	10.7
8:35	67.5	69.5	54.8	27.8	22.3	16.7	32.2	24.7	40.2	47.4	59.7	27.3	18.7	15.7	14.4	10.1
8:40	69.4	70.1	53.1	25.6	19.0	22.2	27.4	21.2	48.8	55.8	57.3	25.7	20.2	28.1	11.1	10.2
8:45	69.1	69.3	50.8	28.3	18.1	19.2	30.7	18.5	39.5	62.1	57.8	24.0	22.3	25.0	27.8	8.8
8:50	68.8	68.4	51.0	25.2	26.6	18.0	30.1	17.6	27.1	64.7	60.4	23.6	16.9	25.7	18.9	14.1
8:55	68.5	68.5	49.8	23.7	19.3	20.0	30.9	28.0	24.2	54.4	59.6	26.3	16.1	22.3	20.4	12.6

Chapter 2   Model Calibration

The models were calibrated in accordance with the calibration criteria specified in the ICM "AMS Experimental Plan for I-15, San Diego." These guidelines are summarized in Table 2-1.

Table 2-1. Calibration Criteria for the Pioneer Corridor AMS

Calibration Criteria and Measures	Calibration Acceptance Targets
Hourly Flows, Model Versus Observed	
Traffic flows within 15 percent of observed volumes for links with peak-period volumes greater than 2,000	For 85 percent of cases for links with peak-period volumes greater than 2,000
Sum of all link flows	Within 5 percent of sum of all link counts
Travel times within 15 percent	>85 percent of cases
Visual Audits	
Individual Link Speeds: Visually acceptable Speed-Flow relationships	To analyst's satisfaction
Bottlenecks: Visually Acceptable queuing	To analyst's satisfaction

The volume comparisons are based on balanced traffic volumes, which were prepared based on PeMS data for years 2003 and 2004. PeMS data from September to November 2003 and September to November 2004 were utilized as representative typical season data. In order to determine the acceptability target percentage, modeled link flows were compared to the balanced PeMS data.

The travel time comparisons are based on estimated travel times obtained from sample tachometer runs conducted in January 2009.

2.1   About the Calibration of Simulation Models

There are many reasons that simulation models may not exactly replicate perceived performance of the transportation system. Key reasons include the following:

- Even the best traffic monitoring system (whose data are used in model calibration) has imperfections caused by nonworking detectors, aggregation errors, etc.;
- Traffic varies from day to day, and not all calibration data are from the same day;

- People's perception of congestion varies;

- Trip tables from travel demand model are based on data collected at different times than typical day, and are aggregated coarsely;

- Temporal resolution of demand trip tables is not refined enough to match the typical day traffic;

- Corridor models are "windowed" from larger travel demand model networks for the whole region;

- Aggregation/disaggregation of zones at the corridor network boundary produces calibration inconsistencies; and

- Model calibration **for incidents** is further complicated by the fact that incident data are not as accurate as traffic congestion data because incident reporting is often incorrect both in a spatial and temporal sense.

2.2   Model Calibration Results – Typical Day

Link Count Comparisons

A total of 110 freeway link counts on the I-15 corridor were compared against the modeled count output from the TransModeler simulation runs. A comparison of the typical day volumes was done against single seed simulation runs first and secondly verified by running 9 random simulation seed values and averaging results across all the runs. All comparisons provided in the document are based on the average of the 9 simulation runs, except those for incident calibration which are based on a single model run (representing an incident day) to allow for removal of externalities when comparing against non-incident baseline. Two criteria were used to validate the model for each of three hourly time periods comprising the peak period of 6:00 a.m. to 9:00 a.m.: a comparison of observed versus modeled hourly flows for links with greater than 2,000 vehicles per hour (veh/h), and a comparison of aggregate link flows versus aggregate link counts. The detailed comparisons of observed and simulated volumes by locations are presented in Tables A-2 through A-4 of Appendix A.

06:00-07:00 a.m. Link Count Validation

A summary of the link count validation statistics for the first modeled hour, 06:00 to 07:00, is presented in Table 2-2.

Table 2-2. Link Count Summary, 06:00-07:00 a.m.

Criteria and Measures	Model Versus Observed	Percentage
Within 15%, for Flow > 2,000 veh/h (for > 85% of links)	35 (35) {pass counts (total)}	100%
Within 5%, sum of all link flows	254,265 (263,382) {model flow (observed counts)}	3%

07:00-08:00 a.m. Link Count Validation

A summary of the link count validation statistics for the second modeled hour, 07:00 to 08:00, is presented in Table 2-3.

Table 2-3. Link Count Summary, 07:00-08:00 a.m.

Criteria and Measures	Model Versus Observed	Percentage
Within 15 percent, for Flow > 2,000 veh/h (for > 85 percent of links)	35 (35) {pass counts (total)}	100%
Within 5 percent, sum of all link flows	275,804 (291,444) {model flow (observed counts)}	5 %

08:00-09:00 a.m. Link Count Validation

A summary of the link count validation statistics for the third modeled hour, 08:00 to 09:00, is presented in Table 2-4.

Table 2-4. Link Count Summary, 08:00-09:00 a.m.

Criteria and Measures	Model Versus Observed	Percentage
Within 15 percent, for Flow > 2,000 veh/h (for > 85 percent of links)	35 (35) {pass counts (total)}	100%
Within 5 percent, sum of all link flows	256,205 (263,549) {model flow (observed counts)}	3%

All hourly flow criteria were met for the three modeled hours (06:00 to 09:00 hrs), as per the guidelines set in the AMS Experimental Plan for I-15, San Diego.

Figures 2-1 through 2-3 show a comparison of freeway traffic volumes at individual detector stations against modeled freeway volumes for the peak direction on the I-15 corridor. As the figures show, *simulated volumes are within 15 percent of observed volumes for more than 99 percent of the observations.*

Speed Profile Comparisons

Observed speed contours were developed based on the PeMS database for September to October 2003. These observed speed contours were compared with simulation model-generated speed contour profiles, based on a weighted volume average across 9 simulation runs. The PeMS database provided five-minute speed data between 6:00 a.m. and 9:00 a.m. at 16 locations along the southbound I-15 corridor and at 15 locations along the northbound I-15 corridor. The northbound I-15

speed contours, from the PeMS database and from the calibrated simulation model are shown in Tables 2-5 and 2-6, respectively. Corresponding speed contours for the southbound I-15 corridor, from the PeMS database and from the calibrated simulation model, are shown in Tables 2-7 and 2-8, respectively.

Figure 2-1. Detector Volume Comparison for Southbound I-15, *06:00-07:00 a.m.*
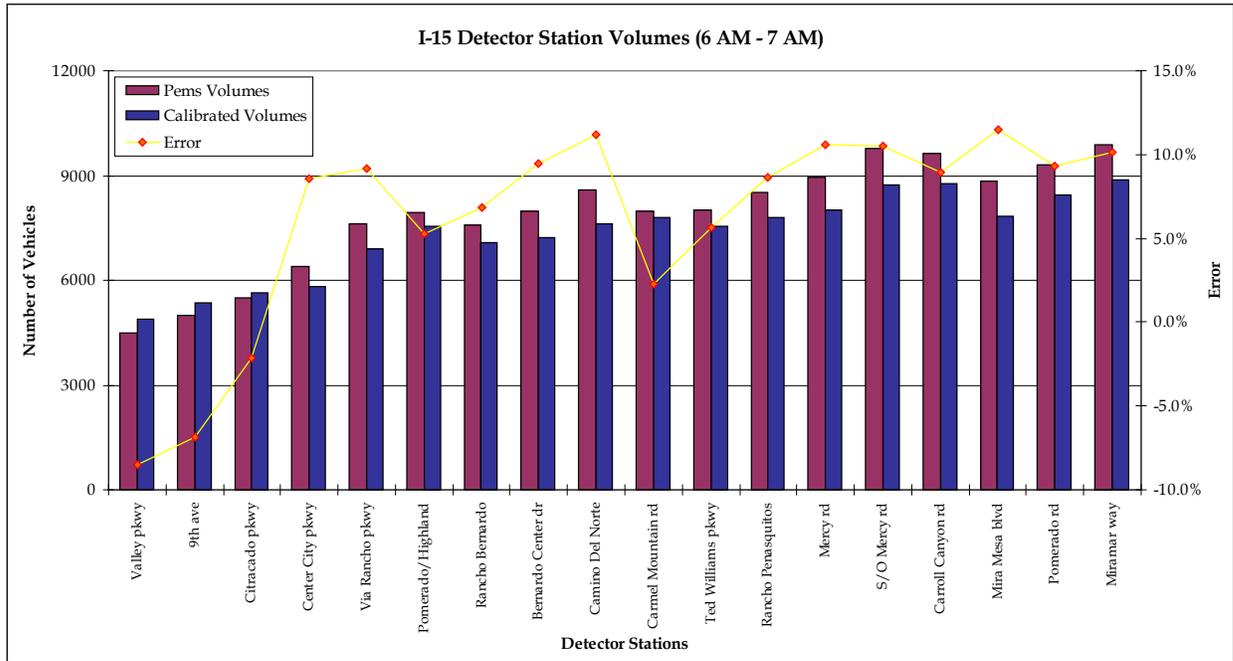
Figure 2-2. Detector Volume Comparison for Southbound I-15, *07:00-08:00 a.m.*
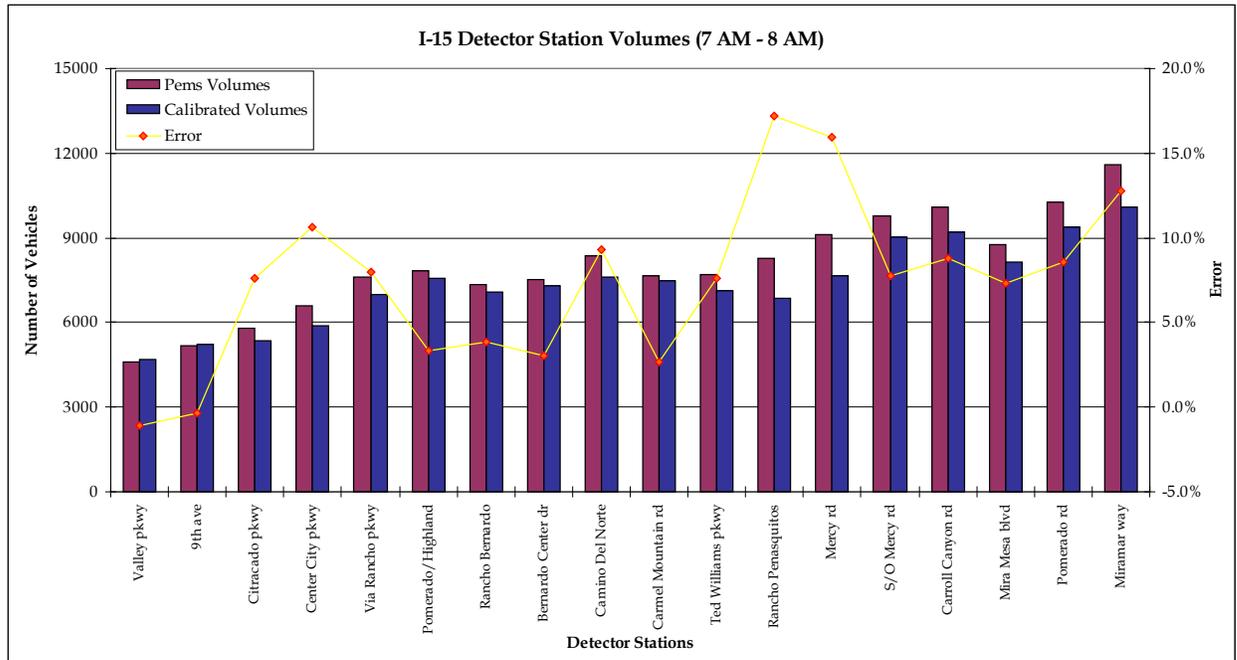
Figure 2-3. Detector Volume Comparison for Southbound I-15, *08:00-09:00 a.m.*
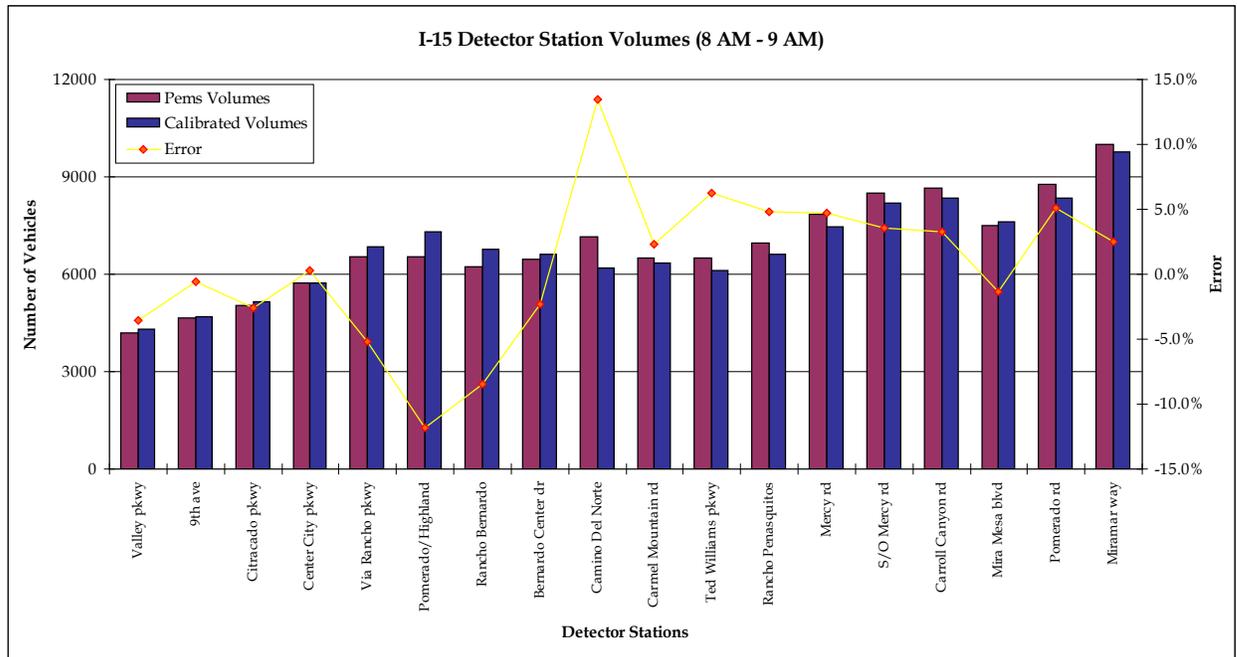
Table 2-5. Northbound Observed Speed Contours at Five-Minute Intervals, 06:00-09:00 a.m.

PeMS, 2003

Northbound I-15 PeMS Speed Contours at 5-Minute Intervals														
	PeMS Detector Stations													
Segment	Miramar Way	EB Miramar Rd	Carroll Canyon Rd	EB Mira Mesa Blvd	Mercy Rd	EB Poway Rd	Carmel Mountain Rd	Camino Del Norte	Bernardo Center Dr	Rancho Bernardo	Pomerado/Highland	Via Rancho Pkwy	Citracado Pkway	Auto Park Way	Valley Pkwy
Detector	1108536	1108454	1108439	1108415	1108717	1108585	1108590	1108592	1108597	1108595	1108562	1108767	1108769	1108771	1108773
Time Period (a.m.)														
6:00-6:05	70.5	69.6	69.5	67.9	71.3	68.4	67.9	70.5	69.1	69.3	68.8	64.6	69.0	68.3	69.0
6:05-6:10	70.5	69.2	68.9	67.7	70.8	67.6	66.9	69.7	68.3	69.0	68.6	64.4	69.0	68.3	69.0
6:10-6:15	69.4	68.8	68.7	67.7	70.5	67.1	66.8	69.3	67.8	68.7	68.0	63.8	68.9	68.2	68.9
6:15-6:20	68.9	68.2	67.7	68.0	70.6	67.1	66.7	69.2	67.7	68.7	68.1	64.0	69.1	68.4	69.1
6:20-6:25	68.5	67.8	67.4	67.9	70.3	66.3	66.9	69.7	68.0	68.9	68.3	64.3	69.1	68.4	69.1
6:25-6:30	68.1	67.4	67.2	67.7	70.3	66.5	67.0	69.5	68.0	69.0	68.7	64.7	69.1	68.4	69.1
6:30-6:35	67.8	67.5	67.5	67.6	69.8	66.0	66.6	69.3	68.2	69.4	69.2	65.4	69.2	68.5	69.2
6:35-6:40	67.6	67.6	67.3	67.8	69.8	66.0	66.8	69.2	68.1	69.2	69.0	65.0	69.4	68.7	69.4
6:40-6:45	68.0	67.9	68.0	68.2	70.0	66.0	66.6	69.0	68.0	69.2	69.1	65.0	69.5	68.8	69.5
6:45-6:50	67.8	68.2	68.1	68.4	70.5	66.5	67.1	68.7	68.0	68.8	69.5	65.4	69.9	69.2	69.9
6:50-6:55	68.2	68.2	67.9	68.3	71.0	65.9	67.8	69.1	68.5	69.0	69.3	65.0	70.2	69.5	70.2
6:55-7:00	68.6	68.8	68.5	68.7	71.5	66.7	67.8	69.5	68.8	69.3	69.8	65.6	70.2	69.5	70.2
7:00-7:05	68.6	67.8	65.9	68.2	71.6	67.3	68.3	69.7	69.3	69.6	69.7	65.1	70.1	69.4	70.1
7:05-7:10	68.6	67.2	65.0	68.0	71.1	66.7	67.8	69.2	69.4	69.7	70.0	65.5	70.0	69.3	70.0
7:10-7:15	67.0	66.1	64.8	67.8	70.8	66.4	67.7	68.9	69.1	69.4	69.7	65.3	69.9	69.2	69.9
7:15-7:20	65.9	65.6	64.9	67.7	70.4	66.0	67.6	68.7	68.6	69.3	69.5	65.2	69.6	68.9	69.6
7:20-7:25	66.0	65.7	65.4	67.7	70.4	64.6	67.4	68.5	68.4	69.3	69.4	65.0	69.4	68.7	69.4
7:25-7:30	65.5	65.5	65.4	67.9	70.0	62.5	67.6	68.5	68.4	69.6	69.6	65.3	69.4	68.7	69.4
7:30-7:35	65.6	65.7	65.5	67.4	69.2	61.3	67.6	68.0	68.7	69.6	69.6	65.4	69.2	68.5	69.2
7:35-7:40	65.6	65.3	65.0	67.4	69.0	60.7	67.4	68.3	68.8	69.5	69.7	65.2	69.2	68.5	69.2
7:40-7:45	65.7	65.3	65.0	67.4	68.3	57.2	67.3	68.4	68.8	69.8	69.7	65.5	69.2	68.5	69.2
7:45-7:50	65.3	65.6	65.1	67.1	66.7	54.5	67.4	68.3	68.7	69.9	69.7	65.4	69.2	68.5	69.2
7:50-7:55	65.1	65.2	65.0	65.8	62.4	52.2	67.2	68.1	68.8	69.9	70.0	65.6	69.5	68.8	69.5
7:55-8:00	65.6	65.4	64.8	64.6	60.3	47.5	67.5	68.1	68.9	69.9	70.0	65.7	69.4	68.7	69.4
8:00-8:05	65.5	66.1	65.5	63.6	58.1	45.5	67.1	67.9	68.8	69.7	70.2	65.8	69.6	68.9	69.6
8:05-8:10	66.0	66.4	66.0	63.4	57.8	48.7	66.8	67.2	68.2	69.5	69.8	65.3	69.3	68.6	69.3
8:10-8:15	65.8	66.1	65.7	63.7	59.1	49.2	66.6	67.2	68.5	69.4	69.4	65.2	69.0	68.3	69.0
8:15-8:20	65.8	66.3	65.4	62.9	58.1	47.4	66.5	67.0	67.9	69.1	69.2	64.8	68.8	68.1	68.8
8:20-8:25	65.8	66.2	65.6	62.1	56.6	45.3	65.9	66.6	67.5	68.5	69.0	64.8	68.7	68.0	68.7
8:25-8:30	65.5	65.7	65.6	62.6	57.7	44.1	66.0	66.3	67.3	68.0	68.3	64.3	68.5	67.8	68.5
8:30-8:35	66.1	66.3	66.0	62.5	57.6	43.1	65.4	66.3	67.0	67.7	68.1	64.5	68.5	67.8	68.5
8:35-8:40	66.6	66.9	66.5	61.1	55.9	43.6	65.7	66.2	66.9	67.8	68.1	63.8	68.2	67.5	68.2
8:40-8:45	67.0	67.2	66.5	61.1	55.3	43.4	65.0	65.7	66.6	67.5	68.1	64.0	68.1	67.4	68.1
8:45-8:50	66.7	66.5	66.1	62.0	57.8	45.8	65.2	65.9	66.9	67.7	68.2	64.3	67.9	67.2	67.9
8:50-8:55	66.9	66.7	65.9	62.3	59.0	48.9	65.2	65.7	66.6	67.6	68.3	64.4	68.1	67.4	68.1
8:55-9:00	68.4	67.1	66.0	62.7	60.6	51.5	65.0	65.5	66.4	67.5	68.1	64.0	68.1	67.4	68.1

Table 2-6. Northbound Simulation Model Speed Contours at Five-Minute Intervals, 06:00-09:00 a.m.

	Northbound I-15 Calibrated Simulation Model Speed Contours at 5-Minute Intervals														
	PeMS Detector Stations														
Segment	Miramar Way	EB Miramar Rd	Carroll Canyon Rd	EB Mira Mesa Blvd	Mercy Rd	EB Poway Rd	Carmel Mountain Rd	Camino Del Norte	Bernardo Center Dr	Rancho Bernardo	Pomerado/Highland	Via Rancho Pkwy	Citracado Pkway	Auto Park Way	Valley Pkwy
Detector	1108536	1108454	1108439	1108415	1108717	1108585	1108590	1108592	1108597	1108595	1108562	1108767	1108769	1108771	1108773
Time Period (a.m.)															
6:00-6:05	63.6	65.1	63.1	65.8	63.2	63.4	65.7	66.5	66.2	65.4	64.8	68.2	66.8	64.0	66.7
6:05-6:10	64.8	64.7	65.2	65.5	64.7	62.5	65.2	66.5	65.3	64.5	62.9	68.1	64.8	64.2	67.8
6:10-6:15	63.3	66.6	64.5	66.0	65.5	63.4	65.7	64.0	63.4	65.8	63.3	66.9	65.8	62.9	68.6
6:15-6:20	64.5	65.4	65.8	66.6	62.2	62.4	63.9	66.8	65.9	65.5	63.4	66.7	65.6	63.8	66.6
6:20-6:25	64.1	63.8	61.7	66.2	62.6	62.9	64.6	67.7	65.1	64.9	63.6	65.7	65.4	64.5	66.3
6:25-6:30	65.3	65.6	63.4	64.9	62.8	64.7	65.4	66.3	67.0	65.6	63.1	66.6	64.3	64.0	65.7
6:30-6:35	62.8	63.5	64.9	67.2	65.3	64.3	66.6	66.8	65.4	65.8	62.5	67.0	65.6	64.5	66.5
6:35-6:40	63.9	65.0	66.0	66.8	65.0	63.9	65.4	64.2	63.8	67.1	64.6	68.3	67.3	66.3	68.5
6:40-6:45	63.4	66.0	64.5	67.1	63.6	65.9	65.3	66.2	62.9	64.7	64.7	67.0	65.6	64.9	65.9
6:45-6:50	63.5	65.9	63.6	66.7	65.5	64.6	65.6	66.9	65.0	66.0	63.1	66.9	65.3	65.0	69.9
6:50-6:55	63.8	65.1	66.8	65.8	64.0	65.5	66.0	64.4	64.0	66.2	61.5	65.6	64.8	63.3	65.9
6:55-7:00	63.8	65.1	62.7	66.2	62.4	64.2	64.3	65.8	63.8	63.7	62.4	66.8	65.8	64.9	65.4
7:00-7:05	63.7	62.5	65.9	66.7	64.2	61.2	66.2	65.7	65.3	66.5	63.9	65.6	66.4	64.7	66.2
7:05-7:10	62.8	64.2	63.9	67.4	57.3	63.0	66.6	63.1	62.5	63.9	63.9	67.5	66.4	62.6	66.2
7:10-7:15	62.3	65.2	61.6	68.3	64.8	60.1	64.4	63.9	65.1	62.8	63.1	68.0	65.1	63.5	64.7
7:15-7:20	62.6	63.4	60.3	67.4	61.4	65.2	65.2	62.8	65.1	65.5	64.5	66.5	65.2	63.4	67.9
7:20-7:25	63.0	66.2	56.3	69.0	63.1	66.0	66.7	61.8	64.8	66.8	62.5	65.8	67.0	65.4	66.8
7:25-7:30	63.9	64.6	57.4	68.9	60.9	63.9	63.8	62.0	65.6	65.3	63.6	66.5	65.7	65.0	67.1
7:30-7:35	63.4	64.2	58.5	69.3	61.1	63.9	65.6	64.0	65.6	67.0	63.3	67.8	65.8	63.5	65.8
7:35-7:40	63.7	64.2	63.5	68.7	63.5	64.8	64.7	63.3	64.2	65.9	62.2	65.8	65.2	64.8	66.9
7:40-7:45	63.8	64.2	60.3	66.7	62.7	64.3	65.3	63.4	65.7	66.5	63.3	65.8	64.7	64.4	65.5
7:45-7:50	62.7	63.2	63.3	67.3	62.2	63.0	66.4	63.7	53.5	69.1	64.5	66.7	65.8	63.4	64.6
7:50-7:55	64.6	64.3	62.1	70.4	62.5	63.2	64.5	65.2	52.2	67.0	64.6	66.0	65.0	64.8	65.4
7:55-8:00	64.1	64.5	63.7	66.2	63.3	63.6	64.4	64.3	52.0	67.6	64.3	68.5	66.0	63.9	65.3
8:00-8:05	64.3	62.6	63.8	68.4	61.3	61.5	65.0	63.8	51.5	65.9	64.3	66.9	63.9	63.0	66.9
8:05-8:10	62.3	62.0	64.8	67.0	63.8	58.7	64.6	63.6	53.2	67.9	65.4	66.1	64.7	62.7	65.4
8:10-8:15	61.7	60.3	61.3	68.4	62.4	65.1	65.0	66.3	52.8	66.6	63.5	65.4	64.5	63.4	68.1
8:15-8:20	62.3	62.5	58.3	68.3	62.9	59.2	66.0	63.3	55.6	67.8	64.6	65.8	64.7	63.7	64.3
8:20-8:25	62.7	60.5	56.5	67.1	62.4	56.6	64.1	60.7	49.5	72.3	66.5	69.3	66.2	63.4	67.6
8:25-8:30	64.7	62.8	55.7	67.3	60.0	59.1	65.5	60.3	50.1	66.7	65.3	69.7	68.2	68.3	68.4
8:30-8:35	64.1	66.1	55.4	66.7	64.6	60.5	65.1	58.9	51.8	64.0	67.8	67.5	66.6	65.3	66.3
8:35-8:40	62.7	62.4	64.0	68.8	67.3	61.6	64.6	56.7	50.3	69.2	67.1	69.3	67.4	66.2	67.5
8:40-8:45	64.9	63.9	64.0	67.5	63.1	60.4	60.1	56.5	50.7	68.9	68.6	69.5	66.7	67.0	67.0
8:45-8:50	64.9	62.2	65.3	67.8	64.6	60.0	59.3	55.9	54.8	60.6	63.2	65.6	65.2	66.8	67.6
8:50-8:55	64.2	63.5	64.0	66.9	59.3	61.8	57.2	55.4	58.2	51.8	60.8	64.1	66.3	61.4	64.5
8:55-9:00	64.6	63.4	64.8	67.1	65.5	61.5	55.1	53.2	64.7	63.9	63.2	69.4	65.4	52.8	61.0

Table 2-7. Southbound Observed Speed Contours at Five-Minute Intervals, 06:00-09:00 a.m.

PeMS, 2003

Southbound I-15 PeMS Speed Contours at 5-Minute Intervals																		
PeMS Detector Stations																		
Segment	Miramar Way	WB Pomerado Rd	Carrol Canyon Rd**	WB Mira Mesa Blvd	Mercy Rd	WB Rancho	Ted Williams Pkwy	Carmel Mountain Rd	Camino Del Norte	Bernardo Center Dr	Rancho Bernardo	Pomerado/Highland	Via Rancho Pkwy	Center City Pkwy	Citracado Pkway	9th Ave	Valley Pkwy
Detector	1108607	1108495		1108491	1108450	1108489	1108429	1108427	1108425	1108519	1108538	1108541	1108543	1108545	1108516	1108558	1108556
Time Period (a.m.)	13.35	14.61		16.23	17.39	18.49	19.03	20.68	22.05	23.05	24.00	26.10	27.03	27.70	28.88	30.22	30.93
6:00-6:05	69.0	68.4	-	67.1	66.3	64.4	65.9	61.9	67.4	65.5	66.0	54.8	27.6	17.1	22.3	20.6	15.1
6:05-6:10	68.5	67.7	-	66.2	65.5	64.0	65.9	60.6	67.1	63.9	65.1	55.2	28.2	17.5	20.8	16.3	12.9
6:10-6:15	68.3	67.2	-	64.9	64.8	63.7	66.2	58.7	66.4	64.1	64.6	54.9	28.1	18.2	19.9	14.0	11.0
6:15-6:20	68.1	67.4	-	64.8	64.3	63.5	65.8	56.2	66.4	64.3	65.2	54.7	27.3	17.0	19.8	12.4	9.9
6:20-6:25	68.3	67.1	-	64.2	63.5	63.8	66.3	55.6	64.2	64.2	65.1	56.7	27.0	15.2	18.9	12.9	8.9
6:25-6:30	68.3	67.3	-	64.1	63.3	64.4	66.3	54.6	60.3	64.5	65.1	56.7	27.5	15.0	16.5	12.3	9.0
6:30-6:35	68.0	66.9	-	63.5	61.1	65.1	66.7	53.2	56.6	64.2	65.6	56.8	27.8	15.0	16.8	10.9	8.4
6:35-6:40	68.0	66.8	-	62.5	57.8	65.4	67.2	52.6	53.5	63.4	66.1	56.2	27.4	15.1	16.8	11.1	7.6
6:40-6:45	68.8	67.0	-	61.4	55.4	63.0	67.8	51.7	48.5	61.2	65.6	54.8	29.0	15.4	16.6	11.1	7.7
6:45-6:50	69.2	67.0	-	60.2	51.8	61.2	66.2	51.7	44.1	57.7	65.0	54.0	26.5	17.1	16.4	11.1	7.5
6:50-6:55	69.5	67.2	-	58.2	49.9	58.6	64.3	50.8	41.7	54.4	63.6	55.5	27.0	16.1	19.1	10.8	7.4
6:55-7:00	69.0	66.6	-	57.2	45.9	55.6	61.6	49.4	38.4	53.9	62.0	57.6	26.6	17.2	16.6	12.3	7.6
7:00-7:05	68.8	66.9	-	55.8	42.9	52.2	59.6	48.0	37.2	51.3	60.0	56.8	26.9	16.9	18.9	11.2	8.0
7:05-7:10	68.2	66.5	-	56.3	40.4	47.6	55.8	47.4	34.7	49.6	57.6	55.0	28.2	16.9	18.8	11.4	7.7
7:10-7:15	67.9	65.9	-	55.7	37.8	41.9	50.7	46.9	33.9	47.0	53.8	54.7	28.3	16.4	18.7	11.7	8.0
7:15-7:20	68.2	66.2	-	55.6	36.2	35.0	44.1	46.8	32.0	45.0	51.7	54.8	27.7	16.4	18.3	12.4	8.3
7:20-7:25	67.5	65.7	-	54.8	34.6	28.9	34.9	44.3	30.5	43.1	50.8	51.6	25.6	16.7	18.4	12.3	8.3
7:25-7:30	66.8	64.0	-	54.5	34.9	25.5	29.0	41.3	27.7	45.0	52.2	54.3	25.0	15.6	18.4	12.8	8.2
7:30-7:35	66.5	64.7	-	54.5	33.7	22.5	26.1	37.3	27.1	40.5	53.8	54.1	25.7	16.6	17.7	12.1	8.4
7:35-7:40	66.8	64.6	-	52.4	33.3	22.1	23.6	34.4	24.7	40.7	53.3	57.4	26.8	17.0	19.6	12.4	8.2
7:40-7:45	66.5	63.9	-	53.9	31.4	22.3	22.6	30.7	23.9	41.0	54.3	58.3	25.7	16.8	20.1	13.0	8.2
7:45-7:50	66.7	63.9	-	54.2	31.1	19.9	20.7	28.0	23.1	43.9	52.8	55.1	25.0	16.0	19.1	13.7	8.9
7:50-7:55	66.5	64.5	-	53.1	32.5	19.9	17.9	28.4	23.7	45.3	51.9	56.1	25.7	15.9	18.9	13.6	9.3
7:55-8:00	66.2	65.2	-	52.9	34.9	20.2	18.7	28.4	25.3	43.6	52.6	55.6	25.7	16.1	18.9	13.7	9.1
8:00-8:05	66.4	66.0	-	52.9	34.6	20.7	19.1	31.4	26.7	42.5	52.1	54.8	25.6	17.5	18.9	13.2	9.8
8:05-8:10	66.5	65.7	-	53.1	33.2	21.8	18.7	30.2	29.7	42.2	50.3	54.9	26.0	16.8	20.6	13.9	9.6
8:10-8:15	66.3	65.6	-	52.7	34.2	21.6	19.6	34.2	29.4	42.0	48.2	53.0	25.0	17.2	21.2	17.0	10.1
8:15-8:20	66.0	65.3	-	52.7	35.9	23.0	19.3	32.3	29.8	41.0	47.6	54.9	25.4	17.0	21.5	17.7	11.4
8:20-8:25	66.2	65.7	-	53.1	36.2	23.7	20.6	32.2	30.6	44.4	48.5	53.9	25.5	17.9	20.5	17.8	14.0
8:25-8:30	66.1	65.8	-	52.6	37.7	25.1	22.0	32.1	30.6	43.3	50.7	53.3	24.5	17.8	21.2	17.7	15.8
8:30-8:35	66.3	65.5	-	52.7	38.3	28.3	24.5	36.2	29.9	43.7	51.4	54.4	24.5	16.7	23.5	19.6	18.6
8:35-8:40	66.0	65.5	-	53.4	38.7	29.2	26.8	39.6	32.8	45.0	51.9	55.1	25.4	16.4	22.4	22.9	22.4
8:40-8:45	66.3	65.9	-	52.7	35.0	32.7	28.0	41.3	38.9	46.3	52.9	55.0	25.1	18.1	20.8	24.9	26.2
8:45-8:50	66.0	65.6	-	52.3	36.4	30.8	32.5	42.0	44.1	50.1	53.9	54.5	24.4	19.3	26.0	26.9	30.5
8:50-8:55	65.8	65.4	-	52.2	39.4	31.6	32.3	44.6	46.5	54.7	56.0	54.5	24.6	19.7	30.2	31.1	37.7
8:55-9:00	66.0	65.4	-	52.4	40.7	36.7	35.9	45.1	48.4	57.6	58.6	54.2	26.3	24.3	30.6	33.0	46.6

Table 2-8. Southbound Simulation Model Speed Contours at Five-Minute Intervals, 06:00-09:00 a.m.

							Southbound I-15 Calibrated Simulation Model Speed Contours at 5-Minute Intervals											
							PeMS Detector Stations											
Segment	Miramar Way	WB Pomerado Rd	Carrol Canyon Rd	WB Mira Mesa Blvd	Mercy Rd	WB Rancho	Ted Williams Pkwy	Carmel Mountain Rd	Camino Del Norte	Bernardo Center Dr	Rancho Bernardo	Pomerado/Highland	Via Rancho Pkwy	Center City Pkwy	Citracado Pkway	9th Ave	Valley Pkwy
Detector	1108607	1108495		1108491	1108450	1108489	1108429	1108427	1108425	1108519	1108538	1108541	1108543	1108545	1108516	1108558	1108556
Time Period (a.m.)	13.35	14.61		16.23	17.39	18.49	19.03	20.68	22.05	23.05	24.00	26.10	27.03	27.70	28.88	30.22	30.93
6:00-6:05	62.7	64.3	-	55.8	61.6	64.0	65.1	53.9	33.1	49.4	65.3	62.9	22.0	13.5	33.2	59.7	43.6
6:05-6:10	62.9	65.3	-	56.7	64.7	63.3	64.9	59.2	39.5	43.8	65.1	63.0	21.1	14.6	23.6	56.2	41.5
6:10-6:15	63.3	64.2	-	58.0	63.0	62.4	64.3	51.3	41.0	40.8	64.9	63.9	20.4	13.1	21.8	57.6	45.3
6:15-6:20	61.7	62.6	-	56.7	63.7	63.1	64.4	52.5	43.9	51.4	67.0	62.1	21.6	13.7	17.1	54.5	38.4
6:20-6:25	64.3	63.9	-	56.8	64.4	62.7	64.5	60.4	34.9	54.3	64.7	64.1	19.7	13.6	14.1	56.1	43.5
6:25-6:30	64.6	65.3	-	58.7	63.8	64.3	64.8	52.2	41.3	55.0	66.5	62.8	20.0	13.5	13.0	53.4	45.1
6:30-6:35	62.8	64.1	-	59.6	48.5	62.9	63.8	60.1	36.6	46.2	64.6	62.1	21.6	13.6	12.8	52.4	43.3
6:35-6:40	64.6	66.6	-	57.6	23.8	63.0	63.5	54.2	55.4	38.8	64.8	63.3	20.6	13.9	12.3	49.2	40.0
6:40-6:45	62.7	64.8	-	60.1	12.8	62.7	65.3	56.2	41.6	41.6	66.9	63.9	19.5	12.9	12.3	47.5	40.0
6:45-6:50	64.4	63.4	-	58.2	13.5	64.1	64.9	55.8	42.8	46.4	66.8	61.5	19.2	13.5	11.7	49.5	47.1
6:50-6:55	63.4	65.4	-	58.5	12.7	63.3	64.2	46.5	38.9	55.0	66.9	64.6	19.3	13.2	11.8	45.8	46.1
6:55-7:00	63.3	64.9	-	59.6	11.6	63.5	65.0	51.1	33.7	59.1	65.7	62.8	19.1	13.4	11.8	32.7	41.7
7:00-7:05	61.9	62.6	-	59.1	12.4	63.5	66.1	57.5	45.7	55.3	64.7	62.9	19.5	13.3	11.6	24.9	41.9
7:05-7:10	62.4	65.0	-	59.5	11.9	64.5	65.4	53.2	36.2	56.0	65.9	63.3	19.4	14.0	11.8	15.2	35.1
7:10-7:15	63.7	67.1	-	58.7	13.2	64.3	65.6	36.5	29.6	52.6	64.9	62.8	18.7	12.9	12.8	10.9	21.5
7:15-7:20	61.5	64.5	-	60.0	11.6	60.7	65.1	16.9	27.4	49.8	65.5	63.7	19.9	13.6	11.5	10.4	13.4
7:20-7:25	62.3	67.3	-	59.5	10.6	21.0	65.2	15.9	23.2	56.4	65.4	62.4	21.0	15.5	12.0	10.0	10.6
7:25-7:30	61.5	64.1	-	56.1	12.6	12.5	65.7	13.2	25.5	49.1	66.5	63.7	18.4	13.6	13.6	10.1	9.7
7:30-7:35	62.2	64.5	-	58.3	12.4	12.8	60.3	14.4	32.0	45.8	65.4	62.6	19.3	13.1	12.1	10.8	10.6
7:35-7:40	63.6	64.9	-	59.2	11.9	14.7	44.2	14.0	24.0	50.2	66.5	63.0	22.4	16.3	11.7	10.9	11.0
7:40-7:45	63.3	66.1	-	60.2	13.9	13.4	26.1	16.2	27.2	54.0	64.9	63.6	22.8	16.2	13.8	10.3	11.0
7:45-7:50	62.9	63.1	-	61.3	11.2	15.0	18.3	14.4	23.8	52.4	66.4	63.2	23.0	16.1	14.2	11.0	11.8
7:50-7:55	63.4	64.3	-	59.5	11.7	13.6	16.2	13.3	21.6	53.9	66.2	62.8	20.0	15.7	14.1	11.4	12.7
7:55-8:00	63.8	64.6	-	59.7	11.3	12.1	13.4	14.7	19.7	57.1	65.0	62.0	21.9	14.5	13.6	11.6	13.0
8:00-8:05	63.5	65.9	-	58.3	12.2	13.3	11.1	13.2	15.6	52.5	64.9	64.1	21.4	15.7	12.4	12.1	11.6
8:05-8:10	62.6	66.0	-	59.3	12.6	12.9	11.2	13.8	14.5	48.0	67.0	61.3	21.7	15.0	13.0	11.8	11.8
8:10-8:15	62.6	64.0	-	58.1	12.0	12.8	11.4	13.8	14.7	37.7	66.2	62.0	21.5	15.1	13.6	11.2	11.5
8:15-8:20	62.9	65.8	-	59.5	11.7	13.4	11.6	11.0	13.3	34.5	65.4	63.9	20.6	15.5	14.0	10.9	10.2
8:20-8:25	64.1	64.8	-	59.1	12.0	14.2	12.3	10.6	9.9	41.0	66.6	62.5	20.9	15.1	13.7	11.9	9.8
8:25-8:30	62.9	66.6	-	58.9	13.0	13.6	12.1	10.5	9.5	54.0	67.0	64.5	21.2	16.4	12.7	12.0	10.8
8:30-8:35	63.4	65.0	-	60.5	13.7	14.8	12.1	10.9	11.0	50.3	67.3	62.8	22.3	15.3	13.8	11.9	11.7
8:35-8:40	63.1	62.9	-	60.8	12.0	16.4	13.1	10.9	9.7	35.9	65.8	64.2	20.5	15.5	13.7	11.4	11.5
8:40-8:45	63.8	65.3	-	60.0	12.2	14.8	15.1	12.3	11.6	23.9	65.4	62.9	23.2	16.4	13.7	12.6	11.1
8:45-8:50	63.7	65.4	-	60.1	13.6	13.8	11.8	14.3	11.9	19.4	66.9	63.1	22.8	17.7	15.0	11.4	11.0
8:50-8:55	64.4	61.5	-	59.1	12.4	15.1	11.6	14.9	12.3	23.5	72.0	63.4	23.7	19.1	15.5	12.4	10.6
8:55-9:00	63.3	63.5	-	59.1	14.1	13.7	13.7	11.7	11.8	60.1	67.4	63.4	25.1	18.9	16.1	13.0	11.4

In the southbound direction, PeMS data suggest heavy congestion north of Lake Hodges during the a.m. peak period. This observed bottleneck extends all the way to the north end of the study corridor. The calibrated simulation model duplicates this bottleneck very closely, as can be seen in the observed and simulated speed profiles. The PeMS database also suggests some congestion between Mercy Road and Bernardo Center Drive sections of the freeway in the southbound direction. The simulation model approximates the severity and extent of this congestion, and shows two separate bottlenecks at Mercy Road and Camino Del Norte, as observed in the PeMS speed profile.

I-15 in the northbound direction flowed freely during the a.m. peak period in 2003. The PeMS speed database, as well as the calibrated simulation model, both suggest free-flowing traffic in the northbound direction.

Overall, the similarities between observed and model speed patterns signify that the model adequately replicates bottlenecks, travel times, and congestion on the I-15 Corridor for a typical day. For further details on calibration methodologies, please refer to Appendix A of this document.

2.3   Model Calibration Results – Incident Day

This section provides a summary of the simulation model calibration results for an incident day on I-15. The incident modeled on I-15 is located at the freeway southbound lanes, just south of the Mira Mesa Boulevard interchange. The incident location and duration are based on an actual incident from the PeMS data base. The incident is blocking one lane of traffic, starting at 6:36 a.m. and ending at 6:51 a.m. The location of the incident is marked with a blue-star in Figure 2-4. Reported incident day statistics are based on a single simulation run, in order to ensure that the same calibrated model seed is used to estimate the incident impact on performance measures, and thus the incident versus non-incident comparison is not influenced by external factors.

The I-15 model calibration findings are listed below, following the U.S. DOT incident calibration guidance.

1. **Freeway bottleneck locations should be on a modeled segment that is consistent in location, design, and attributes of the representative roadway section.** The incident modeled on I-15 is located at the freeway southbound south of the Mira Mesa Boulevard interchange, blocking one lane of traffic, starting at 6:36 a.m. and ending at 6:51 a.m. Traveler information for diversion is dispersed starting at 6:40 a.m. and ending at 7:30 a.m. Figure 2-4 shows the incident location and affected links. Calibration criterion is met – modeled segment is consistent in location, design, and attributes of the representative roadway section.

2. **Duration of incident-related congestion – duration where observable within 25 percent.** Tables 2-9 through 2-13 show speed contours for PeMS baseline with no incident (Table 2-9), PeMS baseline with incident (Table 2-10), model baseline with no incident (Table 2-11), model baseline with incident and no diversion information to travelers (Table 2-12), and model baseline with incident and diversion information to 20 percent of travelers (Table 2-13). **Qualitative expectations are met:** a) modeled congestion is more with incident than without, as it is in PeMS, b) modeled congestion is less with 20 percent informed travelers than with no informed travelers. **Quantitative expectations are also met:** a) incident-caused (6:40 a.m. to 7:30 a.m.) congested speeds (red or under 30 mph) in PeMS occupy

53 five-minute periods/segments (Table 2-10), while model incident-congested speeds occupy **50** five-minute periods/segments (Table 2-12). **The difference of three periods/ segments is well within the 25 percent range recommended by the U.S. DOT.**

Figure 2-4. I-15 Transportation Network Showing Incident Location and Affected Links
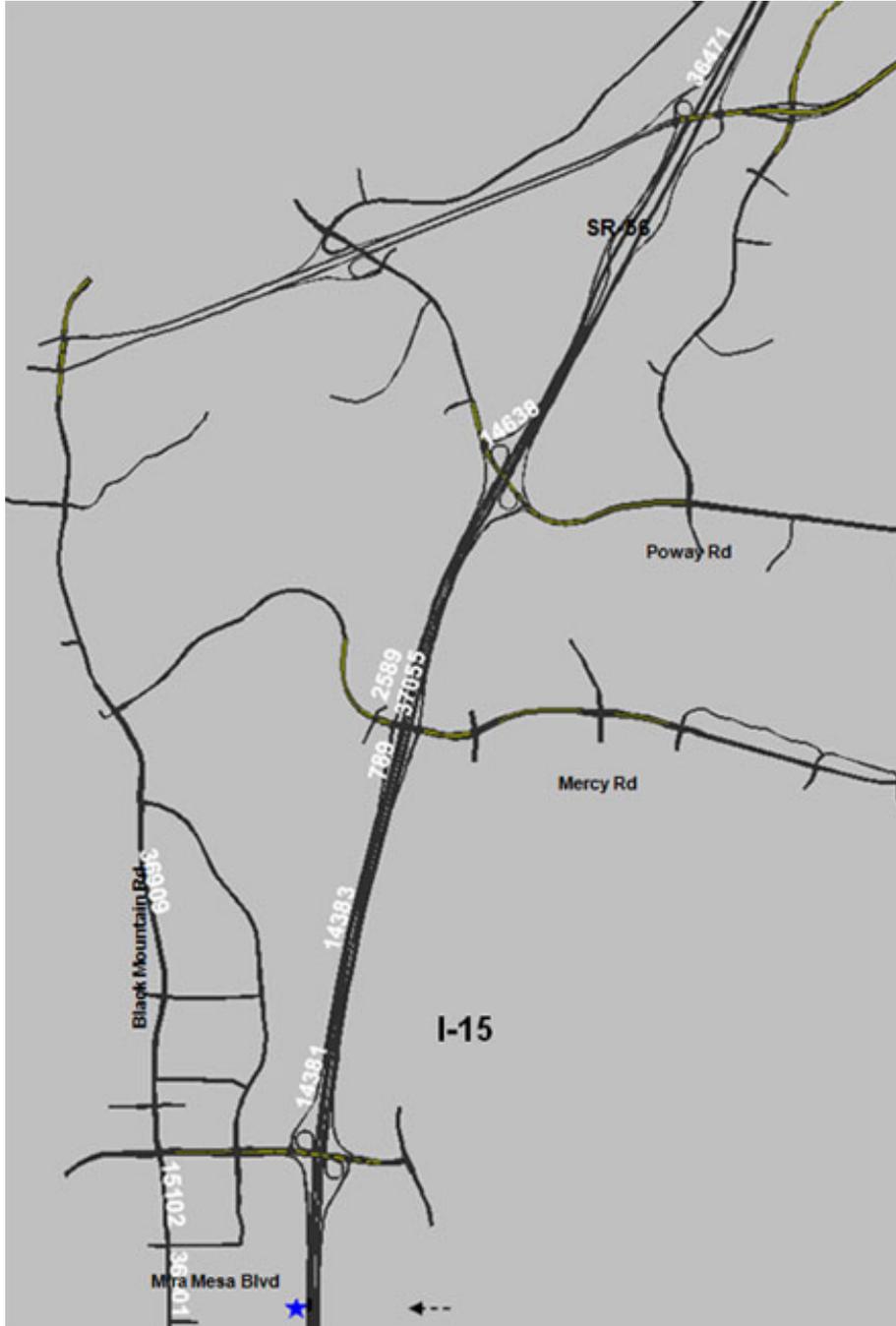
[Source: TransModeler output screen capture ©Caliper Corporation.]

Table 2-9. PeMS Baseline Without Incident

Segment	Miramar Way	WB Pomerado Rd	WB Mira Mesa Blvd	Mercy Rd	WB Rancho	Ted Williams Pkwy	Carmel Mountain Rd	Camino Del Norte	Bernardo Center Dr	Rancho Bernardo	Pomerado /Highland	Via Rancho Pkwy	Center City Pkwy	Citracado Pkway	9th Ave	Valley Pkwy
Detector	1108607	1108495	1108491	1108450	1108489	1108429	1108427	1108425	1108519	1108538	1108541	1108543	1108545	1108516	1108558	1108556
Segment Ids	37332	14407	37344	789	14660	570	37338	37339	37342	37022	8810	722	562	12946	12944	36530
Time Period (a.m.)																
6:00-6:05	69.0	68.4	67.1	66.3	64.4	65.9	61.9	67.4	65.5	66.0	54.8	27.6	17.1	22.3	20.6	15.1
6:05-6:10	68.5	67.7	66.2	65.5	64.0	65.9	60.6	67.1	63.9	65.1	55.2	28.2	17.5	20.8	16.3	12.9
6:10-6:15	68.3	67.2	64.9	64.8	63.7	66.2	58.7	66.4	64.1	64.6	54.9	28.1	18.2	19.9	14.0	11.0
6:15-6:20	68.1	67.4	64.8	64.3	63.5	65.8	56.2	66.4	64.3	65.2	54.7	27.3	17.0	19.8	12.4	9.9
6:20-6:25	68.3	67.1	64.2	63.5	63.8	66.3	55.6	64.2	64.2	65.1	56.7	27.0	15.2	18.9	12.9	8.9
6:25-6:30	68.3	67.3	64.1	63.3	64.4	66.3	54.6	60.3	64.5	65.1	56.7	27.5	15.0	16.5	12.3	9.0
6:30-6:35	68.0	66.9	63.5	61.1	65.1	66.7	53.2	56.6	64.2	65.6	56.8	27.8	15.0	16.8	10.9	8.4
6:35-6:40	68.0	66.8	62.5	57.8	65.4	67.2	52.6	53.5	63.4	66.1	56.2	27.4	15.1	16.8	11.1	7.6
6:40-6:45	68.8	67.0	61.4	55.4	63.0	67.8	51.7	48.5	61.2	65.6	54.8	29.0	15.4	16.6	11.1	7.7
6:45-6:50	69.2	67.0	60.2	51.8	61.2	66.2	51.7	44.1	57.7	65.0	54.0	26.5	17.1	16.4	11.1	7.5
6:50-6:55	69.5	67.2	58.2	49.9	58.6	64.3	50.8	41.7	54.4	63.6	55.5	27.0	16.1	19.1	10.8	7.4
6:55-7:00	69.0	66.6	57.2	45.9	55.6	61.6	49.4	38.4	53.9	62.0	57.6	26.6	17.2	16.6	12.3	7.6
7:00-7:05	68.8	66.9	55.8	42.9	52.2	59.6	48.0	37.2	51.3	60.0	56.8	26.9	16.9	18.9	11.2	8.0
7:05-7:10	68.2	66.5	56.3	40.4	47.6	55.8	47.4	34.7	49.6	57.6	55.0	28.2	16.9	18.8	11.4	7.7
7:10-7:15	67.9	65.9	55.7	37.8	41.9	50.7	46.9	33.9	47.0	53.8	54.7	28.3	16.4	18.7	11.7	8.0
7:15-7:20	68.2	66.2	55.6	36.2	35.0	44.1	46.8	32.0	45.0	51.7	54.8	27.7	16.4	18.3	12.4	8.3
7:20-7:25	67.5	65.7	54.8	34.6	28.9	34.9	44.3	30.5	43.1	50.8	51.6	25.6	16.7	18.4	12.3	8.3
7:25-7:30	66.8	64.0	54.5	34.9	25.5	29.0	41.3	27.7	45.0	52.2	54.3	25.0	15.6	18.4	12.8	8.2
7:30-7:35	66.5	64.7	54.5	33.7	22.5	26.1	37.3	27.1	40.5	53.8	54.1	25.7	16.6	17.7	12.1	8.4
7:35-7:40	66.8	64.6	52.4	33.3	22.1	23.6	34.4	24.7	40.7	53.3	57.4	26.8	17.0	19.6	12.4	8.2
7:40-7:45	66.5	63.9	53.9	31.4	22.3	22.6	30.7	23.9	41.0	54.3	58.3	25.7	16.8	20.1	13.0	8.2
7:45-7:50	66.7	63.9	54.2	31.1	19.9	20.7	28.0	23.1	43.9	52.8	55.1	25.0	16.0	19.1	13.7	8.9
7:50-7:55	66.5	64.5	53.1	32.5	19.9	17.9	28.4	23.7	45.3	51.9	56.1	25.7	15.9	18.9	13.6	9.3
7:55-8:00	66.2	65.2	52.9	34.9	20.2	18.7	28.4	25.3	43.6	52.6	55.6	25.7	16.1	18.9	13.7	9.1
8:00-8:05	66.4	66.0	52.9	34.6	20.7	19.1	31.4	26.7	42.5	52.1	54.8	25.6	17.5	18.9	13.2	9.6
8:05-8:10	66.5	65.7	53.1	33.2	21.8	18.7	30.2	29.7	42.2	50.3	54.9	26.0	16.8	20.6	13.9	9.6
8:10-8:15	66.3	65.6	52.7	34.2	21.6	19.6	34.2	29.4	42.0	48.2	53.0	25.0	17.2	21.2	17.0	10.1
8:15-8:20	66.0	65.3	52.7	35.9	23.0	19.3	32.3	29.8	41.0	47.6	54.9	25.4	17.0	21.5	17.7	11.4
8:20-8:25	66.2	65.7	53.1	36.2	23.7	20.6	32.2	30.6	44.4	48.5	53.9	25.5	17.9	20.5	17.8	14.0
8:25-8:30	66.1	65.8	52.6	37.7	25.1	22.0	32.1	30.6	43.3	50.7	53.3	24.5	17.8	21.2	17.7	15.8
8:30-8:35	66.3	65.5	52.7	38.3	28.3	24.5	36.2	29.9	43.7	51.4	54.4	24.5	16.7	23.5	19.6	18.6
8:35-8:40	66.0	65.5	53.4	38.7	29.2	26.8	39.6	32.8	45.0	51.9	55.1	25.4	16.4	22.4	22.9	22.4
8:40-8:45	66.3	65.9	52.7	35.0	32.7	28.0	41.3	38.9	46.3	52.9	55.0	25.1	18.1	20.8	24.9	26.2
8:45-8:50	66.0	65.6	52.3	36.4	30.8	32.5	42.0	44.1	50.1	53.9	54.5	24.4	19.3	26.0	26.9	30.5
8:50-8:55	65.8	65.4	52.2	39.4	31.6	32.3	44.6	46.5	54.7	56.0	54.5	24.6	19.7	30.2	31.1	37.7
8:55-9:00	66.0	65.4	52.4	40.7	36.7	35.9	45.1	48.4	57.6	58.6	54.2	26.3	24.3	30.6	33.0	46.6

Table 2-10. PeMS Baseline With Incident

Segment	Miramar Way	WB Pomerado Rd	WB Mira Mesa Blvd	Mercy Rd	WB Rancho	Ted Williams Pkwy	Carmel Mountain Rd	Camino Del Norte	Bernardo Center Dr	Rancho Bernardo	Pomerado/ Highland	Via Rancho Pkwy	Center City Pkwy	Citracado Pkway	9th Ave	Valley Pkwy
Detector	1108607	1108495	1108491	1108450	1108489	1108429	1108427	1108425	1108519	1108538	1108541	1108543	1108545	1108516	1108558	1108556
Segment Ids	37332	14407	37344	789	14660	570	37338	13664	13653	37022	8810	722	562	12946	12944	36530
Time Period (a.m.)	28.66	27.07	26.81	25.79	24.85	24.18	22.26	19.71	18.45	16.29	15.79	13.83	13.11	12.27	11.35	10.21
6:00	68.3	68.1	61.2	64.5	62.2	66.0	61.2	66.8	61.3	63.1	59.4	25.0	16.6	23.7	25.7	24.8
6:05	69.0	69.0	62.6	65.5	63.5	65.7	60.6	68.6	62.4	65.4	60.3	25.1	14.4	19.7	20.1	17.7
6:10	69.6	68.1	55.9	57.9	65.9	67.4	61.7	68.6	64.5	66.0	59.1	24.2	16.1	17.7	15.7	13.9
6:15	70.3	69.1	58.7	57.7	64.9	66.5	62.3	67.9	64.7	66.3	59.8	27.3	15.1	25.6	12.4	12.4
6:20	69.9	68.7	58.9	61.6	63.9	65.3	59.4	68.5	67.0	67.3	58.1	27.7	15.7	21.0	17.2	9.8
6:25	69.2	67.5	58.9	65.3	64.7	67.7	61.5	69.4	67.3	67.4	45.9	29.6	14.9	20.5	13.7	11.8
6:30	70.0	69.2	62.0	66.4	65.8	68.2	63.6	69.4	65.6	66.5	57.1	27.6	14.0	16.4	12.3	9.3
6:35	70.2	69.3	52.3	51.4	66.7	69.4	63.5	69.6	59.4	60.8	60.8	33.9	15.8	15.3	11.2	10.4
6:40	71.9	70.7	49.0	30.7	48.3	69.3	62.7	68.0	60.0	59.9	61.8	35.9	16.4	16.1	10.6	8.6
6:45	73.3	71.1	48.4	21.6	28.3	40.1	54.8	67.9	65.0	65.1	62.1	34.0	18.0	22.0	12.6	7.7
6:50	73.7	71.6	50.1	17.2	21.1	24.5	53.3	69.0	67.5	67.1	62.0	37.3	18.2	20.4	13.8	7.7
6:55	73.3	70.9	51.0	16.3	15.6	17.3	40.2	68.4	68.3	68.5	63.9	29.3	17.0	21.3	12.6	10.2
7:00	71.4	68.2	50.5	20.8	13.1	13.0	26.7	64.8	69.3	68.1	63.2	26.9	19.7	17.7	12.7	9.9
7:05	69.3	68.2	47.6	31.4	15.8	12.3	20.8	38.2	67.0	65.7	60.6	33.6	20.1	25.6	11.5	9.1
7:10	69.3	67.6	48.6	38.3	20.6	17.8	17.1	24.9	39.4	55.6	63.4	36.3	20.9	23.3	15.2	8.2
7:15	69.7	68.4	51.4	39.9	22.7	20.6	20.4	17.4	25.6	37.7	61.9	30.6	22.8	21.3	13.2	9.0
7:20	71.3	69.2	50.9	29.6	26.0	20.1	24.9	15.9	17.7	27.4	63.4	27.5	17.1	24.7	12.7	10.7
7:25	70.2	67.4	50.4	36.7	19.9	20.3	40.6	14.4	17.5	24.0	62.8	27.4	22.0	18.8	18.4	9.2
7:30	70.5	67.6	47.5	43.5	25.4	16.4	44.2	21.0	14.9	20.9	38.3	25.5	16.7	20.2	13.4	10.3
7:35	70.7	69.9	44.7	35.0	26.3	25.6	32.9	26.1	30.0	20.8	25.5	18.3	14.9	16.2	15.1	9.9
7:40	69.5	68.4	48.5	37.7	20.8	22.3	29.1	19.6	43.3	28.8	31.4	14.5	11.4	14.7	12.8	9.2
7:45	68.8	68.4	48.9	34.7	23.6	19.3	41.6	17.3	28.7	43.2	30.2	15.5	9.4	12.2	10.6	8.4
7:50	69.9	68.8	48.5	30.5	24.1	19.0	30.3	25.9	22.3	41.2	32.0	20.8	10.0	10.1	9.1	7.3
7:55	69.9	67.6	51.2	31.4	21.9	18.0	30.9	22.1	40.1	39.4	46.6	26.0	12.3	11.3	7.4	6.5
8:00	68.9	67.6	51.3	31.5	20.0	17.9	34.4	17.2	37.4	51.9	40.2	29.8	13.5	13.8	7.7	5.8
8:05	68.4	67.7	51.8	36.5	19.4	16.0	32.0	18.6	27.6	59.3	52.6	26.3	16.4	19.6	8.5	6.7
8:10	68.8	68.9	50.6	35.4	21.6	14.5	28.2	17.6	28.6	57.3	60.1	25.8	15.3	18.5	10.8	6.4
8:15	68.2	68.7	50.4	29.0	23.6	21.6	36.8	15.5	25.7	62.5	61.2	26.8	17.7	17.6	11.6	8.6
8:20	69.3	69.7	52.3	24.8	19.3	24.2	29.6	21.9	21.0	63.0	60.5	28.5	16.8	20.9	11.6	10.3
8:25	68.2	69.7	47.8	23.5	15.6	20.2	42.3	17.0	29.9	54.9	60.2	24.5	15.2	19.8	12.8	9.3
8:30	68.5	69.3	51.0	29.6	16.1	17.6	40.9	23.0	25.2	54.8	59.6	28.0	13.7	18.8	17.9	10.7
8:35	67.5	69.5	54.8	27.8	22.3	16.7	32.2	24.7	40.2	47.4	59.7	27.3	18.7	15.7	14.4	10.1
8:40	69.4	70.1	53.1	25.6	19.0	22.2	27.4	21.2	48.8	55.8	57.3	25.7	20.2	28.1	11.1	10.2
8:45	69.1	69.3	50.8	28.3	18.1	19.2	30.7	18.5	39.5	62.1	57.8	24.0	22.3	25.0	27.8	8.8
8:50	68.8	68.4	51.0	25.2	26.6	18.0	30.1	17.6	27.1	64.7	60.4	23.6	16.9	25.7	18.9	14.1
8:55	68.5	68.5	49.8	23.7	19.3	20.0	30.9	28.0	24.2	54.4	59.6	26.3	16.1	22.3	20.4	12.6

Table 2-11. Model Baseline Without Incident

Segment	Miramar Way	WB Pomerado Rd	WB Mira Mesa Blvd	Mercy Rd	WB Rancho	Ted Williams Pkwy	Carmel Mountain Rd	Camino Del Norte	Bernardo Center Dr	Rancho Bernardo	Pomerado /Highland	Via Rancho Pkwy	Center City Pkwy	Citracado Pkway	9th Ave	Valley Pkwy
Detector	1108607	1108495	1108491	1108450	1108489	1108429	1108427	1108425	1108519	1108538	1108541	1108543	1108545	1108516	1108558	1108556
Segment Ids	37332	14407	37344	789	14660	570	37338	13664	13653	37022	8810	722	562	12946	12944	36530
Time Period (a.m.)	28.7	27.1	26.8	25.8	24.9	24.2	22.3	19.7	18.5	16.3	15.8	13.8	13.1	12.3	11.4	10.2
6:00	63.6	65.1	58.7	64.4	62.3	66.4	53.5	46.0	52.9	63.6	62.9	19.3	15.2	62.8	60.3	48.5
6:05	66.0	65.3	60.8	64.4	63.4	64.1	58.1	48.8	48.7	65.1	62.5	20.8	13.4	60.2	62.6	44.7
6:10	64.1	65.4	56.8	62.0	62.0	61.6	56.7	28.2	52.0	66.5	63.4	19.1	14.2	56.8	62.0	46.6
6:15	64.4	62.4	58.1	57.4	64.8	64.9	47.6	40.7	56.3	67.4	62.2	18.3	13.1	49.4	59.6	51.4
6:20	62.8	64.6	58.8	23.4	62.8	65.2	45.3	54.9	56.7	64.8	63.2	21.9	12.3	38.7	62.3	41.9
6:25	63.8	64.9	57.6	13.0	63.0	65.7	55.9	42.2	55.7	65.5	59.9	20.5	13.7	28.8	57.0	46.5
6:30	62.7	66.3	59.8	11.3	63.5	64.4	53.4	54.7	55.3	67.0	62.2	21.1	13.7	23.5	62.8	32.9
6:35	64.9	65.0	58.4	11.5	63.0	64.9	57.3	46.4	55.8	66.5	63.4	20.7	13.4	18.4	59.4	43.2
6:40	64.9	64.2	59.8	11.3	63.2	65.1	54.9	53.4	54.9	67.5	64.0	20.5	12.4	14.9	63.8	50.4
6:45	64.2	61.8	58.3	11.4	62.5	65.2	51.6	48.1	53.6	65.7	62.7	20.9	13.8	13.7	62.6	44.8
6:50	63.0	64.9	56.2	11.4	62.6	64.9	53.4	35.7	48.4	66.9	63.5	19.5	13.4	13.2	58.6	45.8
6:55	64.4	66.5	59.6	12.3	51.6	65.1	47.0	42.4	47.9	64.5	62.5	20.5	13.8	12.4	61.5	43.5
7:00	63.9	66.1	60.1	11.4	24.2	64.6	46.0	31.3	46.7	63.6	61.1	21.0	13.2	11.8	52.9	46.5
7:05	62.0	64.2	57.3	11.5	17.6	65.0	23.8	26.6	50.2	63.9	63.4	20.4	13.7	12.0	43.9	45.2
7:10	63.3	64.9	61.3	11.4	12.2	64.9	17.0	27.4	47.2	68.1	61.4	19.2	12.9	12.3	28.7	28.5
7:15	62.5	66.1	58.6	11.6	11.5	39.3	14.7	23.8	54.1	64.5	63.9	19.7	13.2	11.6	15.8	41.1
7:20	63.3	65.7	57.9	13.1	13.6	18.3	14.9	24.0	53.4	66.3	61.4	22.2	13.1	11.2	12.2	30.4
7:25	61.4	63.6	58.9	12.3	13.6	12.8	13.6	34.5	49.1	65.8	62.4	21.4	13.3	12.0	11.1	25.3
7:30	63.6	62.6	57.4	13.8	13.8	12.3	12.9	42.3	50.4	66.1	62.1	20.9	14.1	12.1	10.6	23.6
7:35	63.2	63.6	59.7	12.9	13.1	11.3	15.1	32.6	51.7	65.2	62.4	21.2	13.7	12.3	11.5	20.2
7:40	62.1	64.5	58.4	13.2	14.7	12.2	13.6	25.2	53.0	64.1	61.2	20.8	13.6	12.3	11.3	20.4
7:45	64.0	65.2	57.7	13.6	15.4	13.6	14.8	18.7	52.0	66.6	62.8	21.5	14.1	12.2	10.9	20.7
7:50	62.3	63.1	59.0	11.9	15.4	13.9	10.9	19.7	54.5	67.0	62.8	22.3	14.7	13.2	10.9	18.8
7:55	62.6	63.8	58.9	11.0	12.9	13.8	11.5	14.8	49.8	65.5	63.1	22.1	13.9	13.1	11.2	16.9
8:00	62.0	64.5	59.2	13.3	12.5	11.8	11.8	11.4	51.8	65.0	61.7	20.4	14.0	12.4	11.1	16.5
8:05	63.3	63.9	60.1	11.0	13.9	11.6	12.4	12.5	45.1	66.4	61.8	21.6	14.3	12.4	10.9	12.9
8:10	62.6	64.6	57.7	13.6	12.8	11.9	9.1	10.4	50.3	66.5	62.4	21.0	13.8	12.6	11.0	11.8
8:15	63.8	64.9	57.9	11.8	13.1	10.2	10.1	9.7	47.6	65.8	62.6	21.3	13.4	12.1	10.9	10.2
8:20	62.3	63.7	59.5	11.7	14.4	11.3	9.2	9.2	26.0	66.4	62.6	22.0	14.1	12.3	10.6	10.7
8:25	63.3	66.2	59.1	12.5	13.2	12.0	10.3	8.7	17.3	65.3	61.6	21.9	14.2	13.1	10.4	9.1
8:30	63.5	64.7	60.8	12.6	13.4	12.1	11.3	9.9	14.0	66.6	62.9	21.4	14.1	13.1	11.6	10.4
8:35	63.7	65.6	63.2	11.1	14.9	12.5	11.1	9.9	12.6	65.5	62.0	21.6	15.3	13.0	10.9	10.7
8:40	63.8	64.2	61.7	13.1	14.3	14.2	11.6	9.6	11.0	66.7	63.3	21.9	16.4	13.7	10.9	8.9
8:45	64.3	64.4	58.6	12.2	14.3	12.8	13.4	10.6	12.6	67.2	64.5	22.5	16.0	14.9	10.7	11.5
8:50	63.4	63.2	59.5	11.9	16.9	13.1	12.9	16.9	13.4	65.3	62.0	25.1	15.8	13.9	12.1	13.8
8:55	63.9	63.6	59.5	11.7	12.6	14.6	10.1	18.2	12.3	65.0	61.3	24.1	17.8	14.4	13.0	16.1

Table 2-12. Model Baseline With Incident

No Informed Drivers

Segment	Miramar Way	WB Pomerado Rd	WB Mira Mesa Blvd	Mercy Rd	WB Rancho	Ted Williams Pkwy	Carmel Mountain Rd	Camino Del Norte	Bernardo Center Dr	Rancho Bernardo	Pomerado /Highland	Via Rancho Pkwy	Center City Pkwy	Citracado Pkway	9th Ave	Valley Pkwy
Detector	1108607	1108495	1108491	1108450	1108489	1108429	1108427	1108425	1108519	1108538	1108541	1108543	1108545	1108516	1108558	1108556
Segment Ids	37332	14407	37344	789	14660	570	37338	13664	13653	37022	8810	722	562	12946	12944	36530
Time Period (a.m.)	28.7	27.1	26.8	25.8	24.9	24.2	22.3	19.7	18.5	16.3	15.8	13.8	13.1	12.3	11.4	10.2
6:00	64.3	62.9	58.6	58.1	65.0	64.7	58.7	52.4	55.7	63.5	61.3	21.3	13.3	19.3	64.6	45.0
6:05	63.7	64.2	59.2	40.6	62.8	63.3	51.7	44.1	52.0	62.2	62.2	20.5	14.3	17.3	64.2	46.8
6:10	64.5	63.7	56.8	22.1	58.5	63.5	54.4	41.6	60.5	65.0	65.0	19.5	13.7	15.7	63.8	40.1
6:15	63.5	64.7	58.4	16.4	66.2	66.5	52.3	43.7	57.5	66.4	62.9	21.6	14.1	13.3	60.5	46.5
6:20	62.4	64.4	57.1	13.4	63.4	66.7	55.0	48.4	60.4	65.0	62.0	21.6	14.1	13.1	62.5	42.1
6:25	64.1	64.7	58.1	12.6	62.5	60.3	49.7	55.3	57.0	66.3	65.0	21.0	14.3	12.9	61.3	49.4
6:30	64.7	65.3	58.2	11.6	59.2	64.9	56.3	41.3	56.1	67.7	62.3	24.3	14.6	12.7	63.2	51.2
6:35	64.7	66.2	57.5	12.3	63.3	65.6	50.2	47.6	54.7	64.7	63.0	22.2	15.0	12.8	60.2	43.0
6:40	65.5	67.3	22.7	11.6	62.2	64.4	51.1	41.0	53.1	64.6	63.1	20.5	14.3	13.2	55.7	41.1
6:45	65.4	67.1	12.4	9.9	64.2	65.1	45.9	38.6	58.7	66.1	63.4	21.4	12.9	12.5	46.4	43.8
6:50	65.1	66.4	15.1	7.7	27.0	66.2	37.8	44.3	55.5	65.1	64.4	19.3	14.4	11.9	48.1	37.2
6:55	63.2	64.9	23.6	9.9	8.2	51.6	20.2	46.4	60.6	65.5	63.4	20.6	13.7	12.6	35.6	40.8
7:00	64.0	66.4	26.1	13.1	11.0	15.1	17.1	45.1	59.5	66.0	63.0	19.8	14.3	12.3	28.8	42.6
7:05	61.4	64.9	34.5	13.0	12.0	9.7	16.0	36.1	51.3	64.7	63.9	20.5	13.8	12.1	20.4	36.7
7:10	62.0	65.7	57.8	11.9	13.9	12.6	15.0	31.4	51.9	64.8	61.9	22.0	13.5	12.2	13.7	27.4
7:15	63.7	63.0	59.6	11.9	14.4	12.0	11.4	35.3	53.9	68.2	64.5	19.6	14.7	12.5	10.6	17.8
7:20	62.7	63.9	59.2	11.3	13.0	12.6	11.1	31.8	56.3	64.7	62.5	19.8	14.4	12.3	10.1	12.6
7:25	63.9	65.7	58.6	11.5	12.2	11.1	11.5	17.8	43.4	65.1	61.6	20.6	14.9	12.5	11.2	13.2
7:30	60.3	63.9	60.0	12.4	13.2	11.4	10.5	10.9	58.0	66.3	63.2	21.9	16.4	12.6	10.2	11.8
7:35	62.9	61.9	60.6	13.5	14.2	12.3	10.9	9.1	52.3	66.1	62.6	22.0	15.5	13.7	10.3	11.8
7:40	63.4	66.3	60.2	12.1	14.9	13.6	10.2	9.5	44.4	66.2	62.4	21.1	14.5	13.7	11.4	11.9
7:45	61.1	63.6	59.2	11.8	14.7	13.7	12.1	10.0	24.3	68.2	63.8	21.7	15.8	12.7	11.7	13.2
7:50	62.3	64.9	59.7	12.1	13.2	12.6	13.2	10.1	17.5	65.5	62.3	20.6	14.4	14.2	11.0	12.0
7:55	63.5	64.8	61.8	10.6	13.8	13.0	14.0	10.4	14.6	65.8	61.9	21.5	14.7	13.2	11.6	12.7
8:00	62.6	63.5	56.5	10.7	11.4	11.1	10.0	11.5	16.7	65.1	62.8	21.2	14.9	13.3	11.0	12.6
8:05	62.4	66.5	58.4	12.4	11.8	10.7	12.1	8.5	15.4	66.4	62.9	20.8	15.6	13.2	11.5	12.5
8:10	61.4	65.9	59.1	11.9	13.5	11.8	9.5	10.6	13.9	66.2	64.1	21.1	15.2	13.9	11.8	10.8
8:15	63.3	65.2	60.5	11.1	13.3	11.4	8.1	8.4	14.8	66.9	61.9	22.5	14.8	13.3	12.0	11.2
8:20	62.0	64.6	59.9	11.4	12.1	12.0	10.4	7.2	10.5	64.8	62.5	21.8	15.8	13.8	11.5	9.9
8:25	62.5	64.5	58.6	11.4	11.9	10.7	11.3	10.4	12.7	67.1	63.1	20.8	16.5	14.3	11.6	10.6
8:30	63.5	63.2	61.0	10.6	12.4	9.5	10.2	9.8	13.2	65.7	62.9	22.1	16.4	14.6	11.9	10.6
8:35	62.7	64.4	58.6	12.6	13.5	11.3	9.4	9.3	14.7	61.6	63.4	23.1	16.7	14.5	11.7	10.4
8:40	63.9	63.7	59.9	12.3	15.1	12.9	8.4	8.8	12.9	30.9	65.0	23.4	17.5	14.5	12.6	11.7
8:45	62.6	64.6	62.6	12.4	13.0	12.4	11.8	8.1	10.8	16.5	63.8	24.3	18.9	14.8	12.5	14.8
8:50	62.2	65.6	62.8	11.5	13.6	13.1	12.4	10.4	14.0	9.4	62.2	24.2	18.5	15.3	12.0	14.6
8:55	62.5	65.5	58.6	11.6	11.6	10.9	13.9	9.6	12.6	9.3	63.0	23.7	20.4	16.2	13.1	18.9

Table 2-13. Model Baseline With Incident

Segment	Miramar Way	WB Pomerado Rd	WB Mira Mesa Blvd	Mercy Rd	WB Rancho	Ted Williams Pkwy	Carmel Mountain Rd	Camino Del Norte	Bernardo Center Dr	Rancho Bernardo	Pomerado /Highland	Via Rancho Pkwy	Center City Pkwy	Citracado Pkway	9th Ave	Valley Pkwy
Detector	1108607	1108495	1108491	1108450	1108489	1108429	1108427	1108425	1108519	1108538	1108541	1108543	1108545	1108516	1108558	1108556
Segment Ids	37332	14407	37344	789	14660	570	37338	13664	13653	37022	8810	722	562	12946	12944	36530
Time Period (a.m.)	28.7	27.1	26.8	25.8	24.9	24.2	22.3	19.7	18.5	16.3	15.8	13.8	13.1	12.3	11.4	10.2
6:00	63.3	63.4	59.0	62.9	62.7	64.0	52.1	45.7	52.6	66.3	64.7	19.9	13.7	29.3	62.9	48.0
6:05	63.7	64.3	57.5	64.4	60.6	63.4	58.9	47.7	60.7	64.9	62.4	19.9	12.9	22.8	61.4	47.7
6:10	61.8	64.4	60.5	62.9	63.0	63.7	61.3	42.5	57.8	66.7	62.4	19.2	13.2	18.0	59.8	43.8
6:15	62.2	65.2	57.8	59.4	63.0	64.7	54.5	46.0	60.8	66.2	64.0	20.9	12.5	14.9	60.1	38.1
6:20	63.4	65.5	59.3	34.8	63.7	64.5	55.0	28.6	58.9	65.4	63.2	19.9	14.3	12.4	55.3	41.6
6:25	63.4	65.5	59.1	18.1	62.5	66.4	52.9	48.0	54.9	65.1	62.4	21.6	12.4	12.4	62.0	42.2
6:30	63.2	64.8	59.3	12.7	62.5	65.2	52.1	36.3	55.4	66.7	63.5	21.4	14.1	11.5	55.1	46.5
6:35	65.7	67.0	59.3	12.7	62.8	65.8	54.3	40.2	49.2	65.5	63.8	20.2	13.4	12.3	50.3	44.6
6:40	64.2	65.7	24.2	12.5	62.0	65.4	53.4	48.8	49.6	65.5	64.0	20.6	14.0	12.3	44.5	46.5
6:45	65.8	65.9	14.8	11.0	65.6	66.8	50.0	50.1	61.2	66.9	68.3	20.8	14.0	13.4	43.9	47.3
6:50	61.7	63.9	15.5	11.8	65.3	65.8	53.3	49.5	61.0	65.7	64.7	20.2	13.3	12.5	45.6	44.2
6:55	61.1	64.9	27.0	9.7	64.1	65.2	56.4	49.9	57.4	66.7	66.0	18.4	13.7	11.9	42.7	45.9
7:00	61.8	65.1	52.1	12.3	62.8	66.2	56.6	40.4	58.5	65.4	64.2	20.6	12.6	11.9	32.5	42.9
7:05	61.9	66.1	57.6	11.7	62.5	62.8	54.0	39.7	60.0	64.3	64.0	20.4	13.4	11.5	20.1	38.6
7:10	62.5	64.2	57.0	12.9	49.1	65.0	52.2	32.7	60.9	62.3	63.3	18.6	13.3	12.1	13.1	30.6
7:15	61.7	63.0	56.4	13.4	17.3	65.6	51.9	35.2	59.9	65.3	63.1	21.5	12.3	12.3	10.5	21.6
7:20	62.7	64.4	58.8	11.7	13.4	65.7	35.2	35.5	49.2	65.2	63.8	19.8	15.0	12.1	10.5	13.8
7:25	60.9	65.5	61.6	11.9	12.6	63.5	28.2	43.1	57.9	64.5	62.4	20.3	17.3	13.2	10.0	12.6
7:30	62.9	62.9	58.6	12.5	13.2	42.5	26.6	37.0	48.7	64.5	62.9	21.6	16.2	14.4	11.2	14.8
7:35	61.3	65.4	60.4	11.5	13.4	26.8	21.3	37.4	54.4	65.7	62.7	20.6	15.9	14.2	11.5	15.4
7:40	61.6	66.0	59.6	13.1	12.5	17.0	18.5	37.6	47.5	65.7	63.4	21.6	13.6	13.8	11.9	16.6
7:45	63.3	67.1	63.0	12.9	13.9	11.5	16.5	32.3	51.9	66.2	62.5	20.1	15.7	12.2	11.9	15.8
7:50	64.9	66.3	63.6	6.0	14.3	13.4	14.7	37.6	58.6	64.7	62.8	22.0	14.6	13.4	10.9	13.8
7:55	65.0	66.2	64.2	6.4	6.2	7.4	12.7	42.4	58.3	64.0	62.0	22.9	14.4	13.5	11.1	13.2
8:00	65.3	67.9	61.8	7.4	7.1	7.1	10.8	43.0	57.1	67.4	64.0	21.6	15.7	12.9	11.4	12.2
8:05	67.1	66.9	62.8	7.3	7.5	6.8	6.5	31.0	52.4	66.3	63.6	20.7	14.7	13.4	11.1	11.0
8:10	65.4	70.0	60.2	7.1	6.7	6.3	5.2	6.8	52.7	66.5	63.2	21.1	15.5	13.0	11.5	10.9
8:15	65.2	68.3	61.5	6.4	7.9	6.1	4.8	5.2	31.3	65.8	64.0	21.6	15.8	13.1	11.1	10.6
8:20	66.2	67.1	62.3	4.8	5.9	7.0	6.1	4.7	9.3	66.9	62.6	22.0	15.9	14.2	10.7	10.3
8:25	67.4	69.5	61.8	6.4	6.1	4.8	6.5	6.2	5.5	65.8	62.9	23.8	15.1	14.1	11.2	10.7
8:30	66.7	67.6	62.8	5.8	7.2	6.7	3.9	4.4	8.8	51.5	62.4	24.1	17.7	13.8	12.1	11.2
8:35	66.5	67.8	60.7	6.8	6.6	5.7	5.7	4.1	6.2	11.1	64.7	22.9	18.2	14.9	11.5	10.5
8:40	65.1	68.0	61.9	6.1	8.0	7.1	5.3	5.1	5.0	5.3	64.2	22.2	18.2	15.9	12.1	10.7
8:45	65.7	68.0	60.9	5.9	5.8	6.4	5.9	4.8	6.8	5.3	64.1	22.5	16.6	15.6	13.1	12.5
8:50	64.7	67.9	63.2	5.8	6.0	6.9	4.9	5.2	7.7	5.5	63.4	22.7	17.2	14.3	12.9	13.6
8:55	68.2	67.8	57.7	5.1	6.5	5.9	5.7	4.5	6.4	7.3	39.6	22.1	19.2	14.7	12.6	16.8

3. **Extent of queue propagation: should be within 20 percent**. The bulk of incident-caused (6:40 a.m. to 7:30 a.m.) congestion (red or speeds under 30 mph) in PeMS extends for seven freeway segments, or about 10.4 miles upstream of the incident (Table 2-11 – up to Rancho Bernardo, PM 26.8 to PM 16.3), while model incident caused congestion extends for five freeway segments, about 7 miles upstream of the incident (Table 2-13 – up to Camino del Norte, PM 26.8 to PM 19.7). The difference of 3.4 miles is not within the 20 percent range recommended by the U.S. DOT and as such, this criterion is not met in the strict sense. However, PeMS congestion in the last segment (Rancho Bernardo – 25 minutes of red) can be countered by the 25 minutes of congestion in the model at the incident location (westbound Mira Mesa Boulevard), which does not appear in PeMS. Recommendation: This criterion may need to be relaxed to 30 percent. A major source of uncertainty in measuring queues in simulation models and in data archival systems has to do with the location of detectors at specific post-miles. The exact extent of queue propagation cannot be accurately measured in both data archival systems (such as PeMS) and in simulation models unless detectors are placed at very short, consistent intervals (e.g., 0.1 mile). Because in some freeway locations detector spacing varies from 0.25 mile to 1 mile apart, queue measurement is not reliable.

4. **Diversion flows: increase in ramp volumes where diversion is expected to take place**. Table 2-14 shows a comparison of model traffic volumes on freeway southbound, off-ramps, and parallel arterials for: a) baseline without incident, b) baseline with incident and no traveler information, and c) baseline with incident and traveler information to 20 percent of travelers. Overall findings include: a) freeway volumes decrease upstream of the incident, and increase after incident information is provided to travelers; b) off-ramp volumes increase upstream of the incident, especially between 6:00 a.m. and 7:00 a.m.; c) parallel arterial volumes increase upstream of the incident between 6:00 a.m. and 8:00 a.m. when diversion information is provided to travelers. **This criterion is met**. Freeway volumes decrease and off-ramp and parallel arterial volumes increase as a result of the incident.
Recommendation: In the specification of this criterion, we recommend that freeway and parallel arterial performance is included in addition to the performance of the off-ramps.

5. **Arterial breakdown when incident. Cycle failures or lack of cycle failures**. Diverted traffic of approximately 225 vph is not deemed enough to induce traffic signal cycle failures on the parallel arterial (Black Mountain Road). Recommendation**:** Evaluation of this criterion requires that traffic signal data are recorded and are available for the exact same times of incident occurrence and resulting freeway congestion. In our experience, traffic signal systems do not archive these data; and as such, there is no means of evaluating model performance against this criterion.

Overall findings: Criteria 1, 2, and 4 are met. Criterion 3 is not. Criterion 5 is not applicable. ***The model adequately replicates traffic volumes, bottlenecks, travel times, and congestion on the I-15 Corridor for an incident day.***

Table 2-14. Comparison of Traffic Volumes for I-15 Incident Model Calibration

Road Locations (with Link ID# in TransModeler)		SB I-15 Freeway Mainlines (From North to South)			SB I-15 Off-Ramps (From North to South)			SB Arterial Roads (From North to South)			Vehicle Hours Traveled (Vehicle-hours)
		Between Mercy Road Ramps (#789)	Between Mercy Road and Mira Mesa (#14383)	To SR 56 (#36471)	To Poway Road (#14638)	To Mercy Road (#2589)	To Mira Mesa Boulevard (#14381)	Black Mountain Road (#36909)	Black Mountain Road (#15102)	Black Mountain Road (#36901)	
6:00-7:00 a.m.	A. Flow-baseline no incident	8,294	9,146	577	132	433	817	395	300	416	8,154.6
	B. Flow-baseline with incident without traveler information	7,546	8,399	578	127	404	781	378	282	391	8,309.7
	C. Flow-baseline with incident and improved traveler information (20% market penetration)	7,871	8,716	777	121	463	969	622	523	643	8,185.3
	Percent change A to B	-9.0%	-8.2%	0.2%	-3.8%	-6.7%	-4.4%	-4.3%	-6.0%	-6.0%	1.9%
	Percent change B to C	4.3%	3.8%	34.4%	-4.7%	14.6%	24.1%	64.6%	85.5%	64.5%	-1.5%
7:00-8:00 a.m.	D. Flow-baseline no incident	7,816	8,815	597	122	371	937	914	441	675	12,040.1
	E. Flow-baseline with incident without traveler information	7,677	8,682	546	112	340	940	856	467	682	12,735.7
	F. Flow-baseline with incident and improved traveler information (20% market penetration)	7,252	7,843	633	126	346	720	1115	509	753	12,781.4
	Percent change D to E	-1.8%	-1.5%	-8.5%	-8.2%	-8.4%	0.3%	-6.3%	5.9%	1.0%	5.8%
	Percent change E to F	-5.5%	-9.7%	15.9%	12.5%	1.8%	-23.4%	30.3%	9.0%	10.4%	0.4%

APPENDIX A. Calibration Methodology

During the calibration process for the I-15 ICM project, several tests and adjustments were made to parameters and settings within the simulation software, TransModeler. These tests and adjustments were made to ensure that the travel patterns and driver behavior exhibited in the model realistically portray the driving conditions observed along these corridors. This appendix provides details on these adjustments and tests, as well as the outcomes of these actions on the calibration results and the model outputs. The calibration was ongoing with two other corridors in San Diego, on which the same team was working, and a number of calibration lessons learned and summarized, a result of testing across different corridors.

This appendix is broken up into three parts: parameter adjustments, matrix time distribution, and software build updates. The first section, which includes details on the tests CS conducted on the global and local simulation parameters of the software, constitutes the majority of the adjustments made during the calibration process. The second section deals with adjustments made to the time distribution of when trips enter the network. The last section provides a comparison of the model outputs using the current build of TransModeler with the most recent update to the software.

Global and Local Simulation Parameter Adjustments

Global Simulation Parameters

As part of the calibration process, CS made adjustments to global and local parameters. The global simulation parameters available in TransModeler cover the general mechanics of the simulation, vehicle attributes, and driver behavior, while the local parameters are limited to driving behavior only. Some of the more significant parameter adjustment included vehicle attributes and driver behavior. The vehicle attribute parameters dictate the vehicles types, and the distribution of vehicle classes and performance that can be found in the model. The vehicle attribute parameters were adjusted to ensure model vehicles reflect those typically found on the corridor. The different driver behavior parameters that were adjusted to ensure that the model incorporates and effectively characterizes the typical driving population are listed below.

Headway Thresholds

The headway thresholds parameter impacts the acceleration model of the simulation. The acceleration model controls a vehicle's acceleration or deceleration in response to the vehicle in front of it. A vehicle's acceleration or deceleration can fall within one of three regimes: emergency braking, car following, and free-flow.

The headway thresholds parameter distinguishes which regime a vehicle is in, based on the lower- and upper-bound time headways between the subject and the front vehicle. When headways fall below the lower bound, the vehicle is governed by the emergency braking regime, headways greater than the upper bound fall within free-flow, and those in between the two bounds fall under car following. A distribution of lower- and upper-bound time headways also can be set to capture varying driver behavior. Slight adjustments to the default headway thresholds parameters were made to

ensure that drivers did not accept unnecessarily low or high headway thresholds, which prevented any large percentage of the driving population from behaving too aggressively or too cautiously.

Variance of Acceleration

After analyzing the issues with the car-following behavior of the software, Caliper suggested increasing the variance of acceleration among drivers to introduce more turbulence in the simulation. This parameter determines the upper bound and lower bound of driver acceleration, and can help in creating a more heterogeneous set of drivers, with different accelerating values.

CS tested changing this parameter on the median run of the nine runs. Table A-1 below shows the median run speed contour for the same network, utilizing the default acceleration variance of magnitude of 0.1 ft/s^2.

The same simulation was also run with an increased acceleration variance of magnitude 0.5 ft/s^2 increased from the default value of 0.1 ft/s^2. Table A-2 shows the speed contour for the corresponding run.

After comparing Table A-1 and A-2, there is a slight difference in the speed contours. CS could not observe a specific trend in impact of this parameter change on simulation, as the correlation of the different factors with this parameter was hard to determine in the absence of a detailed experimental design set-up. However, the overall congestion on the corridor is less, indicating a possible effect of changing the parameter contrary to expectations.

Conversations with the software vendor, Caliper, revealed that there might be undesirable instability in acceleration behavior. This test is therefore inconclusive about the impacts of variance in acceleration on improving queue propagation behavior.

Table A-1. Sample Speed Contour With Default Variance of Acceleration at 0.1 ft/s^2

Segment	JCT I-5	Mira Mesa Blvd	Sorrento Valley Rd	Miramar Rd	Nobel Dr	Governor Dr	Clairemont Mesa	Balboa Ave	Mesa College Dr	Murray Ridge Rd	El Cajon Blvd	University Ave	Home Ave	Market St	Imperial Ave	47th St	Plaze Blvd	SR-54	Bonita Rd	East H St	Telegraph Canyon	Palm Ave	San Ysidro
Detector	1114649	1108551	1113473	1108413	1108764	1108410	1108398	1108395	1108393	1108391	1111542	1111543	1111544	1111545	1111546	1111547	1111548	1114370	1114363	1114396	1114402	1114376	1114356
Time Period (p.m.)	28.7	27.1	26.8	25.8	24.9	24.2	22.3	21.3	19.7	18.5	16.3	15.8	13.8	13.1	12.3	11.4	10.2	9.3	8.1	6.6	5.4	2.4	1.2
15:00	64.2	64.2	64.4	38.8	22.4	47.6	62.7	62.9	60.1	58.7	63.4	62.3	59.5	53.0	37.0	61.3	55.9	57.0	35.4	63.7	66.2	62.1	68.4
15:05	65.0	66.2	66.6	30.3	22.4	45.1	59.1	62.4	54.1	58.7	60.9	64.6	57.5	53.6	33.6	58.2	61.7	54.2	39.8	58.9	65.3	61.8	67.6
15:10	65.4	63.1	64.6	23.8	23.3	45.6	61.5	62.3	61.2	62.1	61.3	60.8	57.0	61.0	34.7	58.3	60.4	54.8	38.8	61.6	64.6	62.0	66.6
15:15	64.8	67.2	66.7	22.8	24.4	44.4	59.3	62.4	57.0	52.2	64.5	62.8	53.4	54.7	40.1	57.3	59.2	52.2	39.4	63.7	65.4	62.4	66.8
15:20	66.4	65.9	66.1	23.4	25.4	43.3	62.1	61.9	64.2	55.3	60.4	60.6	57.1	56.5	36.8	56.4	58.9	52.4	36.6	64.7	64.9	62.4	66.8
15:25	64.7	63.4	66.5	28.6	25.2	46.2	60.1	62.9	62.7	56.9	60.5	54.9	58.4	55.1	39.0	59.9	60.2	53.4	36.5	55.6	66.0	64.2	67.7
15:30	64.7	62.2	67.2	25.3	24.0	46.9	62.0	63.9	56.8	58.2	64.2	55.4	48.9	51.6	42.9	60.8	58.8	57.4	36.6	64.1	65.6	65.8	68.2
15:35	64.8	62.0	62.9	23.3	27.0	45.7	58.6	63.1	60.2	49.3	62.1	62.5	58.3	51.7	32.6	55.0	58.7	55.5	38.6	64.3	65.3	63.8	66.5
15:40	64.1	53.9	43.4	23.8	23.4	47.2	54.6	62.5	48.6	54.0	62.7	62.3	55.2	51.4	40.3	58.0	57.8	56.0	35.9	49.9	64.9	59.5	67.7
15:45	65.5	35.9	27.2	22.1	23.4	45.3	57.0	61.7	33.3	53.4	62.9	57.9	53.9	42.9	38.4	59.8	58.8	46.8	35.7	62.4	65.6	63.0	66.9
15:50	64.7	28.4	21.6	20.9	23.4	45.2	54.4	62.1	33.5	57.6	60.1	60.9	54.7	43.4	32.3	59.3	55.5	33.7	38.6	64.3	65.9	63.5	66.7
15:55	66.0	22.1	19.6	22.7	25.3	46.2	61.7	62.6	33.2	42.0	59.7	50.6	54.8	40.0	33.3	57.3	57.8	42.8	39.8	62.7	64.2	60.9	66.9
16:00	64.7	21.4	20.1	23.0	24.8	41.6	54.2	63.5	35.7	42.1	53.4	60.9	57.7	45.1	24.2	59.5	60.2	29.8	37.0	54.9	65.1	60.8	67.5
16:05	64.0	22.2	22.2	23.1	25.4	46.0	55.7	62.0	33.1	48.7	63.1	63.2	58.6	45.3	21.9	57.4	58.8	30.7	38.8	50.9	64.3	62.6	66.7
16:10	65.3	21.3	19.4	23.3	24.8	46.9	61.3	63.1	37.5	43.5	62.9	61.5	56.1	45.3	22.2	57.9	36.7	25.7	38.0	46.1	63.7	60.5	65.3
16:15	64.2	25.1	22.5	22.8	27.6	50.2	58.1	62.1	31.7	40.8	64.5	64.5	62.6	38.2	21.6	58.8	23.5	23.6	41.0	62.2	64.5	63.4	66.3
16:20	64.8	20.2	19.2	24.2	28.9	52.0	43.8	62.1	32.7	38.9	63.1	63.3	64.6	38.2	21.5	58.2	20.6	26.9	36.2	63.5	65.2	63.9	68.0
16:25	64.9	22.4	18.9	24.5	32.6	49.3	55.8	62.3	32.1	37.3	60.9	64.1	62.0	56.7	21.8	33.1	22.5	22.4	38.4	62.1	64.8	66.4	67.7
16:30	63.5	23.7	20.4	24.8	27.5	45.1	60.0	60.8	32.1	36.4	62.4	65.0	58.3	53.0	21.6	20.1	21.1	23.9	33.7	63.9	65.3	63.7	67.6
16:35	63.8	23.7	20.2	22.5	27.3	47.0	53.1	63.0	31.0	38.6	62.7	64.4	55.5	50.0	17.0	19.7	18.0	26.9	38.1	58.5	64.5	65.3	66.8
16:40	64.6	21.1	18.9	24.4	26.8	47.7	62.7	62.8	33.5	37.5	63.6	65.3	55.9	32.1	17.9	20.1	19.6	32.3	37.1	58.3	65.1	66.5	67.0
16:45	64.7	22.5	21.2	24.3	27.2	46.3	61.7	59.8	32.8	37.6	62.4	64.1	52.2	30.2	18.4	20.9	20.1	26.5	37.5	60.7	64.4	64.8	66.2
16:50	64.3	27.0	21.4	21.5	27.6	41.3	61.3	61.3	34.2	39.9	62.1	64.6	25.0	28.2	19.0	20.8	20.6	28.0	33.6	57.7	65.0	64.8	65.9
16:55	64.8	27.0	21.3	23.6	26.0	48.2	59.5	61.4	31.2	37.6	62.4	64.8	28.6	26.6	17.9	21.1	20.7	28.3	36.0	56.1	64.1	64.5	67.8
17:00	65.8	35.6	22.5	22.2	29.1	49.7	59.0	59.8	30.0	38.9	61.7	64.8	39.9	27.7	17.5	21.2	21.8	25.5	36.6	55.4	64.6	63.4	66.4
17:05	62.5	44.2	24.7	24.8	27.7	46.9	61.9	56.7	34.0	34.9	57.2	66.2	31.1	26.8	17.4	16.4	20.8	27.6	34.5	58.8	63.4	65.9	66.4
17:10	65.4	50.9	33.7	22.7	26.9	46.2	62.2	55.0	30.1	39.1	62.3	64.8	26.8	24.7	18.3	21.9	21.6	35.7	35.6	53.7	65.4	63.7	67.3
17:15	65.0	56.3	35.1	22.9	22.0	42.3	58.7	63.4	33.1	37.9	60.5	61.7	25.9	25.4	17.6	29.2	24.6	32.0	34.1	58.5	64.9	61.5	69.1
17:20	64.2	50.2	29.3	20.2	23.8	45.7	63.2	64.0	35.0	37.6	63.4	62.6	27.0	24.5	19.8	39.5	23.5	38.7	36.2	47.6	65.2	64.9	67.2
17:25	64.0	44.4	24.9	20.9	23.2	48.5	63.2	63.2	39.9	35.9	60.5	60.7	28.5	26.4	20.8	45.6	25.3	28.0	36.0	60.6	64.6	62.7	67.4
17:30	64.6	37.3	25.7	21.9	25.6	44.0	59.4	63.1	43.7	36.9	62.4	61.3	27.4	29.5	21.7	56.2	22.7	32.4	37.8	61.0	65.2	63.7	67.3
17:35	66.4	49.1	30.7	22.9	23.9	45.3	63.4	63.8	39.1	41.6	60.2	64.0	37.3	30.6	22.1	58.3	22.5	26.9	36.1	62.5	64.9	64.4	67.5
17:40	64.8	49.9	30.1	22.2	24.6	43.8	62.9	64.3	46.7	37.6	63.0	58.9	55.5	32.3	25.1	55.4	21.5	28.7	37.4	55.5	66.5	62.4	67.0
17:45	64.0	57.7	33.9	21.5	25.4	46.1	63.3	63.7	43.6	42.9	61.5	63.5	59.5	38.8	26.2	39.7	22.3	30.9	36.3	56.2	65.1	62.9	67.4
17:50	65.3	61.5	32.9	22.7	26.4	46.1	62.4	62.6	42.7	42.2	63.4	64.1	58.4	45.9	27.7	37.7	22.8	31.0	38.9	64.3	65.6	59.0	66.7
17:55	63.4	65.4	47.0	21.9	25.3	44.2	61.6	63.6	52.7	54.9	62.1	62.6	58.6	58.2	37.4	41.6	22.5	31.6	39.1	64.8	65.3	65.4	67.3
18:00	65.6	69.1	61.9	23.1	26.2	44.0	62.7	62.6	46.3	52.7	63.9	64.8	59.2	54.1	42.4	53.6	23.5	29.9	38.7	62.7	66.0	63.9	68.1
18:05	64.4	66.5	67.9	22.9	26.2	41.4	63.7	64.6	52.0	49.1	62.5	62.9	58.1	61.0		56.8	22.8	29.8	36.7	58.4	65.3	63.0	67.6
18:10	64.8	66.2	67.3	25.5	26.3	49.9	63.9	63.5	60.0	56.0	58.2	63.0	62.6	62.2	56.5	62.5	24.8	33.7	40.4	60.8	65.0	63.6	66.3
18:15	64.3	67.5	68.4	27.4	27.5	49.5	62.4	63.6	60.4	58.0	63.3	63.1	58.4	55.2	53.4	59.6	27.2	38.6	36.4	55.5	66.2	62.5	67.9
18:20	65.2	66.6	67.1	28.6	28.4	44.9	63.1	63.6	60.9	56.1	61.5	57.5	59.2	51.0	54.3	62.9	43.4	29.4	36.1	58.6	66.1	64.2	66.5
18:25	66.6	65.8	66.5	33.5	25.1	47.4	62.0	63.9	60.8	59.2	62.3	62.3	54.7	60.1	61.1	61.1	31.6	33.4	36.4	55.1	65.4	66.1	67.7
18:30	66.6	66.8	67.7	39.0	46.5	50.5	60.5	63.1	56.2	57.6	64.9	65.3	63.1	61.6	64.3	60.4	32.1	32.8	34.8	62.6	65.5	63.6	66.8
18:35	65.0	65.8	67.9	55.8	40.2	51.1	62.6	63.5	58.5	59.9	59.2	62.3	61.8	60.3	65.2	62.2	56.8	28.0	35.4	63.1	64.8	67.0	66.5
18:40	65.6	68.3	67.8	57.2	57.3	51.3	62.5	64.0	60.7	58.7	60.4	61.6	58.4	58.3	64.5	61.4	63.5	31.8	34.2	59.1	62.2	62.8	66.7
18:45	64.7	66.9	68.5	63.8	65.3	54.6	63.1	63.6	63.0	60.9	62.3	62.2	59.7	60.4	64.7	61.6	62.5	40.0	39.1	63.7	65.9	64.9	65.8
18:50	67.8	68.7	69.0	66.7	65.1	55.5	62.4	63.7	63.3	60.1	64.0	64.6	58.1	57.0	64.1	62.0	60.7	60.6	41.0	62.9	66.5	64.3	68.4
18:55	65.6	67.6	67.4	60.8	65.8	58.8	63.1	64.0	65.1	56.8	64.2	64.8	59.4	55.5	65.5	64.5	63.3	60.9	35.0	63.0	65.4	64.3	67.0

Table A-2. Sample Speed Contour With Default Variance of Acceleration at 0.5 ft/s^2

Segment	JCT I-5	Mira Mesa Blvd	Sorrento Valley Rd	Miramar Rd	Nobel Dr	Governor Dr	Clairemont Mesa	Balboa Ave	Mesa College Dr	Murray Ridge Rd	El Cajon Blvd	University Ave	Home Ave	Market St	Imperial Ave	47th St	Plaze Blvd	SR-54	Bonita Rd	East H St	Telegraph Canyon	Palm Ave	San Ysidro
Detector	1114649	1108551	1113473	1108413	1108764	1108410	1108398	1108395	1108393	1108391	1111542	1111543	1111544	1111545	1111546	1111547	1111548	1114370	1114363	1114396	1114402	1114376	1114356
Time Period (p.m.)	28.7	27.1	26.8	25.8	24.9	24.2	22.3	21.3	19.7	18.5	16.3	15.8	13.8	13.1	12.3	11.4	10.2	9.3	8.1	6.6	5.4	2.4	1.2
15:00	65.3	62.5	66.7	56.1	32.6	47.6	56.9	62.7	54.7	36.6	62.1	63.4	48.9	51.5	59.6	59.4	59.6	56.0	38.0	64.2	65.3	64.4	66.2
15:05	65.1	65.3	67.1	53.9	31.9	46.3	57.9	62.7	61.7	36.1	58.1	63.4	59.3	43.0	61.7	59.6	54.2	55.9	35.8	64.2	65.0	63.9	68.7
15:10	64.3	64.0	66.7	58.7	35.3	39.8	61.1	62.8	61.6	36.5	59.5	54.6	49.9	52.5	58.3	60.7	59.0	50.7	39.6	61.9	64.8	61.6	65.1
15:15	64.4	64.0	65.3	47.0	26.3	40.3	62.3	63.0	59.4	35.9	61.5	52.1	54.5	51.4	54.6	56.9	58.8	51.5	38.0	61.7	65.2	63.3	66.4
15:20	65.5	63.0	65.5	35.7	23.3	44.2	60.6	62.8	49.5	44.9	61.3	54.4	56.2	57.7	56.5	62.3	62.7	55.1	36.9	62.6	65.9	61.5	67.9
15:25	64.7	61.3	66.4	30.3	23.9	42.9	61.5	63.8	35.9	55.8	61.1	61.9	55.0	49.6	48.6	60.7	61.6	56.9	40.9	60.1	65.2	61.1	67.2
15:30	64.9	64.5	64.7	24.7	22.7	42.4	58.7	63.0	38.0	46.2	61.9	60.3	50.7	50.7	43.9	61.7	59.4	54.8	39.5	61.8	64.3	59.1	67.0
15:35	64.8	61.1	65.6	24.4	21.9	46.4	61.5	64.0	48.7	39.7	60.9	50.3	56.3	50.7	38.7	58.6	57.5	52.3	38.9	51.9	64.7	63.8	65.8
15:40	64.2	64.9	64.7	24.0	23.7	41.9	57.5	63.3	59.5	44.1	62.8	61.0	53.2	51.8	44.2	57.3	55.2	52.9	33.3	56.4	64.3	63.9	67.9
15:45	63.9	66.1	58.6	22.6	22.1	44.7	58.3	63.6	57.2	39.0	62.9	61.8	54.5	46.1	33.5	59.7	61.4	51.5	36.3	63.1	65.4	62.4	67.6
15:50	65.8	53.0	32.1	21.3	21.6	46.6	53.3	62.3	47.6	48.6	61.7	60.1	53.5	45.8	29.9	58.2	56.9	54.4	37.6	59.6	64.1	60.4	66.5
15:55	63.8	39.7	25.0	22.1	25.2	48.3	59.9	61.9	39.9	42.4	63.9	61.6	53.9	40.7	30.5	61.4	62.3	31.6	35.6	54.5	65.4	62.6	67.1
16:00	64.7	30.9	23.0	22.8	23.7	43.1	45.1	62.0	35.0	36.8	63.9	64.1	50.7	39.0	25.0	58.3	61.9	32.7	37.8	61.7	64.1	61.9	66.9
16:05	64.4	27.7	22.0	22.2	24.0	43.1	57.2	62.8	34.2	41.3	64.7	62.4	58.1	35.0	22.2	60.2	58.8	34.5	36.6	64.9	64.8	61.8	66.6
16:10	64.6	28.5	21.7	21.2	23.9	44.3	53.0	60.9	33.6	36.1	64.2	61.9	57.2	40.0	21.9	57.8	56.4	29.6	37.4	64.0	65.1	58.9	67.6
16:15	64.9	33.6	22.2	22.1	25.3	49.2	52.0	61.0	38.5	41.1	63.6	64.8	51.8	35.0	22.2	57.1	37.0	26.2	38.9	65.0	64.9	64.2	67.3
16:20	65.0	36.0	21.3	23.2	25.8	49.2	57.7	62.8	37.5	35.8	62.8	63.7	56.1	35.7	24.6	58.9	24.3	25.3	36.1	65.3	64.2	59.2	67.8
16:25	63.7	29.9	21.0	23.1	25.0	45.3	60.6	62.5	34.1	36.1	63.5	63.9	57.2	44.9	24.3	57.9	19.3	26.9	38.7	64.1	65.6	64.7	66.6
16:30	63.7	35.5	23.5	24.3	24.2	45.1	50.3	62.2	34.7	36.2	65.0	65.0	56.2	52.8	23.1	30.6	19.5	28.7	34.8	61.5	65.1	62.2	66.9
16:35	63.5	37.2	22.5	23.1	26.2	48.8	58.9	62.8	34.6	42.9	62.3	64.4	58.4	59.4	23.3	20.2	19.4	28.8	36.0	63.7	65.5	64.5	65.3
16:40	65.8	35.3	21.7	23.9	26.1	45.7	59.2	62.5	32.5	37.1	64.3	64.5	58.6	54.6	21.4	21.4	20.2	24.2	37.5	64.2	63.4	64.0	66.8
16:45	64.3	37.9	24.1	23.6	26.9	45.4	56.0	62.8	31.8	36.5	64.0	66.7	60.2	47.0	18.9	18.9	18.7	24.2	39.4	63.9	65.1	59.9	66.8
16:50	65.0	38.8	24.3	23.9	25.3	45.7	61.1	63.2	28.7	35.3	65.3	66.8	58.0	53.9	17.0	21.5	20.1	27.7	34.5	59.3	65.2	62.5	66.7
16:55	65.3	36.8	23.4	22.3	25.7	46.6	54.2	61.9	33.9	39.6	64.7	66.3	56.0	47.6	17.4	17.8	21.4	26.2	38.1	57.3	64.5	62.7	66.6
17:00	64.8	39.8	24.6	22.0	26.5	45.5	60.6	60.8	33.5	40.3	65.6	65.8	56.0	38.3	17.4	20.4	21.4	28.2	38.1	57.6	65.0	60.1	65.8
17:05	65.0	42.3	24.9	22.1	24.2	45.3	61.1	61.2	31.9	35.7	63.9	65.0	53.1	30.6	17.2	21.1	20.2	26.8	34.3	55.9	64.0	63.7	66.0
17:10	64.2	42.6	24.2	21.8	24.8	44.4	61.5	63.2	35.0	32.5	64.5	66.0	52.2	29.7	20.2	24.8	19.8	25.8	37.9	58.5	64.4	64.0	67.5
17:15	65.4	42.8	28.9	23.2	24.7	46.5	63.1	64.7	29.8	32.1	62.8	63.2	54.6	27.9	22.0	26.3	20.5	36.5	38.2	61.0	65.3	60.9	67.5
17:20	63.9	43.7	30.0	24.2	24.5	45.0	61.2	63.4	32.9	31.3	63.5	62.2	54.8	29.8	20.8	28.3	21.1	35.0	38.7	44.8	64.3	64.8	68.1
17:25	63.2	52.2	35.8	22.5	25.2	45.9	62.4	62.6	33.8	31.7	60.5	59.3	51.4	34.3	19.9	28.0	22.9	37.1	35.5	57.1	65.9	62.1	65.8
17:30	65.5	58.2	38.7	22.8	23.7	50.2	63.1	63.9	35.6	28.5	63.2	63.9	58.1	35.7	20.1	30.9	21.7	34.5	37.5	63.5	65.6	58.2	66.8
17:35	65.2	55.6	37.7	23.1	25.5	45.7	61.4	63.3	39.0	44.2	60.2	56.4	62.2	51.4	22.9	37.9	20.6	32.9	36.1	60.7	65.5	64.6	66.9
17:40	64.2	56.6	38.9	22.6	25.0	44.5	62.1	63.4	32.7	43.1	62.9	59.5	60.5	42.8	49.3	38.3	20.8	30.8	36.1	54.3	65.5	59.6	66.8
17:45	65.8	56.2	41.0	23.0	24.2	45.1	61.1	62.2	34.7	44.9	62.5	62.5	61.7	43.0	60.4	45.7	19.9	29.7	35.0	58.8	65.1	61.5	67.9
17:50	63.8	53.2	36.8	23.2	25.9	48.5	61.2	63.5	40.7	38.1	63.1	61.3	57.1	46.7	62.6	53.2	21.4	28.3	33.3	62.8	64.9	59.4	66.6
17:55	63.7	63.1	45.4	21.9	25.3	47.6	61.1	63.5	38.1	38.5	61.6	61.6	59.1	51.8	61.7	58.7	20.7	29.2	37.6	56.4	64.6	62.2	66.2
18:00	64.6	66.9	46.6	20.5	22.1	45.6	62.4	64.0	39.2	43.4	61.5	62.4	60.5	58.1	57.2	61.9	20.2	33.0	37.6	62.4	65.0	60.6	66.4
18:05	64.4	66.0	65.1	21.1	25.2	48.1	62.6	63.5	56.4	49.0	63.7	61.8	62.0	61.8	56.8	62.1	21.8	43.5	37.8	55.9	66.1	64.3	66.2
18:10	64.8	66.1	67.7	26.4	28.2	46.6	62.5	63.9	60.3	58.8	64.5	65.3	59.2	58.2	52.7	63.6	26.8	37.7	34.9	57.4	65.8	62.8	69.1
18:15	63.9	67.3	67.2	26.4	27.2	43.1	61.1	64.1	60.3	57.9	60.4	60.4	57.8	57.0	51.4	59.6	25.7	28.4	37.6	60.1	65.4	61.8	66.4
18:20	63.5	66.9	67.6	28.2	25.9	49.5	62.6	64.1	59.6	54.7	62.4	61.5	55.5	48.6	57.2	56.4	25.5	34.2	36.1	61.3	65.8	64.1	66.9
18:25	65.0	67.2	68.0	29.0	26.9	45.5	61.4	61.3	59.0	60.5	59.6	62.5	56.0	56.5	61.5	59.8	26.4	30.0	36.5	56.1	65.0	65.2	68.3
18:30	64.6	67.9	67.7	30.3	30.0	46.9	62.2	62.7	58.8	56.1	59.6	55.4	57.8	58.2	64.1	62.4	26.9	32.0	40.2	64.0	63.8	61.4	67.4
18:35	66.2	66.7	66.4	49.1	30.0	47.3	60.8	62.9	57.9	58.7	62.9	63.1	60.9	60.9	64.7	57.9	36.2	30.8	35.0	63.7	64.9	64.8	65.7
18:40	64.9	68.5	66.8	50.3	42.2	46.5	63.5	63.8	62.1	60.5	64.9	63.6	60.7	56.5	64.5	64.5	57.9	35.0	36.2	65.0	66.7	60.9	67.3
18:45	65.7	66.6	68.3	57.0	49.2	52.0	63.1	63.6	58.8	59.0	61.0	63.3	59.3	57.7	66.3	64.1	62.2	40.3	37.1	64.3	66.1	62.8	67.7
18:50	64.7	67.5	67.7	61.1	65.0	47.9	63.0	62.6	61.5	58.1	57.9	64.0	54.7	60.5	64.3	60.4	62.1	59.4	35.5	60.1	65.7	63.1	66.3
18:55	65.6	66.3	66.0	62.2	65.4	58.4	62.5	62.9	64.9	58.5	63.6	63.8	64.1	62.7	64.0	60.2	62.1	58.4	38.2	61.2	65.7	61.0	66.8

Lane-Changing Models

There are typically two lane-changing scenarios modeled within the software: discretionary and mandatory. A discretionary lane change occurs because the driver perceives that the alternative lane provides an improved traffic condition, such as higher speeds. A mandatory lane change occurs when a lane change is necessary, such as an instance when a vehicle must change lanes to take an exit. Both lane-changing scenarios have parameters that can be adjusted to calibrate the model. These parameters and the adjustments made are the following:

- **Discretionary Lane-Changing Model –** One of the parameters that govern how a driver chooses among eligible lanes is the discretionary lane-changing model. There are two choices provided in TransModeler: neighboring lane model and target lane model. In the neighboring lane model, the driver chooses only from the lanes directly adjacent to the one it is currently in. In the target lane model, a driver can choose from all eligible lanes. The neighboring lane model was the preferred choice because, in testing the performance of both models, the target lane model was found to cause vehicles to weave in and out of lanes more often than expected.

- **Mandatory Lane-Changing Parameters –** The mandatory lane-changing parameters include *look ahead* and *critical distance*. The look-ahead parameter sets how many links away or how long from a crucial decision point is the vehicle made aware that it must make a mandatory lane change. The look-ahead parameter was kept to its default values, because it only affects how far from a critical decision point a vehicle is made aware of an upcoming mandatory lane change, and not necessarily when the driver will change lanes.

Critical distance, however, governs the distance for a mandatory lane-change decision at a mandatory decision point (i.e., exit off-ramp, lane drop, fork in the road). This parameter also allows for users to set a distribution of critical distances that different types of drivers may accept. The default list of critical distances ranges from 1,250 feet to 3,500 feet. The default distribution within the software sets the majority of drivers to accept critical distances around 2,000 to 2,500 feet. Because the driving population within the a.m. and the p.m. peak periods tends to be commuters who are familiar with the daily traffic conditions and available routes along the corridors, it can be assumed that the driving population may accept critical distances of shorter values. The critical distance parameter distribution was therefore adjusted so that the majority of the driving population makes their mandatory lane changes at distances ranging from 1,250 to 1,750 feet.

Response to Traffic Controls

Some other minor driver behavior parameter adjustments were made in the model to control the percentage of drivers who comply with lane use rules, signals, and signage.

Update Step Size Interval

Although the model's speeds and bottleneck locations, as shown by the speed contour diagrams, seem to match those shown through PeMS, the formation of shockwaves that contributed to these bottlenecks was not as apparent in the model. The formation of shockwaves within the simulation is crucial in generating realistic bottleneck formations. One parameter that was tested was the update step size interval, which is under the general mechanics parameters of TransModeler, and dictates how frequent a vehicle's current state and behavior models are updated. The step size interval can

therefore be representative of a driver's reaction time to its current surroundings. Different step size intervals can be applied to various driver states/scenarios, including stopped, decelerating, cruising, accelerating, and lane changing. Tests adjusting the step size interval were conducted to determine whether or not the size of the bottleneck can be impacted and shockwaves generated by reducing or increasing the decelerating or accelerating step sizes. These tests included a scenario where the update step size interval parameter was isolated as a change. A second scenario included a combination of the step size parameter, along with some local parameter adjustments, such as those described in the following section. One last scenario test included only the impacts of the local parameter changes. Comparisons of these scenarios have shown that appearance of shockwaves did not differ significantly from the different types of scenarios tested. This parameter change was therefore abandoned.

Local Simulation Parameters

Although both local and global parameters can be used to make sure that the model reflects typical driving conditions, as well as meet the calibration targets, there are some instances when using one type of parameter is more appropriate than the other. Adjusting driver behavior parameters was found to be the most effective in replicating the bottleneck speeds and extents from PeMS. However, because the causality of each bottleneck differs based upon the geometric and operational features within that localized area, the use of local driver behavior parameters was found to be more appropriate than global parameters in order to avoid adverse effects at other sections of the network when replicating these bottlenecks. In TransModeler, these local parameters are limited to four driver behavior options: car following, critical distance, headway thresholds, and look-ahead distance. Of the four, three of these parameters: car following, critical distance, and headway thresholds; and their sensitivities to various traffic scenarios were tested. The look-ahead distance parameter was not used because, as previously mentioned, this affects when the driver is made aware of a potential mandatory lane change, but does not necessarily dictate at what point the driver will actually change lanes.

Acceleration Model Parameters

Two of the chosen local parameters, headway thresholds and car following, impact the acceleration model of the software. The acceleration model controls a vehicle's acceleration or deceleration in response to the vehicle in front of it. This set of parameters also divides a vehicle's acceleration/ deceleration profile based on three regimes: emergency braking, car following, and free-flow.

1. **Headway thresholds.** As previously described, these local parameters can be used to set a distribution of the lower- and upper-bound headway times that govern what regime a vehicle is in: emergency braking, car following, or free-flow. The local headway threshold parameters were initially tested with local car-following parameters in an effort to match the gradual speed reductions shown on the PeMS speed contour map. The effort included testing different distributions of headway upper and lower bounds and comparisons of its impacts when used as a stand-alone change, or in combination with other local parameters. Tests, however, showed that this parameter was not as effective as the car-following parameters since the headway thresholds mainly helped in determining what regime vehicles would be in based on their headways. The vehicles' rate of acceleration or deceleration from their desired speed as they approach either the start or end of a bottleneck is better governed by the car-following model.

2. **Car Following.** Another local driver behavior parameter that impacts the acceleration model is car following. When a driver falls within the car-following regime, its vehicle acceleration or deceleration rate is governed by the following equation:

$$A_i[t + \Delta t] = \alpha^{\pm} \frac{V_i^{\beta^{\pm}}[t]}{D_{i,i-1}^{\gamma^{\pm}}[t]} (V_{i-1}[t] - V_i[t]) + \varepsilon_i^{CF}$$

where:

$A_i[t + \Delta t]$	=	Acceleration rate of vehicle i;
$V_i[t]$	=	Speed of subject vehicle i;
$V_{i-1}[t]$	=	Speed of front vehicle i-1;
$D_{i,i-1}^{\gamma^{\pm}}[t]$	=	Distance between the subject and front vehicles;
$\alpha^{\pm}, \beta^{\pm}, \gamma^{\pm}$	=	Model parameters;
ε_i^{CF}	=	Vehicle-specific error term for the car-following regime.

TransModeler users may change the alpha, beta, and gamma model parameters. Testing the sensitivities of these model parameters has shown that increasing or decreasing α, β, γ parameters can have significant impacts on the temporal and spatial extent of the bottleneck. The default car-following parameters is shown in Figure A-1.

Figure A-1. Car-Following Default Parameters
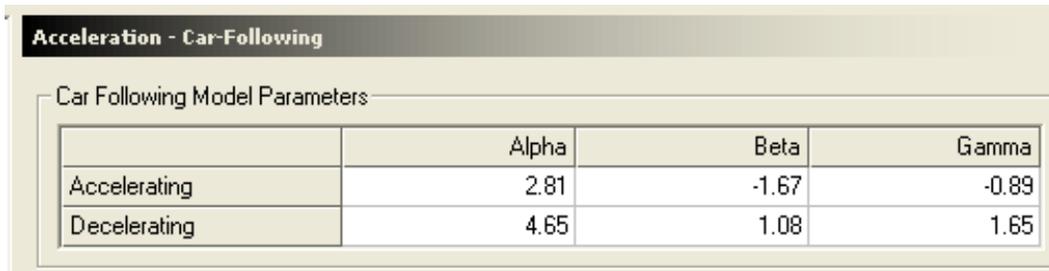
Car Following Model Parameters	Alpha	Beta	Gamma
Accelerating	2.81	-1.67	-0.89
Decelerating	4.65	1.08	1.65

[Source: TransModeler output screen capture ©Caliper Corporation.]

With the default values alone, the bottlenecks typically did not extend far enough upstream. At these default values, vehicles tend to approach the starting point of the bottleneck at high speeds. However, PeMS data suggests that vehicles tend to have more gradual speed reductions as they approach the congestion. This gradual speed reduction is likely influenced by the drivers' ability to see the brake lights far ahead of the vehicle in front of them. Although the simulation's car-following model only allows for the driver to be influenced by the vehicle directly in front of it, the gradual speed reductions can be replicated by decreasing the magnitude of the deceleration gamma, which causes drivers to slow down further away from the vehicle in front of them, as if they were reacting to the brake lights of several vehicles ahead. It also was determined that increasing the magnitude of the acceleration gamma was often needed in parallel to changing the deceleration gamma in order to maintain the appropriate travel times, and to avoid generating excessive congestion at these locations.

Critical Distance Local Parameter

The last local parameter that can be applied in order to match the model and PeMS speeds is to change the distribution set for the *critical distance* parameters. As previously mentioned, this parameter governs the distance for a mandatory lane change. Adjusting the distribution of critical distances can allow the user to set where the lane changing starts, and therefore the approximate location of the head of the bottleneck.

Matrix Time Distribution – Demand Profile Adjustments

In addition to global and local parameters, adjustments also were made to the demand profiles that control the network-wide distribution of demand release. Adjustments made to the time distribution are conducted in an effort to match the model with realistic demand profiles observed on I-15 during the peak periods. Several intervals were tested in increments of 15 to 30 minutes. The 15-minute profiles generated more severe congestion by releasing a large proportion of the hourly traffic within a specific 15-minute interval. However, there is the need to make sure that the target volumes at all the locations across the corridor can be met as well, and that the distribution does not skew the temporal loading pattern in the base year and any future year network. The 15-minute profiles, currently being used for the I-15 networks, allow enough traffic into the congested locations to meet the volume calibration criteria, match field observations, and replicate signal control throughput (volumes released by ramp meters and signals at end of ramps) for the entire corridor. The demand profiles produced as a result of these tests resulted in 15-minute demand distribution intervals.

Updated TransModeler Build (Version 1005 and 1055)

The aforementioned parameter adjustments list the multitude of tests conducted in order to calibrate the models. However, despite such tests, certain limitations in TransModeler's driving behavior model continued to persist. A new build of the software was therefore distributed by Caliper, addressing these issues by making changes to TransModeler's acceleration model. CS conducted a comparison of model results using Build 960 and the latest version, Build 1005, to test these improvements using the I-15 baseline model. Tables A-3 and A-4 show the results of one simulation run of the I-15 model. Table A-3 shows the speed contour diagram for the I-15 model using Build 960, while Table A-4 shows the speed contour for the same model using Build 1005.

Although the two tables show similar speed patterns, the main difference is the appearance of speed gradations at the bottleneck locations. In the earlier TransModeler builds, such as Build 960, vehicles' average speeds appeared to go through more extreme drops or increases at bottleneck locations, as shown in Table A-3. In the latest version of the software, however, Build 1005, average speeds show a more gradual drop, as evident in Table A-4.

Eventually, in order to address some issues related to testing HOT lane scenarios for the future year, Build 1055 of the software had to be utilized. This build rolled in the changes to driving behavior from Build 1005, and included enhancements to the HOT lane modeling capabilities as well. As such, the final results for calibration were reproduced using this build.

Table A-3. I-15 Southbound a.m. Speed Contour, *TransModeler Build 960*

Segment	Miramar Way	WB Pomerado Rd	WB Mira Mesa Blvd	Mercy Rd	WB Rancho	Ted Williams Pkwy	Carmel Mountain Rd	Camino Del Norte	Bernardo Center Dr	Rancho Bernardo	Pomerado /Highland	Via Rancho Pkwy	Center City Pkwy	Citracado Pkway	9th Ave	Valley Pkwy
Detector	1108607	1108495	1108491	1108450	1108489	1108429	1108427	1108425	1108519	1108538	1108541	1108543	1108545	1108516	1108558	1108556
Segment Ids	37332	14407	37344	789	14660	570	37338	13664	13653	37022	8810	722	562	12946	12944	36530
Time Period (a.m.)	28.7	27.1	26.8	25.8	24.9	24.2	22.3	19.7	18.5	16.3	15.8	13.8	13.1	12.3	11.4	10.2
6:00	63.6	65.1	58.7	64.4	62.3	66.4	53.5	46.0	52.9	63.6	62.9	19.3	15.2	62.8	60.3	48.5
6:05	66.0	65.3	60.8	64.4	63.4	64.1	58.1	48.8	48.7	65.1	62.5	20.8	13.4	60.2	62.6	44.7
6:10	64.1	65.4	56.8	62.0	62.0	61.6	56.7	28.2	52.0	66.5	63.4	19.1	14.2	56.8	62.0	46.6
6:15	64.4	62.4	58.1	57.4	64.8	64.9	47.6	40.7	56.3	67.4	62.2	18.3	13.1	49.4	59.6	51.4
6:20	62.8	64.6	58.8	23.4	62.8	65.2	45.3	54.9	56.7	64.8	63.2	21.9	12.3	38.7	62.3	41.9
6:25	63.8	64.9	57.6	13.0	63.0	65.7	55.9	42.2	55.7	65.5	59.9	20.5	13.7	28.8	57.0	46.5
6:30	62.7	66.3	59.8	11.3	63.5	64.4	53.4	54.7	55.3	67.0	62.2	21.1	13.7	23.5	62.8	32.9
6:35	64.9	65.0	58.4	11.5	63.0	64.9	57.3	46.4	55.8	66.5	63.4	20.7	13.4	18.4	59.4	43.2
6:40	64.9	64.2	59.8	11.3	63.2	65.1	54.9	53.4	54.9	67.5	64.0	20.5	12.4	14.9	63.8	50.4
6:45	64.2	61.8	58.3	11.4	62.5	65.2	51.6	48.1	53.6	65.7	62.7	20.9	13.8	13.2	62.6	44.8
6:50	63.0	64.9	56.2	11.4	62.6	64.9	53.4	35.7	48.4	66.9	63.5	19.5	13.4	13.2	58.6	45.8
6:55	64.4	66.5	59.6	12.3	51.6	65.1	47.0	42.4	47.9	64.5	62.5	20.5	13.8	12.4	61.5	43.5
7:00	63.9	66.1	60.1	11.4	24.2	64.6	46.0	31.3	46.7	63.6	61.1	21.0	13.2	11.8	52.9	46.5
7:05	62.0	64.2	57.3	11.5	17.6	65.0	23.8	26.6	50.2	63.9	63.4	20.4	13.7	12.0	43.9	45.2
7:10	63.3	64.9	61.3	11.4	12.2	64.9	17.0	27.4	47.2	68.1	61.4	19.2	12.9	12.3	28.7	28.5
7:15	62.5	66.1	58.6	11.6	11.5	39.3	14.7	23.8	54.1	64.5	63.9	19.7	13.2	11.6	15.8	41.1
7:20	63.3	65.7	57.9	13.1	12.5	18.3	14.9	24.0	53.4	66.3	61.4	22.2	13.1	11.2	12.2	30.4
7:25	61.4	63.6	58.9	12.3	13.6	12.8	13.6	34.5	49.1	65.8	62.4	21.4	13.3	12.0	11.1	25.3
7:30	63.6	62.6	57.4	13.8	13.8	12.3	12.9	42.3	50.4	66.1	62.1	20.9	14.1	12.1	10.6	23.6
7:35	63.2	63.6	59.7	12.9	13.1	11.3	15.1	32.6	51.7	65.2	62.4	21.2	13.7	12.6	11.5	20.2
7:40	62.1	64.5	58.4	13.2	14.7	12.2	13.6	25.2	53.0	64.1	61.2	20.8	13.6	12.3	11.3	20.4
7:45	64.0	65.2	57.7	13.6	15.4	13.6	14.8	18.7	52.0	66.6	62.8	21.5	14.1	12.2	10.9	20.7
7:50	62.3	63.1	59.0	11.9	15.4	13.9	10.9	19.7	54.5	67.0	62.8	22.3	14.7	13.2	10.9	18.8
7:55	62.6	62.8	58.9	11.0	12.9	13.8	11.5	14.8	49.8	65.5	63.1	22.1	13.9	13.1	11.2	16.9
8:00	62.0	64.5	59.2	13.3	12.5	11.8	11.8	11.4	51.8	65.0	61.7	20.4	14.0	12.4	11.1	16.5
8:05	63.3	63.9	60.1	11.0	13.9	11.6	12.4	12.5	45.1	66.4	61.8	21.6	14.3	12.4	10.9	12.9
8:10	62.6	64.6	57.7	13.6	12.8	11.9	9.1	10.4	50.3	66.5	62.4	21.0	13.8	12.6	11.0	11.8
8:15	63.8	64.9	57.9	11.8	13.1	10.2	10.1	9.7	47.6	65.8	62.6	21.3	13.4	12.1	10.9	10.2
8:20	62.3	63.7	59.5	11.7	14.4	11.3	9.2	9.2	26.0	66.4	62.6	22.0	14.1	12.3	10.6	10.7
8:25	63.3	66.2	59.1	12.5	13.2	12.0	10.3	8.7	17.3	65.3	61.6	21.9	14.2	13.1	10.4	9.1
8:30	63.5	64.7	60.8	12.6	13.4	12.1	11.3	9.9	14.0	66.6	62.9	21.4	14.1	13.1	11.6	10.4
8:35	63.7	65.6	63.2	11.1	14.9	12.5	11.1	9.9	12.6	65.5	62.0	21.6	15.3	13.0	10.9	10.7
8:40	63.8	64.2	61.7	13.1	14.3	14.2	11.6	9.6	11.0	66.7	63.3	21.9	16.4	13.7	10.9	8.9
8:45	64.3	63.4	58.6	12.2	14.3	12.8	13.4	10.6	12.6	67.2	64.5	22.5	16.0	14.9	10.7	11.5
8:50	63.4	63.2	59.5	11.9	16.9	13.1	12.9	16.9	13.4	65.3	62.0	25.1	15.8	13.9	12.1	13.8
8:55	63.9	63.6	59.5	11.7	12.6	14.6	10.1	18.2	12.3	65.0	61.3	24.1	17.8	14.4	13.0	16.1

Table A-4. I-15 Southbound a.m. Speed Contour, *TransModeler Build 1005*

Segment	Miramar Way	WB Pomerado Rd	WB Mira Mesa Blvd	Mercy Rd	WB Rancho	Ted Williams Pkwy	Carmel Mountain Rd	Camino Del Norte	Bernardo Center Dr	Rancho Bernardo	Pomerado /Highland	Via Rancho Pkwy	Center City Pkwy	Citracado Pkway	9th Ave	Valley Pkwy
Detector	1108607	1108495	1108491	1108450	1108489	1108429	1108427	1108425	1108519	1108538	1108541	1108543	1108545	1108516	1108558	1108556
Segment Ids	37332	14407	37344	789	14660	570	37338	13664	13653	37022	8810	722	562	12946	12944	36530
Time Period (a.m.)	28.7	27.1	26.8	25.8	24.9	24.2	22.3	19.7	18.5	16.3	15.8	13.8	13.1	12.3	11.4	10.2
6:00	65.0	62.7	53.0	63.5	58.6	65.0	59.3	37.7	37.5	67.4	63.3	21.1	13.2	39.2	47.8	36.2
6:05	62.9	65.4	55.1	62.9	63.5	64.6	49.7	32.5	46.5	66.7	63.0	21.7	13.1	31.1	51.2	37.9
6:10	63.9	62.0	53.7	64.3	64.0	64.9	53.1	32.3	50.7	66.5	64.4	20.7	12.7	24.9	49.0	39.2
6:15	63.8	66.1	53.0	62.2	62.0	67.0	46.2	42.2	48.0	65.4	65.3	18.8	13.5	23.2	48.6	32.8
6:20	64.1	62.4	55.2	64.0	65.0	65.6	49.1	26.2	51.0	66.0	64.9	19.5	11.7	18.4	49.6	34.4
6:25	63.1	64.4	54.8	65.7	61.5	63.3	54.2	27.9	49.5	66.0	65.4	19.1	12.1	16.6	49.3	37.0
6:30	64.0	65.8	54.0	60.7	50.9	65.1	48.5	30.1	54.5	65.7	64.2	20.8	12.0	13.7	56.4	35.7
6:35	63.9	65.6	56.1	27.0	60.9	65.7	51.4	36.3	45.7	65.7	64.2	20.9	12.7	13.6	51.2	35.6
6:40	64.2	65.5	54.0	14.1	63.6	65.5	56.0	31.4	45.3	65.5	64.1	19.8	13.7	13.4	49.6	42.3
6:45	64.8	62.4	57.2	13.9	65.0	65.7	58.5	37.4	38.5	64.1	66.1	19.5	13.1	13.2	48.1	39.4
6:50	63.8	63.4	52.6	12.1	65.0	65.5	56.8	40.2	32.7	66.0	63.5	20.4	12.7	12.8	47.4	36.6
6:55	64.9	65.9	54.3	13.4	61.6	65.2	53.6	35.0	38.9	67.1	64.7	19.9	12.3	12.8	43.6	37.5
7:00	62.7	64.8	54.0	14.1	64.1	64.4	48.7	34.2	37.0	69.4	64.9	20.9	12.5	12.5	35.5	34.8
7:05	61.2	64.3	52.5	11.6	62.1	64.3	50.2	28.2	33.7	66.3	61.8	19.8	12.9	12.7	28.6	30.1
7:10	62.4	65.1	50.8	13.2	61.0	65.1	52.1	26.5	40.0	67.1	63.5	19.9	12.7	12.7	19.3	30.4
7:15	61.3	63.0	51.9	13.2	26.4	65.9	52.8	24.7	38.0	65.3	63.5	17.7	12.7	12.7	14.1	23.8
7:20	63.9	62.0	52.0	13.2	15.8	65.3	52.2	21.9	40.7	67.5	63.3	19.0	12.8	12.9	12.2	19.3
7:25	61.3	62.2	54.7	14.3	14.4	60.7	41.9	25.6	43.1	64.5	63.9	22.7	13.4	12.2	11.3	20.1
7:30	61.6	66.0	55.4	12.8	18.4	44.7	46.0	23.5	49.4	67.0	62.2	20.0	13.4	13.1	11.2	17.4
7:35	63.7	63.0	55.2	11.3	15.3	50.3	48.6	23.1	44.8	60.1	63.8	20.4	12.9	13.4	10.4	17.3
7:40	63.0	61.1	55.1	13.2	12.7	30.0	33.9	24.2	41.2	65.5	64.1	21.2	13.3	12.5	12.8	21.9
7:45	63.5	64.1	54.3	11.9	13.2	16.0	44.2	27.9	39.8	66.2	60.4	21.5	13.0	12.6	11.6	24.8
7:50	63.4	62.9	55.5	13.5	13.7	12.3	53.4	30.8	39.8	67.0	65.8	22.2	13.3	12.9	11.2	24.2
7:55	64.8	64.1	53.9	12.5	14.8	13.4	52.4	25.0	40.3	66.5	64.2	22.6	13.2	13.0	12.3	29.3
8:00	62.9	63.7	57.1	12.7	17.3	14.2	51.5	24.2	43.3	67.1	62.6	21.3	13.1	12.9	12.4	28.3
8:05	63.6	63.6	55.8	12.8	14.4	13.6	38.8	22.1	38.8	69.4	60.9	22.5	13.2	12.4	12.3	21.5
8:10	63.6	62.9	56.2	12.3	14.2	11.9	25.4	30.2	45.4	67.3	64.0	20.2	13.9	12.8	11.7	16.7
8:15	63.3	64.5	56.2	10.8	13.3	12.3	17.4	31.9	54.3	66.6	63.4	18.9	13.0	13.5	11.7	13.5
8:20	64.2	62.7	55.9	13.2	10.3	11.4	15.0	39.1	48.8	66.9	63.7	19.2	13.1	11.5	12.3	13.8
8:25	64.1	65.0	54.2	12.7	14.5	11.8	15.0	27.9	42.1	65.4	63.8	21.1	13.1	12.8	11.1	11.7
8:30	62.0	65.0	58.4	11.1	14.4	12.9	9.9	26.1	39.8	66.5	61.7	20.4	14.2	13.1	11.2	12.4
8:35	62.2	66.1	58.4	11.9	13.0	13.5	12.5	23.1	39.2	66.3	64.7	20.6	13.2	13.4	11.4	13.2
8:40	63.4	64.1	54.5	11.9	14.6	11.6	12.5	30.5	40.9	68.3	64.1	21.0	13.0	13.3	11.2	13.8
8:45	63.9	64.4	55.1	14.0	13.7	13.9	10.2	33.2	56.7	69.6	62.1	21.2	13.7	12.4	11.4	14.6
8:50	64.7	60.4	55.0	13.7	15.2	13.0	12.3	35.1	42.8	66.7	63.3	21.7	14.6	12.9	11.1	14.6
8:55	62.9	62.5	57.8	13.0	17.0	14.0	13.3	32.2	33.6	65.7	63.3	22.4	16.0	13.9	12.2	19.7

APPENDIX B. Calibration Results by Location

Table B-1. Summary of Data Elements and Sources

Infrastructure/ Performance Area	Proposed Performance Measure	Needed Data Elements	Data Sources
Physical Infrastructure	N/A	• Number of lanes (freeway, arterials) • Lane/shoulder widths • Transit routes/capacities • Intersection lane configurations	• Caltrans *Freeway Lane Configuration Diagrams and Traffic Monitoring Stations* • Caltrans "photolog" videos • Google/MSN maps and aerial photography • Site visits
Mobility	Peak-period traffic volumes	• Peak-period mainline traffic volumes • Ramp volumes • Arterial volumes (where available and collected) • Intersection counts (where available and collected) • Signal timing plans • Ramp Metering Plans	• PeMS • Miscellaneous counts from past projects/studies • Signal timing from Caltrans/counties/cities
	Travel time (minutes)	• Estimated speeds • Distances • Observed travel times	• PeMS • 511
	Delay (average DVHD)	• Speeds/travel times • Distances • Volumes	• PeMS
Safety	Accidents	• Accidents • Accident Rates	• PeMS • Caltrans TASAS
Other Measures	Truck volumes	• Truck percent of total volume	• Caltrans Traffic Volume and Truck Report web site • FHWA Truck Percent Estimates for TDM
	Vehicle occupancies (passengers per vehicle)	• Average Vehicle Occupancy (AVO)	• Travel Demand Model

Table B-2. Calibration Statistics by Location, 6:00 a.m.-7:00 a.m.

Location	Direction	Observed Counts	Simulated Counts	Percent Difference	Standard Deviation
Miramar Way	S	9,863	9,134	7.4%	73
Carroll Canyon Road	S	9,617	9,081	5.6%	51
WB Pomerado Road	S	9,314	8,810	5.4%	75
S/O Mercy Road	S	9,766	9,187	5.9%	123
Mercy Road	S	8,947	8,319	7.0%	93
WB Mira Mesa Boulevard	S	8,834	8,068	8.7%	49
Bernardo Center Drive	S	7,984	7,515	5.9%	54
Miramar Way	N	7,834	7,904	0.9%	27
Carmel Mountain Road	S	7,969	8,060	1.1%	48
Pomerado/Highland	S	7,955	7,686	3.4%	32
Camino Del Norte	S	8,592	7,957	7.4%	42
WB Rancho Bernardo	S	7,578	7,269	4.1%	39
WB Rancho Penasquito	S	8,519	8,006	6.0%	42
Via Rancho Parkway	S	7,600	7,039	7.4%	16
Ted Williams Parkway	S	8,003	7,672	4.1%	35
EB Miramar Road	N	6,666	6,769	1.5%	45
Carroll Canyon Road	N	5,923	6,077	2.6%	62
Center City Parkway	S	6,385	5,953	6.8%	20
EB Poway Road	N	5,351	5,220	2.4%	73
TED Williams Parkway	N	5,226	5,314	1.7%	65
Camino Del Norte	N	5,163	4,829	6.5%	83
Carmel Mountain Road	N	5,085	5,079	0.1%	67
Mercy Road	N	5,078	5,235	3.1%	56
EB Mira Mesa Boulevard	N	5,056	5,127	1.4%	55
Bernardo Center Drive	N	4,966	4,658	6.2%	89
Pomerado/Highland	N	4,794	4,673	2.5%	84
Citracado Parkway	S	5,514	5,732	3.9%	45
WB Rancho Bernardo	N	4,654	4,540	2.5%	75
9th Avenue	S	4,993	5,209	4.3%	44
Valley Parkway	S	4,488	4,804	7.0%	37
Via Rancho Parkway	N	3,803	3,698	2.8%	55
City Center Parkway	N	3,788	3,779	0.2%	60

Location	Direction	Observed Counts	Simulated Counts	Percent Difference	Standard Deviation
Auto Park Way/9th	N	3,746	3,793	1.2%	68
Citracado Parkway	N	3,743	3,730	0.4%	62
Valley Parkway	N	3,743	3,711	0.9%	70

Table B-3. Calibration Statistics by Location, 7:00 a.m.-8:00 a.m.

Location	Direction	Observed Counts	Simulated Counts	Percent Difference	Standard Deviation
Miramar Way	S	11,585	10,168	12.2%	38
Carroll Canyon Road	S	10,086	8,769	13.1%	52
WB Pomerado Road	S	10,260	8,933	12.9%	49
S/O Mercy Road	S	9,779	8,867	9.3%	27
Mercy Road	S	9,123	7,906	13.3%	86
WB Mira Mesa Boulevard	S	8,768	7,961	9.2%	20
Bernardo Center Drive	S	7,519	7,334	2.5%	446
Miramar Way	N	8,633	8,578	0.6%	24
Carmel Mountain Road	S	7,670	7,928	3.4%	307
Pomerado/Highland	S	7,847	7,611	3.0%	146
Camino Del Norte	S	8,374	7,725	7.8%	389
WB Rancho Bernardo	S	7,366	7,027	4.6%	393
WB Rancho Penasquito	S	8,259	7,309	11.5%	182
VIA Rancho Parkway	S	7,607	7,091	6.8%	34
TED Williams Parkway	S	7,686	7,291	5.1%	174
EB Miramar Road	N	7,635	7,796	2.1%	27
Carroll Canyon Road	N	6,741	7,178	6.5%	39
Center City Parkway	S	6,585	5,970	9.3%	22
EB Poway Road	N	6,303	6,248	0.9%	68
Ted Williams Parkway	N	6,145	6,485	5.5%	74
Camino Del Norte	N	6,408	6,272	2.1%	72
Carmel Mountain Road	N	6,037	6,234	3.3%	81
Mercy Road	N	6,010	6,317	5.1%	63
EB Mira Mesa Boulevard	N	5,427	5,513	1.6%	52
Bernardo Center Drive	N	6,015	5,766	4.1%	42
Pomerado/Highland	N	5,706	5,460	4.3%	103

Location	Direction	Observed Counts	Simulated Counts	Percent Difference	Standard Deviation
Citracado Parkway	S	5,786	5,748	0.7%	30
WB Rancho Bernardo	N	5,470	5,280	3.5%	92
9th Avenue	S	5,196	5,112	1.6%	52
Valley Parkway	S	4,620	4,616	0.1%	55
Via Rancho Parkway	N	4,644	4,507	3.0%	89
City Center Parkway	N	4,991	4,715	5.5%	69
Auto Park Way/9th	N	4,924	4,768	3.2%	88
Citracado Parkway	N	4,926	4,645	5.7%	72
Valley Parkway	N	4,926	4,444	9.8%	85

Table B-4. Calibration Statistics by Location, 8:00 a.m.-9:00 a.m.

Location	Direction	Observed Counts	Simulated Counts	Percent Difference	Standard Deviation
Miramar Way	S	10,009	9,328	6.8%	571
Carroll Canyon Road	S	8,636	8,153	5.6%	677
WB Pomerado Road	S	8,776	8,226	6.3%	614
S/O Mercy Road	S	8,486	8,120	4.3%	577
Mercy Road	S	7,847	7,447	5.1%	587
WB Mira Mesa Boulevard	S	7,518	7,610	1.2%	428
Bernardo Center Drive	S	6,461	6,747	4.4%	1,150
Miramar Way	N	8,102	7,957	1.8%	305
Carmel Mountain Road	S	6,505	6,543	0.6%	832
Pomerado/Highland	S	6,526	6,976	6.9%	1,281
Camino Del Norte	S	7,159	6,743	5.8%	1,064
WB Rancho Bernardo	S	6,238	6,536	4.8%	954
WB Rancho Penasquito	S	6,967	6,583	5.5%	696
VIA Rancho Parkway	S	6,522	6,614	1.4%	1,139
Ted Williams Parkway	S	6,502	6,189	4.8%	716
EB Miramar Road	N	7,350	7,259	1.2%	565
Carroll Canyon Road	N	6,541	6,650	1.7%	689
Center City Parkway	S	5,731	5,344	6.7%	848
EB Poway Road	N	5,928	5,775	2.6%	651
Ted Williams Parkway	N	6,085	6,374	4.7%	616

Location	Direction	Observed Counts	Simulated Counts	Percent Difference	Standard Deviation
Camino Del Norte	N	6,454	6,309	2.2%	846
Carmel Mountain Road	N	5,959	6,067	1.8%	644
Mercy Road	N	5,727	5,747	0.3%	739
EB Mira Mesa Boulevard	N	5,107	5,071	0.7%	543
Bernardo Center Drive	N	5,870	5,293	9.8%	827
Pomerado/Highland	N	5,435	4,920	9.5%	810
Citracado Parkway	S	5,027	5,099	1.4%	709
WB Rancho Bernardo	N	5,212	4,804	7.8%	684
9th Avenue	S	4,653	4,661	0.2%	412
Valley Parkway	S	4,175	4,344	4.0%	222
Via Rancho Parkway	N	4,341	4,107	5.4%	595
City Center Parkway	N	4,754	4,397	7.5%	628
Auto Park Way/9th	N	4,690	4,411	5.9%	622
Citracado Parkway	N	4,675	4,304	7.9%	663
Valley Parkway	N	4,673	4,325	7.4%	571

APPENDIX C. Metric/English Conversion Factors

ENGLISH TO METRIC	METRIC TO ENGLISH)
LENGTH (APPROXIMATE)	**LENGTH (APPROXIMATE)**
1 inch (in) = 2.5 centimeters (cm)	1 millimeter (mm) = 0.04 inch (in)
1 foot (ft) = 30 centimeters (cm)	1 centimeter (cm) = 0.4 inch (in)
1 yard (yd) = 0.9 meter (m)	1 meter (m) = 3.3 feet (ft)
1 mile (mi) = 1.6 kilometers (km)	1 meter (m) = 1.1 yards (yd)
	1 kilometer (km) = 0.6 mile (mi)
AREA (APPROXIMATE)	**AREA (APPROXIMATE)**
1 square inch (sq in, in^2) = 6.5 square centimeters (cm^2)	1 square centimeter (cm^2) = 0.16 square inch (sq in, in^2)
1 square foot (sq ft, ft^2) = 0.09 square meter (m^2)	1 square meter (m^2) = 1.2 square yards (sq yd, yd^2)
1 square yard (sq yd, yd^2) = 0.8 square meter (m^2)	1 square kilometer (km^2) = 0.4 square mile (sq mi, mi^2)
1 square mile (sq mi, mi^2) = 2.6 square kilometers (km^2)	10,000 square meters (m^2) = 1 hectare (ha) = 2.5 acres
1 acre = 0.4 hectare (he) = 4,000 square meters (m^2)	
MASS - WEIGHT (APPROXIMATE)	**MASS - WEIGHT (APPROXIMATE)**
1 ounce (oz) = 28 grams (gm)	1 gram (gm) = 0.036 ounce (oz)
1 pound (lb) = 0.45 kilogram (kg)	1 kilogram (kg) = 2.2 pounds (lb)
1 short ton = 2,000 pounds (lb) = 0.9 tonne (t)	1 tonne (t) = 1,000 kilograms (kg) = 1.1 short tons
VOLUME (APPROXIMATE)	**VOLUME (APPROXIMATE)**
1 teaspoon (tsp) = 5 milliliters (ml)	1 milliliter (ml) = 0.03 fluid ounce (fl oz)
1 tablespoon (tbsp) = 15 milliliters (ml)	1 liter (l) = 2.1 pints (pt)
1 fluid ounce (fl oz) = 30 milliliters (ml)	1 liter (l) = 1.06 quarts (qt)
1 cup (c) = 0.24 liter (l)	1 liter (l) = 0.26 gallon (gal)
1 pint (pt) = 0.47 liter (l)	
1 quart (qt) = 0.96 liter (l)	
1 gallon (gal) = 3.8 liters (l)	
1 cubic foot (cu ft, ft^3) = 0.03 cubic meter (m^3)	1 cubic meter (m^3) = 36 cubic feet (cu ft, ft^3)
1 cubic yard (cu yd, yd^3) = 0.76 cubic meter (m^3)	1 cubic meter (m^3) = 1.3 cubic yards (cu yd, yd^3)
TEMPERATURE (EXACT)	**TEMPERATURE (EXACT)**
[(x-32)(5/9)] °F = y °C	[(9/5) y + 32] °C = x °F

QUICK INCH - CENTIMETER LENGTH CONVERSION

Inches: 0 1 2 3 4 5

Centimeters: 0 1 2 3 4 5 6 7 8 9 10 11 12 13
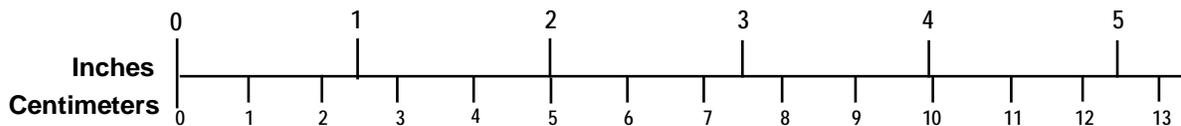
QUICK FAHRENHEIT - CELSIUS TEMPERATURE CONVERSION

°F -40° -22° -4° 14° 32° 50° 68° 86° 104° 122° 140° 158° 176° 194° 212°

°C -40° -30° -20° -10° 0° 10° 20° 30° 40° 50° 60° 70° 80° 90° 100°
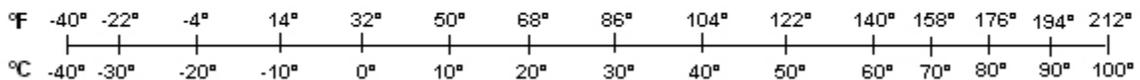
For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50 SD Catalog No. C13 10286

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