Integrated Corridor Management

Stage 3A Analysis, Modeling, and Simulation for the I-15 Corridor in San Diego, California

Pre-Deployment AMS Assessment

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16. Abstract

The objective of the Stage 3A AMS efforts is to ensure that the Stage 2 models and methodologies can sufficiently replicate and evaluate corridor conditions and the proposed ICM strategies prior to deployment. In Stage 3A, the AMS contractor and the Demonstration site staff confirmed, refined, and validated the parameters and assumptions that serve as the basis for the control strategies currently present in the Stage 2 models. These updated and enhanced models and methodologies can provide further insight on ICM implementation and other operational benefits that will help guide the Stage 3 demonstration projects, future ICM deployments, as well as the post-deployment AMS activities.

This ***Pre-Deployment AMS Assessment Report for the I-15 Corridor*** describes the various tasks associated with the refinement and additional analysis of the Stage 2 models and methodologies in order to support the successful implementation of ICM.

Chapter 2 provides a brief description of the I-15 Corridor in San Diego, California, and the methodology used for the overall AMS effort. This chapter describes the overall modeling framework used for the analysis and provides detailed information about the assumptions used to model route and mode shift, as well as rules used in modeling the effects of better traveler information be it pre-trip, en-route, or using Dynamic Message Signs.

Chapter 3 summarizes the AMS work completed as part of the Stage 2 analysis, including analysis scenarios, ICM strategies, modeling assumptions, summary of analysis settings, performance measures, the model calibration effort, and Stage 2 analysis results. **Appendix A** presents the model calibration results from Stage 2 AMS. **Appendix B** provides more information on analysis results from Stage 2 AMS.

Chapter 4 lays out the methodology, model enhancements, model reasonableness assessment, and analysis results for the AMS work completed as part of the Stage 3 pre-deployment analysis. The refined model is capable of adequately representing the pre-deployment corridor operational conditions and corridor management strategies in the I-15 Corridor. Overall, AMS results are intuitive and ICM deployment is expected to produce positive travel time benefits on the I-15 Corridor.

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1.0 Introduction and Background

The objective of the ***Integrated Corridor Management (ICM)*** initiative is to demonstrate how intelligent transportation systems (ITS) technologies can efficiently and proactively manage the movement of people and goods in major transportation corridors. The ICM initiative aims to pioneer innovative multimodal and multi-jurisdictional strategies and combinations of strategies that optimize existing infrastructure to help manage congestion in our nation's corridors. There are many corridors in the country with under-utilized capacity (in the form of parallel transit capacity (bus, rail, bus rapid transit, etc.) and/or arterials and under-utilized travel lanes) that could benefit from ICM. Better utilization of corridor capacity relates to dynamic changes in non-recurrent congestion and the ability of parallel transit or arterials to dynamically provide additional capacity resulting in better optimized capacity utilization.

The maturation of ITS technologies, availability of supporting data, and emerging multi-agency institutional frameworks make ICM practical and feasible. There is a large number of freeway, arterial, and transit optimization strategies available today and in widespread use across the U.S. Most of these strategies are managed locally by individual agencies on an asset-by-asset basis. Even those managed regionally are often managed in a stove-piped manner (asset-by-asset) rather than in an "integrated" fashion across a transportation corridor. Dynamically applying these strategies in combination across a corridor in response to varying conditions is expected to reduce congestion "hot spots" in the system and improve the overall productivity of the system. Furthermore, providing travelers with actionable information on alternatives (such as mode shift, time of travel shift, and/or route shift) is expected to mitigate bottlenecks, reduce congestion, and empower travelers to make more informed travel choices.

One aspect of the ICM program is the enhancement of analytical techniques and tools to support ICM impact assessment. Activity in this area comprises three stages, relative to the needs of the ICM program, in foundational research, methodological development, and deployment support. The Analysis Modeling and Simulation (AMS) contractor is the lead organization in each stage addressing methodological research, and documenting lessons learned and updates to the methodology. The ***"ICM – Tools, Strategies and Deployment Support"*** project is the element of the AMS track within ICM that relates to site-specific analysis. The AMS contractor works in concert with the demonstration site teams and the evaluation team.

The objectives of the ***"ICM – Tools, Strategies and Deployment Support"*** project are to refine Analysis Modeling and Simulation (AMS) tools and strategies, assess the Pioneer Sites' data capabilities, conduct AMS for the ICM Pioneer Sites, and conduct AMS tools pre- and post-demonstration evaluations. In previous AMS efforts, during Stage 2 of the ICM initiative, the expected benefits and impacts of implementing the Pioneer Sites' proposed ICM systems were evaluated. In this current phase of the initiative, Stage 3, the overall objective is to guide the pre- and post-deployment analysis of the proposed ICM systems of the Stage 3 Pioneer Sites. Additional objectives include:

- Develop a pre-deployment AMS Plan in collaboration with ICM Demonstration sites and conduct analyses – this Plan helps coordinate the activities of the AMS Contractor, Site AMS team, and the Evaluation team;
- Support demonstration site-specific ICM demonstration evaluation efforts – identify and facilitate improvements to AMS tools, data used to generate tool inputs, and AMS techniques to improve the capability of site-specific tools to fairly represent and objectively evaluate ICM strategies;
- Manage the successful transition of modeling leadership responsibilities from the AMS contractor to the ICM Demonstration site staff and organizations;
- Support the ICM Demonstration sites integration of AMS tools and methods into ongoing corridor management practices; and
- Provide technical documentation of ICM AMS tool development, data collection and analysis, model calibration and validation methods, and analytical methods deployed to both represent and evaluate ICM impacts.

The activities included in the Stage 3 AMS efforts will be performed under two sub-stages. The first sub-stage, Stage 3A, includes all pre-deployment related AMS activities. The objective of the Stage 3A AMS efforts are to ensure that the Stage 2 models and methodologies can sufficiently replicate and evaluate corridor conditions and the proposed ICM strategies prior to deployment. Therefore in this sub-stage, the AMS contractor and the Demonstration site staff will confirm, refine, and validate the parameters/assumptions that serve as the basis for the control strategies present in these Stage 2 models. These updated and enhanced models and methodologies can provide further insight on ICM implementation and other operational benefits that will help guide the Stage 3 demonstration projects, future ICM deployments, as well as the post-deployment AMS activities.

The second sub-stage, Stage 3B, will include all tasks related to the post-deployment AMS analysis efforts. The objectives of Stage 3B will be to support the ICM Demonstration Evaluation of the Pioneer Sites' deployed ICM systems and to assess and validate the estimated impacts of ICM, as determined in the previous stage. Another objective of Stage 3B AMS is to update the model to reflect the "as built" ICM system and strategies, and to update model parameters using observed data from the evaluation effort. The models and methodologies refined and developed in the pre-deployment AMS effort (Stage 3A) can be utilized to support the post-deployment evaluation and analysis activities.

This ***Pre-Deployment Assessment Report for the I-15 Corridor*** describes the approach, results, benefits, and lessons learned associated with the application of the ICM AMS tools and strategies to this corridor in order to support the pre-deployment analysis and future demonstration of the proposed ICM system. The Pre-Deployment Assessment Report is not intended to provide a comprehensive assessment of predicted ICM impacts. Rather, this report provides technical documentation of ICM AMS tool development, data collection and analysis, model calibration and validation methods, and analytical methods deployed to both represent and evaluate ICM impacts.'

The organization of this report is as follows:

- **Chapter 2** provides a brief description of the I-15 Corridor in San Diego, California, and the methodology used for the overall AMS effort;
- **Chapter 3** summarizes the results of the Stage 2 AMS efforts;

- **Chapter 4** defines the tasks involved in the Stage 3A Pre-Deployment AMS efforts, and presents the analysis approach, results and benefits;
- **Appendix A** presents the model calibration results from Stage 2 AMS; and
- **Appendix B** presents the AMS analysis results from Stage 2 AMS.

2.0 I-15 Corridor Site and AMS Methodology

The Interstate 15 corridor site in San Diego, California, 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 2.1 illustrates the study area. The I-15 corridor in San Diego has been utilized as a test bed for various ITS strategies identified in consultation with the San Diego Association of Governments (SANDAG) and other local stakeholders. These strategies included in the proposed ICM system are detailed in Chapter 3 of this document. The following sections provide a detailed overview of the study corridor and describe the process for the AMS efforts.

2.1 I-15 Corridor Description

Figure 2.1 illustrates the Pioneer Corridor and the roadways included in the study area. I-15 is an eight- 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 2.2 indicates the geographic location of the corridor along with the extents of the mainline study area. The section between SR 78 and SR 163 (study area) will eventually include four center median lanes, which will have two lanes in each direction operating as HOT lanes in the peak direction. According to the Concept of Operations report for the I-15 corridor, current weekday traffic volumes range from 170,000 to 290,000 vehicles on the general purpose lanes of I-15, and approximately 20,000 vehicles use the I-15 Express Lanes during weekdays. 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 2.1 Study Area I-15 Corridor in San Diego, California (Source: SANDAG: AV Graphics, March 2008)

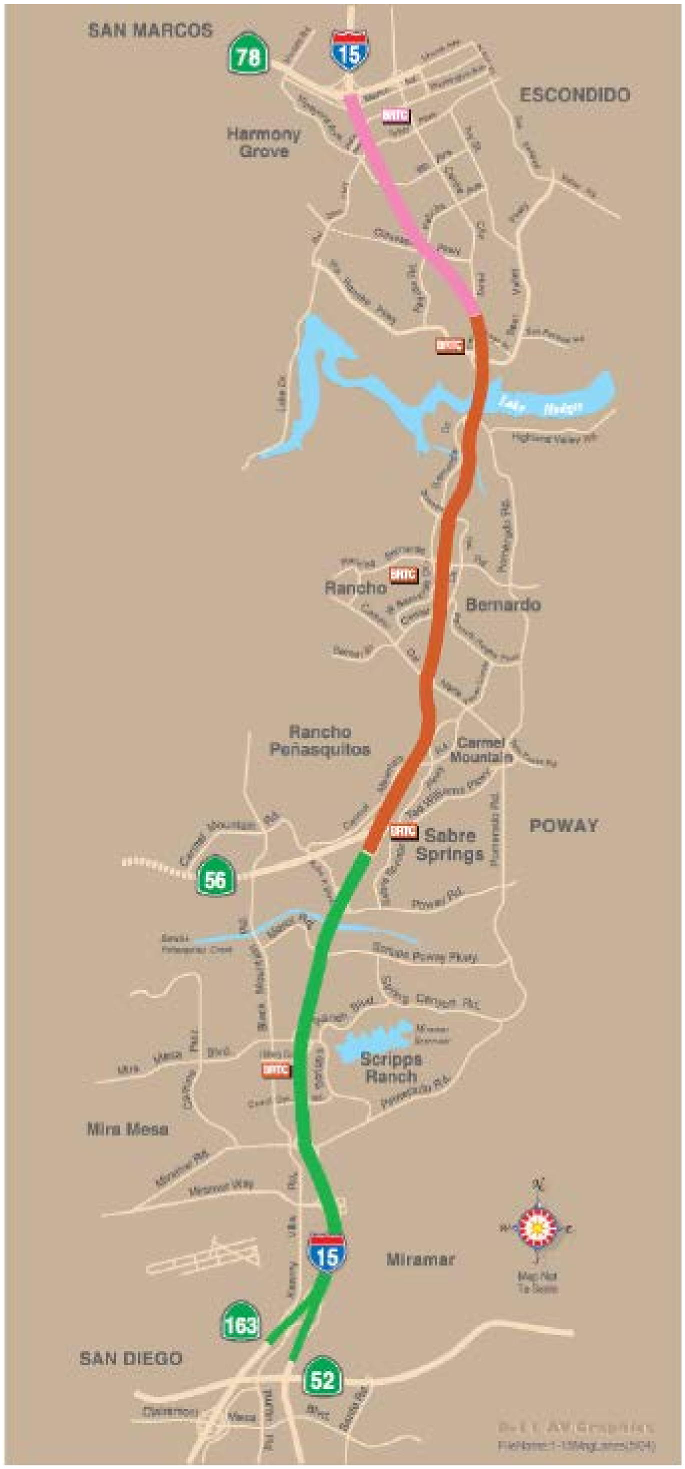

Figure 2.2 Location and Geographic Boundaries of Corridor (Source: ©Microsoft Corporation ©NAVTEC SANDAG, September 2010)

2.2 Modeling Methodology

The modeling methodology that emerged from the analysis of capabilities found in existing AMS tools as well as from the ICM Test Corridor project is an ***integrated platform that can support corridor management planning, design, and operations by combining the capabilities of existing tools.*** The overall integrated methodology is based on ***interfacing travel demand models and microscopic simulation models***. The Pioneer Corridor AMS approach encompasses tools with different traffic analysis resolutions. Two classes of simulation models, macroscopic and microscopic, have been applied for evaluating ICM strategies.

The AMS methodology applied a macroscopic trip table manipulation for the determination of overall trip patterns. The methodology also applied a microscopic analysis of the impact of driver behavior in reaction to ICM strategies (both within and between modes) and the impact of traffic control strategies at roadway junctions (such as arterial intersections or freeway interchanges). The methodology also includes the development of interfaces between different tools, and the application of a performance measurement and benefit/cost module.

The sections below provide an overview of the various modeling components that are utilized in the AMS modeling framework.

Travel Demand Forecasting Model

Predicting travel demand requires specific analytical capabilities, such as the consideration of destination choice, mode choice, time-of-day travel choice, and route choice, as well as the representation of traffic flow in the highway network. These attributes are found in the structure and orientation of travel demand models, which serve as mathematical models that forecast future travel demand from current conditions and future projections of household and employment characteristics.

SANDAG's Travel Demand Model (TDM) for the region has been used to develop the trip tables and networks for the I-15 Corridor. Subarea trip tables and networks were developed from the TDM for use in the simulation models. Parameters from the TDM were also used to analyze mode shifts in response to congestion and to ICM strategies.

Microscopic Simulation Model

Microscopic simulation models simulate the movement of individual vehicles, based on theories of car-following and lane-changing. Typically, vehicles enter a transportation network using a statistical distribution of arrivals (a stochastic process) and are tracked through the network over small time intervals (e.g., one second, or fraction of a second.) Typically, upon entry, each vehicle is assigned a destination, a vehicle type, and a driver type. In many microscopic simulation models, the traffic operational characteristics of each vehicle are influenced by vertical grade, horizontal curvature, and superelevation, based on relationships developed in prior research. The primary means of calibrating and validating microscopic simulation models is through the adjustment of driver sensitivity factors that best match locally measured roadway capacities and current route choice patterns.

The microscopic component of TransModeler was utilized for the analysis of the corridor. The microsimulation model supports the evaluation of traffic control aspects of ICM strategies, such as freeway ramp metering and arterial traffic signal coordination, as well as managed-use lane operations. At any time, the route choice model can be reevaluated in order to update the path choices of drivers en route to their destinations. This model was also used to evaluate the response of drivers in incident situations when they are faced with high levels of congestion. When a driver's path choice is reevaluated, the path costs (e.g., segment travel times) are reconsidered. For driver groups defined in the model parameters as having access to real-time travel information (i.e., informed drivers), an updated, dynamic travel timetable was used to evaluate path costs. Drivers belonging to a driver group that do not have access to real-time information will reconsider their paths using the same (i.e., historical or habitual) travel time information used to evaluate their pre-trip paths.

In addition, the microsimulation model was used to evaluate the transportation system management strategies that need to be taken into consideration with regards to response to congestion. The microsimulation model operates by simulating all the key system components, such as signals, meters, speed limits, and transit vehicles, so it can be used to identify and test different congestion hotspots.

Modeling Route Choice

The traffic assignment models within TransModeler allow the use of static and dynamic assignment procedures based on requirements of different study types. Traffic assignment models are used to estimate the flow of traffic on a network. These models take as input a matrix of flows that indicate the volume of traffic between origin and destination (O-D) pairs. The flows for each O-D pair are loaded onto the network based on the travel time or impedance of the alternative paths that could carry this traffic. For traffic simulation models, the flow on a network is modeled by representing individual vehicle movements, and subsequently the link-based performance measures are evaluated based on movements of these individual vehicles as they rest in queues, travel in free flow, or maneuver through congestion. Whether all vehicles traveling a given path reach all links on the path within a given analysis period is dependent on time-variant travel conditions in the network.[1]

In modeling recurrent congestion and in establishing habitual paths of travelers, the key behavioral assumptions underlying the User Equilibrium assignment model are that every traveler has perfect information concerning the attributes of network alternatives, all travelers choose a route that minimizes their travel time or travel costs, and all travelers have the same valuations of network attributes. At user equilibrium (UE), no individual travelers can unilaterally reduce their travel time by changing paths (Sheffi, 1985). A consequence of the UE principle is that all used paths for an O-D pair have the same minimum cost. An alternative and more realistic equilibrium model was proposed by Daganzo and Sheffi (1977) known as Stochastic User Equilibrium or SUE. This model is premised on the assumption that travelers have imperfect information about network paths and/or vary in their perceptions of network attributes. At stochastic user equilibrium, no travelers believe that they can increase their expected utility by choosing a different path. Because of variations in traveler perceptions and also in the level of service experienced, utilized paths do not necessarily have identical generalized costs. The SUE model is consistent with the concept of applying discrete choice models for the choice of route, but with the necessary aggregation and equilibrium solution.

For the ICM AMS efforts, SUE was utilized for calibration and validation of the base year model. The use of SUE also was consistent with the utilization of managed use lane scripts, which used the cost of different paths with a logit-based route choice model to assign en-route mode and route choice. Details on the use of the logit model are provided in Appendix B of the *Integrated Corridor Management Analysis, Modeling, and Simulation for the I-15 Corridor in San Diego, California*.

Congestion-Sensitive Time-of-Departure

The methodology utilized in the I-15 AMS effort assumes that the level of congestion along the shortest path between any O-D pair will affect the degree of peak spreading that is likely to occur for that O-D pair. This methodology is based on a set of temporal distributions that vary by the ratio of the Average Daily Traffic to Capacity (ADT/C), where capacity is the hourly capacity by facility type – for example, freeway capacity is 2,300 passenger cars per hour per lane (pcphpl), as specified in the SANDAG travel demand model. The temporal distributions, shown in Table 2.1, are used to determine hourly volumes. This methodology has the effect of moving demand from peak hours to off-peak hours as congestion increases, which becomes especially important as future year traffic volumes grow. The shift in demand from peak hours to off-peak hours is proportional to the level of congestion on the route thereby simulating an effective change in the departure choice of the drivers. The time-of-departure (TOD) choice is implemented for the base year model and based on the 24-hour trip tables from the regional travel demand model. The future year models also utilize a TOD adjustment based on the ADT/C ratios in the future networks. However, the future number of trips in the O-D is the same for all the alternatives analyzed.

[1] Transmodeler User Manual.

The main input to simulation models in travel demand is in the form of O-D tables. Ideally, these O-D tables come from regional travel demand models and represent travel demand in small time increments, usually 15-minute slices, to support the dynamic traffic assignment process. Unfortunately, most regional travel demand models, including SANDAG's TDM, are validated to much longer time periods and are estimated by applying regional factors to every O-D pair based on observations from a travel survey. This traditional approach therefore assumes that the temporal distribution of trips is constant by geography, regardless of the location and level of congestion. In order to consider the cumulative effect of congestion over the course of the entire day, a revised methodology based on temporal distributions varying by ADT/C ratios was employed and is described below.

The employed methodology for the I-15 AMS assumes a different temporal distribution for every O-D pair that is related to the level of congestion between each O-D pair. For O-D pairs that experience little or no congestion, no peak spreading will occur. For O-D pairs that experience high congestion levels, peak spreading will occur and will continue to spread as congestion increases over time. In other words, the level of temporal redistribution is sensitive to changes in demand over time or in response to changes in supply.

A set of temporal distributions were developed by Margiotta[2] et al. that vary based on the level of congestion as measured by the daily volume to capacity ratio (ADT/C). These distributions were developed as a mechanistic way of moving demand from one time period to another as the level of congestion changes. Table 2.1 shows the initial average weekday temporal distributions (expressed as a percentage of daily demand) for three ADT/C ratios (ADT/C less than or equal to 7, ADT/C between 7 and 11, and ADT/C greater than 11). The percent of the daily volume for each hour is reported for each range of ADT/C ratio.

Table 2.1 and Figure 2.3 show the temporal distribution of trips by hour for each of the ADT/C ratios. It was determined that direct application of these distributions could lead to illogical results if ADT/C values are at the boundary (e.g., ADT/C = 11). As shown in the figure, the higher ADT/C range (13+) has a flatter distribution than the ADT/C middle range (ADT/C ratios between 7 and 11). This is problematic because congestion for a particular hour may be predicted using a middle range value such as 11, but this same congestion may not be apparent in the same hour for a higher ADT/C ratio such as 13. Therefore, a smoothing procedure was developed to account for these boundary problems and provide distributions for ADT/C ratios above 13. Finally, different sets of curves were developed[3] for each trip purpose as the temporal distribution varies by trip type. For example, home-based work trips have a temporal distribution that is quite different than a home-based shopping trip.

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[2] Margiotta, R., H. Cohen, and P. DeCorla-Souza, *Speed and Delay Prediction Models for Planning Applications*, Sixth National Conference on Transportation Planning for Small and Medium-Sized Communities, Spokane, Washington, 1999.

[3] Simons, C., I-285 *Matrix Variegator: Practical Method for Developing Trip Tables for Simulation Modeling from Travel Demand Modeling Inputs*, Transportation Research Board, Journal Article, Volume 1961, Washington, D.C., 2006.

Table 2.1 Initial Weekday Temporal Distribution by Two-Way ADT/C (Expressed as a Percentage of Daily Demand)

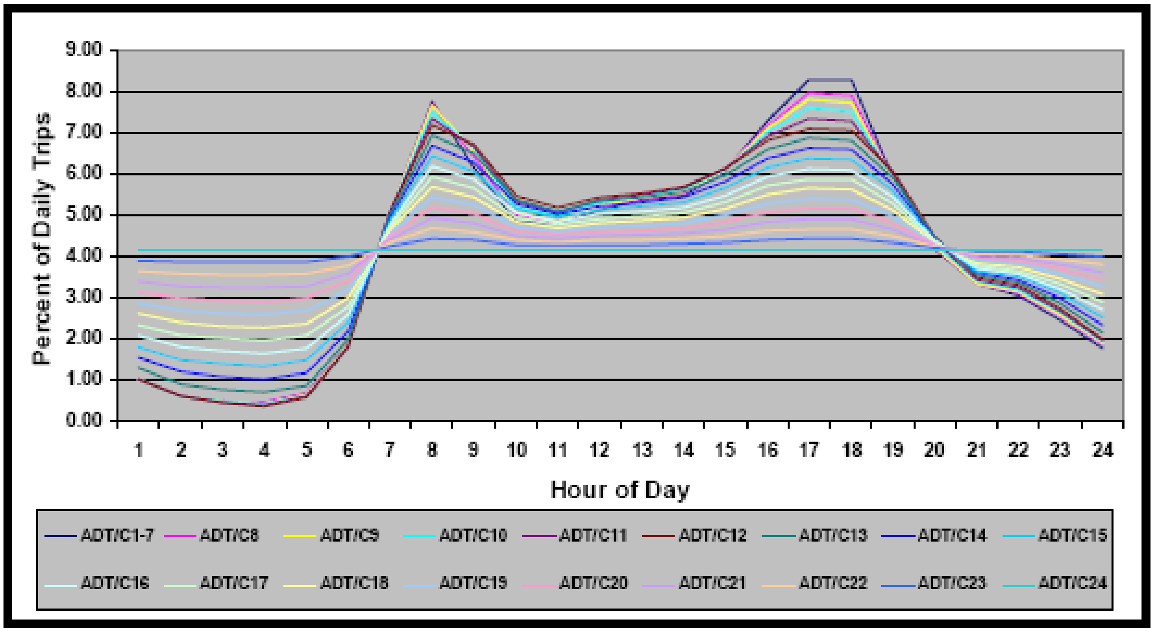
Hour	< = 7	7– – 11	> 11	Hour	< = 7	7– – 11	> 11
1	1.00	1.01	1.01	13	5.36	5.43	5.53
2	0.60	0.61	0.59	14	5.47	5.56	5.68
3	0.48	0.48	0.44	15	6.05	6.08	6.12
4	0.45	0.42	0.36	16	7.27	7.08	6.81
5	0.67	0.63	0.56	17	8.28	7.81	7.10
6	1.85	1.81	1.78	18	8.27	7.71	7.06
7	5.01	5.06	5.04	19	5.89	5.86	6.04
8	7.73	7.64	7.17	20	4.18	4.22	4.48
9	6.13	6.56	6.70	21	3.32	3.33	3.48
10	4.82	5.05	5.47	22	3.03	3.13	3.28
11	4.79	4.84	5.17	23	2.44	2.58	2.73
12	5.12	5.22	5.42	24	1.77	1.88	1.96

For the I-15 AMS, these temporal distributions have been refined to represent local conditions in the San Diego region by applying the models for the base year, summing the hourly trips to the peak period, and comparing to the SANDAG travel model's peak-period trip totals for each trip purpose. Additionally, the process utilized to calibrate the base year travel demand ODME further refined the O-D tables to local conditions.

The worksteps applied in this methodology are as follows:

- Step 1. Create a daily assigned network by summing up the AM, PM, and off-peak assignment results from the SANDAG model.
- Step 2. Calculate the daily volume/capacity ratio for each link. Links with daily volume/capacity ratio more than 9.0 are considered congested links and are flagged.
- Step 3. Perform a network skim on the following variables with shortest path based on congested time: 1) total daily volume; 2) hourly capacity; 3) total volumes for congested links only as flagged in Step 2, and 4) hourly capacity for congested links only.
- Step 4. Identify the O-D pairs where there is congestion. Obtain the congested volume/capacity ratio from Step 3. This creates a matrix with volume/capacity ratios for all O-D pairs that are congested indicating which O-D pairs are subject to peak spreading. The origin-destination cells traveled by non-congested links will have a default value of 1.0, indicating no peak spreading. If there are more than one congested link in a certain path, then an average ADT/C is used for these congested links.
- Step 5. Lookup Hourly Percents. Look up tables by purpose are utilized to estimate the percent of trips by hour for various levels of congestion as calculated in Step 4. These factors are used to split the daily trip tables into hourly demands.

Figure 2.3 Percent Daily Trips by ADT/C Ratio (Source: Cambridge Systematics, Inc., December 2011)



The resulting flow rates were used for the AM peak period since the analysis was conducted for this period only. Furthermore, the resulting flow rates and OD flows are subject to changes made in the model calibration effort that is described in Chapter 3.5 later in this document.

Analysis of Mode Shift and Transit

A known gap in the analysis of ICM relates to the performance and impacts of transit services. Mode shift in the corridor can be influenced by adverse traffic conditions (incidents, heavy demand, and inclement weather) and by ICM strategies (such as traveler information systems). Modeling of mode shift requires input of transit travel times, which are calculated by network segment and at key decision points in the corridor. This can support comparison of network and modal alternatives, and facilitate the analysis of traveler shifts among different transportation modes. For the San Diego I-15 Corridor, the available mode choice models were identified and their applicability was explored.

In order to identify the median weekday mode split, the mode-choice component of the SANDAG travel demand model was utilized. This component calculates the number of travelers at the beginning of the simulation that decide to drive as opposed to take transit. After this mode split is set, there also is the need to model users' choice of mode as en-route information becomes available to them. This is applicable to the I-15 corridor for two reasons: First, the corridor will service a BRT service, with five transit stations within the study corridor, each having direct connections to the HOT lane and also with access to the General Purpose Lanes. This combination allows for significant mode shift opportunities especially in the occurrence of an event, such as a major incident. Secondly, the analysis is being conducted at a microsimulation level, where the behavior of every traveler in the simulation can be modified, if there is benefit to the traveler.

The availability of en-route information may cause travelers to modify their route choices as well as mode choices. Traveler groups are provided with different levels of quality of information. Informed travelers, such as those equipped with Global Positioning System (GPS) devices and 511 users, are assumed to make their decision based on real-time information on managed lane and general purpose lane travel times, as well as transit travel time information. Travelers without in-vehicle GPS or 511-based information will be assumed to consider route- or mode-shift based on VMS-posted information only. The perception of travel times for the two categories of travelers is different: more GPS or 511 users will consider mode- or route-shift than travelers who get their traveler information from VMS.

For more information regarding the methodology for modeling the en-route mode shift, refer to Appendix B in the final report, *Integrated Corridor Management Analysis, Modeling, and Simulation for the I-15 Corridor in San Diego*.

Summary

Two classes of simulation models, macroscopic and microscopic, have been applied for evaluating ICM strategies. The AMS methodology applied a macroscopic trip table manipulation for the determination of overall trip patterns. The methodology also applied a microscopic analysis of the impact of driver behavior in reaction to ICM strategies (both within and between modes) and the impact of traffic control strategies at roadway junctions (such as arterial intersections or freeway interchanges). The methodology also includes the development of interfaces between different tools, and the application of a performance measurement and benefit/cost module. The AMS methodology employs a peak-spreading component that makes trip departures sensitive to congestion. Mode and route choices are calculated simultaneously in “real-time” microsimulation modeling.

3.0 Summary of Stage 2 AMS Analysis

This section provides an overview of the AMS analysis performed as part of Stage 2, including identification of priority ICM strategies for the U.S. 75 Corridor and the scenarios that were studied to analyze the impacts of these strategies. A scenario is defined as a combination of an operational condition and a transportation management response.

3.1 Analysis Scenarios

The I-15 AMS provides tools and procedures capable of supporting the analysis of both recurrent and nonrecurrent congestion scenarios. The Pioneer Corridor nonrecurrent congestion scenarios entail combinations of increases of demand and decreases of capacity. Figure 3.1 depicts how key ICM impacts may be lost if only "normal" travel conditions are considered. The relative frequency of nonrecurrent conditions also is important to estimate in this process–based on archived traffic conditions, as shown in Figure 3.2.

Figure 3.1 Key ICM Impacts may be Lost if Only "Normal" Conditions are Considered (Source: Wunderlich, K., et al., Seattle 2020 Case Study, PRUEVIIN Methodology, Mitretek Systems (Source: FHWA-OP-01-031, May 2002))

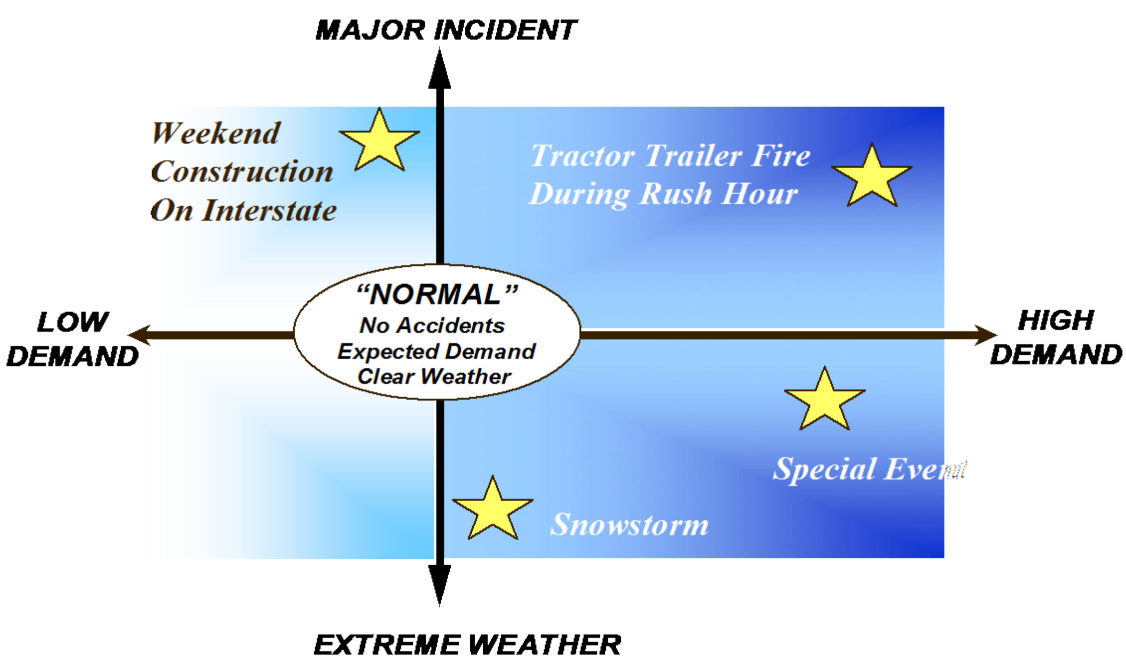
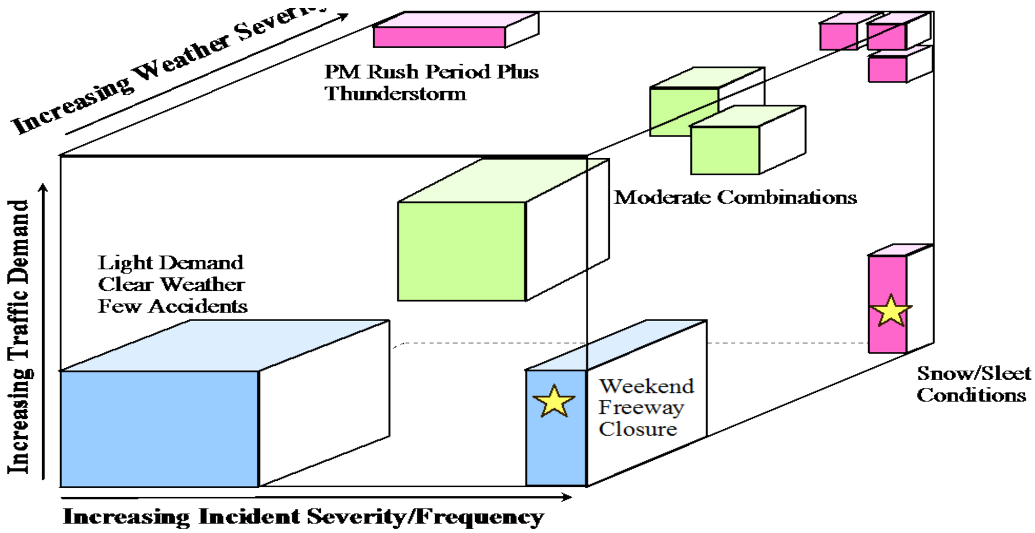


Figure 3.2 Sources of System Variation
Classifying Frequency and Intensity (Source: Wunderlich, K., et al., Seattle 2020 Case Study, PRUEVIIN Methodology, Mitretek Systems (Source: FHWA-OP-01-031, May 2002))



The analysis scenarios for the Stage 2 I-15 AMS focused on the AM high-demand period during a typical day, with and without incidents. The typical day construct was used to establish equilibration and habitual travel behavior patterns. The nonrecurrent congestion scenarios modeled for this corridor include incident scenarios that were identified in the Concept of Operations document. The typical day was identified based on PeMS data for I-15 from April to May and September to November of the base year, and choosing the weekday closest to the average volume for the entire peak season. The determination of closeness was based on a calculation of the standard deviation for the entire time series. The volumes from this day were balanced to reflect the conservation of flow on the corridor.

For the purposes of this study, an analysis of incident and demand data was undertaken by the project team. The primary source of incident data was the CHP and TASAS database within PeMS and the focus of the examination was on incidents that occurred on the southbound general purpose lanes of I-15 between Post Miles 15 and 35 during the Baseline year of 2003.

The analysis focused on the distribution of the number of days in 2003 by incident type and by travel demand level during the AM peak period over the course of the baseline year as shown in Tables 3.1 and 3.2. Demand is measured in terms of vehicle miles traveled (VMT) and demand levels are divided into three categories – low, medium, and high – based on their percentage of median VMT as follows:

- Low, if VMT is less than 75 percent of the median VMT value;
- Medium, if VMT is greater than 75 percent of and less than 102 percent of the median VMT value; and
- High, if VMT is greater than 102 percent of the median VMT value.

This classification was based on an analysis of demand bins of all the days in 2003, for the AM peak period. The nature of the I-15 corridor, being a linear access facility with limited alternative freeway options, makes the typical weekday demand fall in the high demand classification. As shown in Table 3.1, a total of 171 days (i.e., close to 47 percent of the days operate in the same demand bin) have demands that fall within the high demand class. In Tables 3.1 and 3.2 a major incident is defined as one that blocks more than one freeway lane and a minor incident is defined as one that blocks less than one freeway lane.

Table 3.1 Distribution of Number of Days in 2003 by Incident Type and by Demand Level

Number of Days in a Year		Incident			Total
		Major	Minor	No Incident	
Demand	High	38	5	128	171
	Medium	17	4	60	81
	Low	31	1	81	113
Total		**86**	**10**	**269**	**365**

Table 3.2 also shows that there is strong correlation between the number of days with incidents and number of days with high demand, with over 45 percent of the incidents taking place within the same demand class. The table also provides the absolute distribution of different demand-incident scenarios, and counts any day with one or more incidents. While close to 74 percent of the days are showing no incident operations during the peak period, around 10 percent of the days in the year have major incidents occur during the high demand regime.

Table 3.2 Percentage Distribution of Number of Days in 2003 by Incident Type and by Demand Level

Number of Days in a Year		Incident			Total
		Major	Minor	No Incident	
Demand	High	10.4%	1.4%	35.1%	46.8%
	Medium	4.7%	1.1%	16.4%	22.2%
	Low	8.5%	0.3%	22.2%	31.0%
Total		**23.6%**	**2.7%**	**73.7%**	**100.0%**

Tables 3.3 and 3.4 show the distribution of vehicle hours of delay in 2003 by incident type and by travel demand level during the AM peak period over the course of the baseline year. The most striking, yet not surprising, element of the data from these tables is the observation that days with low levels of demand contribute only negligible amounts to total delay.

Table 3.1 shows that low demand conditions with minor incidents occurred only one day in the year, leading to negligible amounts of delay as compared to the other conditions (i.e., high demand and major incident), as shown in Table 3.3.

Table 3.3 Distribution of Vehicle Hours of Delay in 2003 by Incident Type and by Demand Level

Delay		Incident			Total
		Major	**Minor**	**No Incident**	
Demand	High	109,304	18,276	381,466	509,046
	Medium	70,040	23,724	265,704	359,468
	Low	123	0	295	418
Total		**179,467**	**42,000**	**647,465**	**868,932**

Table 3.4 Distribution of Percentage of Delay in 2003 by Incident Type and by Demand Level

Percentage of Delay		Incident			Total
		Major	**Minor**	**No Incident**	
Demand	High	12.6%	2.1%	43.9%	58.6%
	Medium	8.1%	2.7%	30.6%	41.5%
	Low	0.0%	0.0%	0.0%	0.0%
Total		**20.7%**	**4.8%**	**74.5%**	**100.0%**

In addition to the above analysis that determines the probabilities of occurrence of different demand and incident combinations, additional analysis looked at incident frequency versus volume-to-capacity ratio (V/C) during average weekdays (Tuesdays, Wednesdays, and Thursdays) to better understand nonrecurring congestion during various times of such days.

There were a total of 432 incidents in the study corridor that occurred not just during the AM peak period, but also the PM and off-peak periods. During the off-peak, AM peak, and PM peak periods there were 268, 100, and 64 incidents, respectively, in the southbound I-15 direction. Figures 3.3 and 3.4 show the relationship between the number of incidents and their frequency to V/C ratios for both off-peak and peak-hours, respectively. When the V/C ratio is relatively low (<0.65), the incident frequency in the off-peak period is always higher than that of the peak period. When the V/C ratio is relatively high (>=0.65), the incident frequency for the off-peak period is always lower than that for the peak hour. The maximum incident frequency for the off-peak period (approximately 1.8 incidents per mile for V/C ratio 0.5 to 0.55) is higher than for the peak period (1.2 incidents per mile for V/C ratio 0.7 to 0.75).

Figures 3.5 and 3.6 show similar trends for the AM peak period. The maximum incident frequency for the AM peak period is 0.85 incident/mile for a V/C ratio range 0.65 to 0.75.

Figure 3.3 Distribution of the Number of the Incidents by V/C Ratio
(Source: Cambridge Systematics, Inc., September 2010)

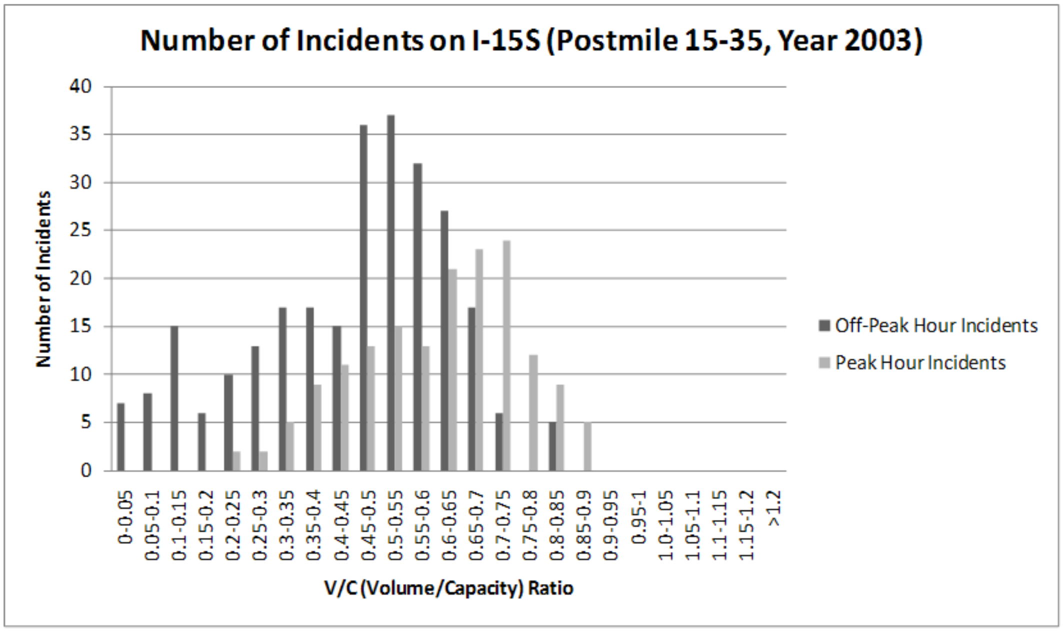


Figure 3.4 Distribution of Incident Frequency by V/C Ratio (Source: Cambridge Systematics, Inc., September 2010)

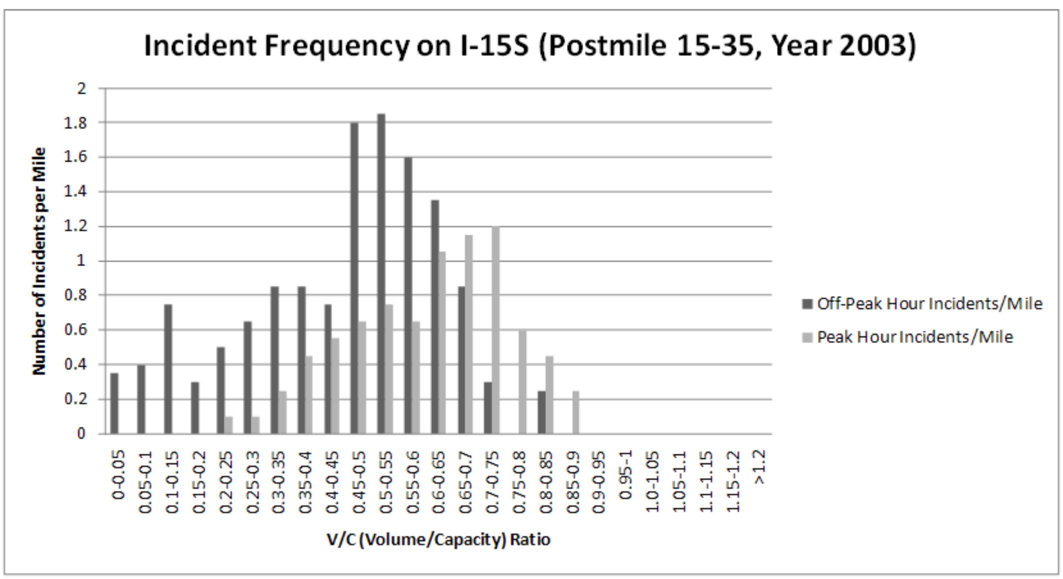


Figure 3.5 Distribution of the Number of the Incidents by V/C Ratio for the AM Peak (Source: Cambridge Systematics, Inc., September 2010)

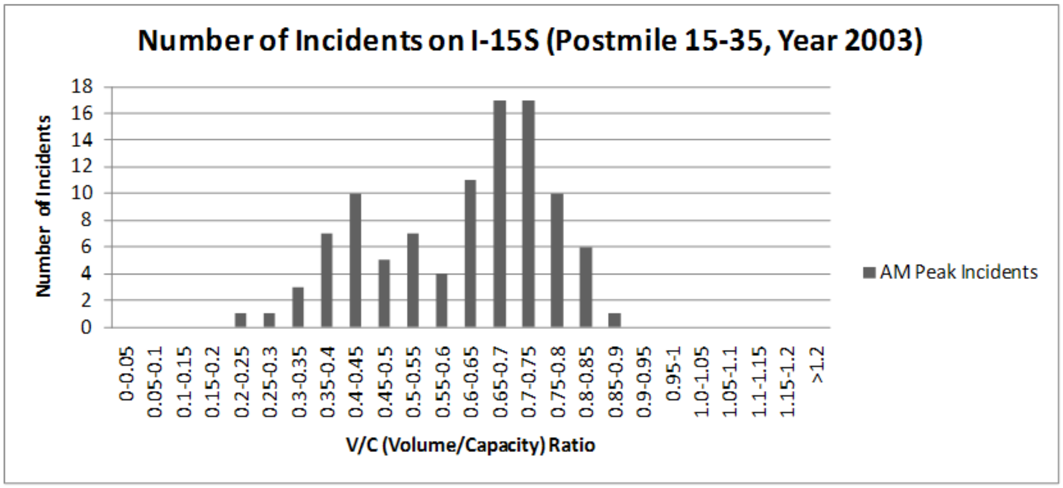
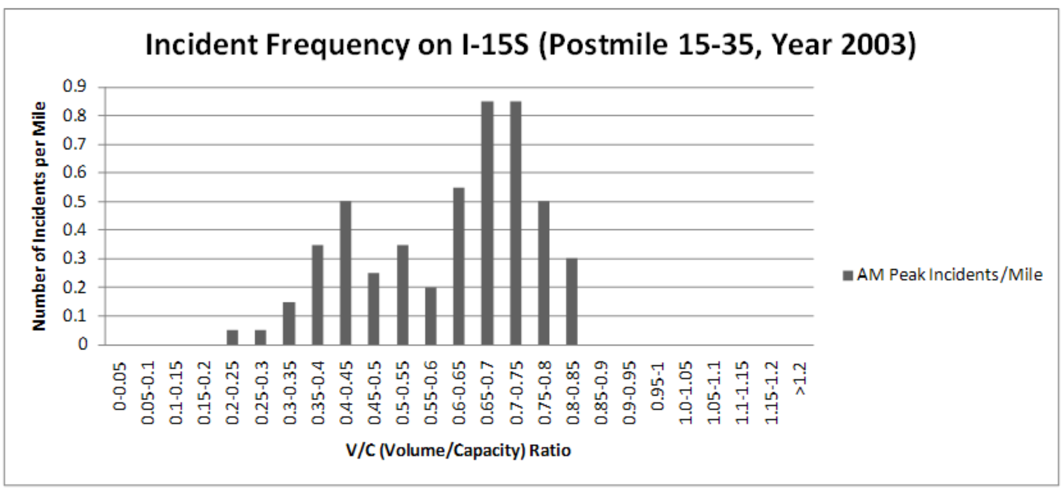


Figure 3.6 Distribution of Incident Frequency by V/C Ratio for the AM Peak (Source: Cambridge Systematics, Inc., September 2010)



The San Diego region has made significant capital investments in transit, highway, and arterial systems. SANDAG, its member agencies, and diverse stakeholders are attempting to optimize operational coordination of multiple transportation networks and cross-network connections to improve corridor mobility within the region. The I-15 Integrated Corridor Management System (ICMS) currently under development along the corridor represents one of the efforts furthest along in developing such a framework that integrates a monitoring and management system providing information to a Decision Support System (DSS) for incident response.

The ICMS will consist of two major subsystems: the existing Intermodal Transportation Management Subsystem, and the new currently under development DSS subsystem. In addition, the ICMS will include organic functions such as Collect and Process Data, Access/Store Historical Data, System

Management, and Lifecycle Support under the System Services subsystem. The DSS subsystem will provide for a new capability for integrating event management, multi-agency collaboration tools, multi-modal response plans, and impact assessment (modeling) to the existing IMTMS network.

Figure 3.7 shows the ICMS, its subsystems, and the systems to which it will be connected. These systems are listed in Table 3.5 along with the owning agency.

Figure 3.7 ICMS Context Diagram (Source: SANDAG, March 2009)

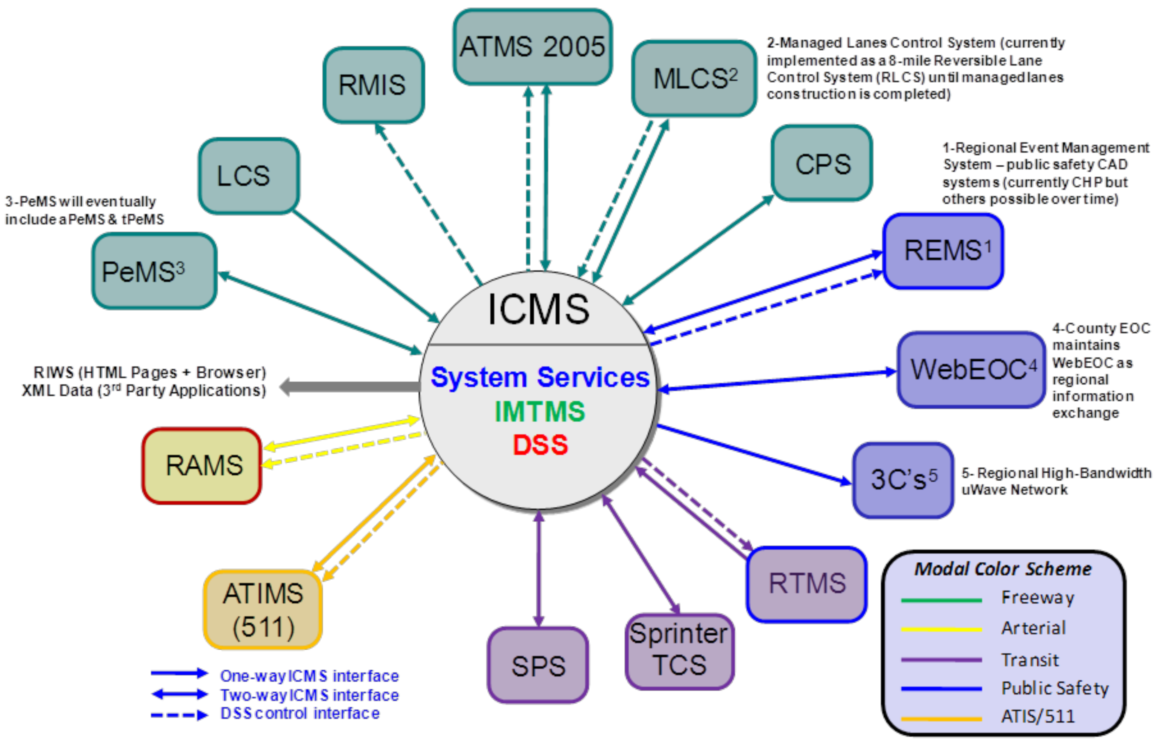


Table 3.5 ICMS Interfacing Systems and Owner Agencies

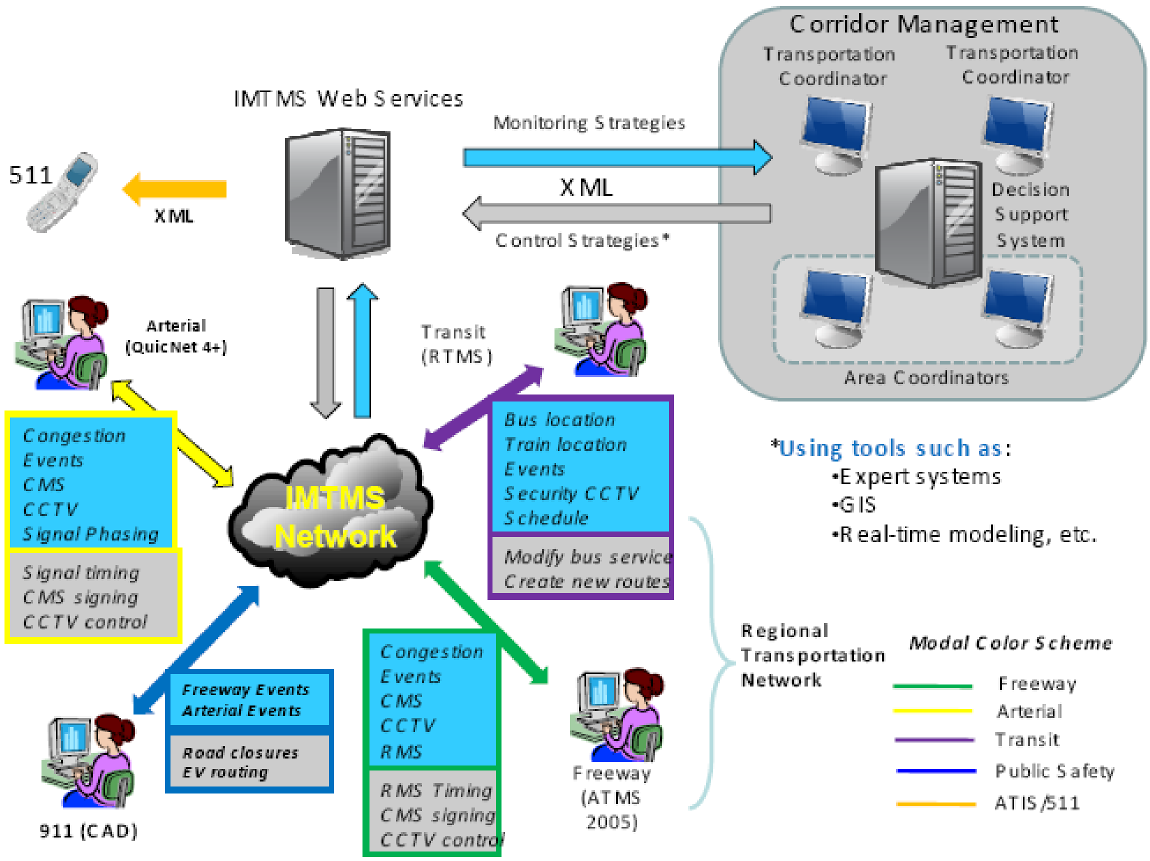
Existing or Planned System	Owning Agency
Advanced Transportation Management System (Freeway Management System)	Caltrans District 11
Reversible [Managed] Lanes Control System (R[M]LCS)	Caltrans District 11 (RLCS becomes Express Lanes Management System)
Ramp Meter Information System (RMIS)	Caltrans District 11
Lane Closure System (LCS)	Caltrans District 11
Regional Transit Management System (Transit Management System)	SANDAG (MTS and NCTD are system operators)
Modeling System (TransModeler)	SANDAG
Regional Arterial Management System (Arterial Management System)	SANDAG (local agencies are system operators)
Regional Event Management System (REMS)	California Highway Patrol (CHP) – in the future, other public safety agencies will be included
Multi-Agency Collaboration (3Cs – Command, Control, and Communications Network)	Regional Technology Partnership
Advanced Transportation Information Management System (ATIMS or 511)	SANDAG
Parking Management System (SPS)	SANDAG (Planned)
Congestion Pricing System (Congestion Pricing System)	SANDAG (FasTrak®)

IMTMS became operational in May 2007, and has a modular, standards-based web service architecture that helps collect information from a variety of modal management systems. The San Diego region envisions the use of these IMTMS informational inputs to create a DSS-based increased sharing of data among corridor agencies. The DSS represents a higher level of decision-making that translates into actionable control strategies, in response to different operational scenarios on the corridor. Figure 3.8 depicts the conceptual monitoring and control strategies, along with the data elements needed to support these strategies. In addition, this figure presents the IMTMS system as an informational exchange utility that interfaces with a variety of decision-making layers.

The *San Diego I-15 ICM Concept of Operations* (ConOps) report lists the following scenarios for the ICM systems that would need to be supported by the DSS:

1. Daily Operations;
2. Freeway Incident;
3. Arterial Incident;
4. Transit Incident;
5. Special Event; and
6. Disaster Response.

Figure 3.8 Sample DSS (Source: SANDAG, March 2008)



These scenarios relate to incidents in different parts of the multimodal system. The detailed information on the scenarios, timelines, and agency responsibilities can be found in the ConOps report. The interpretations of each of these scenarios for the purpose of AMS are:

- **Daily Operations –** No incident scenario for projected 2012 travel demand (future baseline) and optimized for operations using the different ICM strategies. The scenario includes a combination of ICM strategies meant to improve daily operations.
- **Freeway Incident –** One major freeway incident simulated at a central location of the general purpose lanes on I-15 corridor. A major incident will lead to closure of a number of lanes on the segment. From year 2001 to 2006, the number of major freeway incidents on the I-15 southbound section increased from 164 to 244. Major incidents have been classified as those that cause multiple lane closures. The spike in crashes is attributable to construction activity that has been consistently going on in the corridor. The frequency of these incidents was determined by using AADTs. The estimated AADT for the I-15 South corridor in 2005 was 225,657. Based on this number and the number of major incidents on the southbound corridor in 2005 (242), the Initial Crash Rate (ICR) is determined to be 2.94.

- **Arterial Incident –** One major arterial incident simulated at a central location of one of the arterials in the I-15 study area. A major incident will lead to arterial closure for the segment. The frequency of arterial incidents was determined based on data acquired from studies in Caltrans District 11. Currently, these data are available on major arterials in the study area, including Pomerado Road (North and South), Black Mountain Road, and Centre City Parkway. The ICR for Pomerado Road in Poway was 1.15 from 2005 to 2008. The directional ADT estimates for the same time period were 30,700. This information was used to estimate the frequencies of arterial crashes for 2012 future baseline using travel demand forecasts for ADTs.
- **Transit Incident –** An incident simulated on one of the key alternative modes along the I-15 corridor. A transit incident is assumed to cause significant delays along the transit route. Incident frequencies on transit routes were calculated from the detailed transit incident information available on the routes included in the study area.
- **Special Event –** A planned special event simulated by increasing trips to and from a particular zone. The number of trips being simulated will be determined by the event chosen to be represented – examples include the Miramar Air Show or San Diego Chargers games. The frequencies of such scenarios were estimated based on regionally scheduled events for the year 2008 and the same number will be assumed for 2012.
- **Disaster Response Scenario –** This scenario includes wild and urban interface fire assumed to cause shutdown of specific facilities. The Cedar Fire of October 2003 was used as a blueprint to close facilities that were affected during the fire. The regular demand is suppressed to create an evacuation scenario.

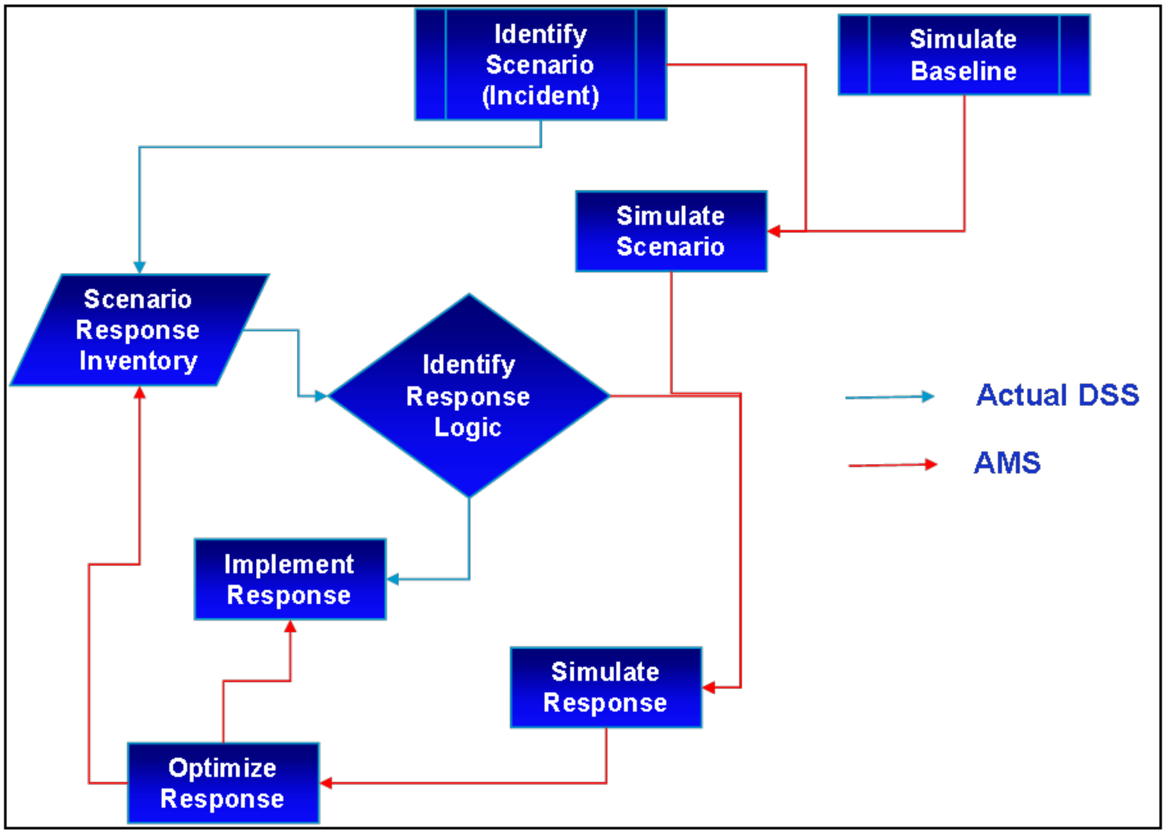
In collaboration with the I-15 stakeholders, the priority order for the different incident scenarios was defined as:

- Freeway Incident;
- Arterial Incident; and
- Special Event/Transit Incident/Disaster Response.

The development of a DSS for any of these scenarios involves the development of a decision logic that combines different response measures, which can be implemented once a particular scenario has been identified to have occurred. The decision logic would consist of the implementation of centrally-controlled measures, such as Ramp Metering, Signal Optimization, En-route Diversion Information, etc., in a certain sequence. In Stage 2, the AMS efforts focused on modeling sample decision logics that would be set in response to particular scenarios (i.e., freeway or arterial incident) in order to replicate the DSS operations within the simulation. The results of these AMS efforts helped to guide and develop responses to different scenarios. The framework developed to simulate and test the DSS would become part of an inventory or database that serves as a “playbook” that would consider all possible conditions and present an associated optimal response strategy. This initial inventory would form the base of the DSS. As the proposed ICMS, which will include the coordination of IMTMS and DSS, moves forward into implementation, the playbook will continue to evolve and develop as new scenarios and responses come into play.

Figure 3.9 shows the assimilation of the simulation process into the DSS. The knowledge-based DSS can be enhanced by including scenarios through model runs. The DSS can also be simultaneously driven by simulation as new events occur. The simulation model plays the key role of optimizing the output (response) from the DSS.

Figure 3.9 Simulation as Part of DSS Response (Source: SANDAG, September 2010)



In order to evaluate the benefits and impacts of San Diego's ICMS, each of the scenarios that are included in the AMS for evaluation was compared with a scenario without DSS. Table 3.6 lists the different model scenarios of the AMS effort. The table presents each scenario number along with the analysis settings for demand levels and incidents. As previously mentioned, the high demand refers to 102 percent of the typical demand (which is classified as median (medium) demand for purpose of this analysis), and low demand refers to 75 percent of the typical demand. This classification is different than the binning process in order to have a significant number of vehicles on the network for all levels of demand. The combination of demand levels and incidents was developed in order to provide a comprehensive evaluation of the impacts of the ICM deployment in San Diego. The next section provides an overview of the I-15 ICM strategies.

Table 3.6 Scenarios for AMS

Scenario	Year	Demand Class	Incident	ICM Operational
Baseline	2003	Typical Day	None	No
A	2012	High	None	No
B	2012	Medium	None	No
C	2012	Low	None	No
D	2012	High	Freeway	No
E	2012	Medium	Freeway	No
F	2012	Low	Freeway	No
G	2012	High	Freeway	Yes
H	2012	Medium	Freeway	Yes
I	2012	Low	Freeway	Yes
J	2012	High	Arterial	No
K	2012	Medium	Arterial	No
L	2012	Low	Arterial	No
M	2012	High	Arterial	Yes
N	2012	Medium	Arterial	Yes
O	2012	Low	Arterial	Yes

3.2 ICM Strategies

Travelers can have multiple responses to congestion and mitigation ICM strategies: route diversion, temporal diversion, mode change, changing travel destination, or canceling their trip are some of these possible traveler responses. The I-15 Corridor will have a number of ICM strategies in operation in the near future. The base year chosen for analysis is 2003, as the most relevant time when no significant construction activity was ongoing on the corridor, and for which there is a validated travel demand model. The number of projects under construction on the corridor makes it imperative that a future baseline scenario is developed for the analysis with all these design changes incorporated. This serves as the ***Future Baseline*** scenario, and the basis of comparison for all the ICM strategies being tested. The Future Baseline scenario was modeled using information on the 2012 configuration of the roadway available as of December 2008, and was utilized with projected 2012 travel demand.

The number of ICM strategies considered for the I-15 corridor has made it necessary to analyze only the AM peak period in order to stay within the time and budget constraints. An analysis of a typical peak-day demand during the AM and PM peak periods for the corridor indicated higher Vehicle Miles Traveled (VMT) in the southbound direction in AM peak period than in the northbound direction during the PM peak. The AM peak period was chosen to be the more useful modeling option, as it represents a higher traffic volume on the HOT lanes and a narrower window of time for time of departure choice, which effect could be captured effectively within the simulation model.

The following ICM strategies were initially identified as primary test strategies:

- Pre-Trip Traveler Information;
- En-Route Traveler Information;
- Freeway Ramp Metering;
- Signal Coordination on Arterials with Freeway Ramp Metering; and
- Reduced time of detection, notification, and verification of incidents.

These strategies are discussed in further detail in the ensuing sections. Their exact nature was finalized based on discussions with SANDAG and U.S. DOT; and on the availability of related information, data, and the necessary resources to complete the work. For more information on the ICM strategies please refer to the *San Diego I-15 ICM Stage 2 AMS Results* report.

Pre-Trip Traveler Information

Pre-trip traveler information includes any travel information accessible to the public that can be used in planning trip routes, estimating departure times, and/or choosing travel mode. Such information can be available through the 511 system, via the phone, the Internet, or public access television. The analysis captured the impacts of such information on traveler's route choice and/or choice of travel mode. The peak spreading methodology described in the previous chapter was used in the baseline model run for each future year analyzed – as such it had the effect of spreading trip starts (starting either earlier or later or both) depending on the amount of congestion for each O-D pair in the network. This was applied to all trips, irrespective of the amount of traveler information available to travelers. It can be considered as background information available to all travelers who modify their trip start time as congestion increases in the long term. Real-time information is then used by "informed" travelers to modify route or mode. The fraction of I-15 users who access real-time information prior to making their trip was estimated based on data sources available in the region, such as available information on utilization of features like 511 and traffic web sites in San Diego. Subsequently, this portion of the traveling population (the "informed travelers") was identified as a particular traveler class within the model. To effectively analyze this strategy, the methodology to model route and mode shift, described in Section 2.1, was utilized. This methodology utilizes the trip tables from the travel demand model, and travel times estimated by simulation models to create a feedback loop for estimation of mode and route choice. In addition to trip tables, the model also utilized historical travel time estimates on major routes as basis of initial traffic assignment.

En-Route Traveler Information

Modeling the impact of en-route information available to drivers is done to assess two major issues: 1) change in route choice, and 2) change in mode en-route.

Change in Route Choice

This relates to real-time change in route choice of drivers based on travel time or congestion updates they receive via radio, 511, or wireless-equipped Personal Digital Assistant (PDA) or GPS devices. This feature was incorporated in the analysis as a fixed percentage of drivers (30 percent in the ICM deployment year) who would be likely to have this information (e.g., sample set of PDA/GPS users or number of 511 users).

The current information available through the San Diego 511 system deals exclusively with usage statistics. San Diego 511 has been operational since February 2007. The number of requests for I-15 traffic information for 2007 and 2008 were 73,168 and 65,669, respectively. This is the extent of the 511 information available dealing with I-15. No user survey has yet been conducted. Current estimates of GPS penetration by Consumer Electronics Association (CEA) show that 20 percent of the households in the United States own portable GPS units. An additional nine percent of the households have cars with in-built GPS units. Market penetration of GPS units is expected to rise in the future. The current technology does support the real-time update of the GPS units to current road traffic conditions – a subscription service that not all GPS units have. Future efforts might make GPS unit information more active, and create some well-informed drivers that are always being updated of their route choices all the way to their destinations. Based on the information available from CEA, it was assumed that the GPS market penetration between 2008 and 2012 will rise to 30 percent of the population being able to use the traffic diversion information through in-vehicle information systems. These travelers were assumed to trust the information on the device so that the reported travel times from the device becomes their perceived travel time.

In TransModeler, 30 percent of travelers, who have the ability to access such information, were placed under a particular traveler class. At the onset of a particular incident, a macro is activated to update the route choices of travelers falling within this class. The percentage of travelers, who stays on their original route, divert their route, or change modes, was based upon the level of diversion stemming from the probabilistic route choice model within TransModeler. The amount of route diversion that occurs also varied based on the type of scenario being modeled. This traveler type was part of the multiple categories of travelers that are able to view the information on variable message signs, and base their mode choice decisions on the logit model mentioned in Section 2.0. This means that an informed traveler is able to change route or mode based on the availability of information, and the percentage that do will be based on the traffic conditions and every 'traveler's value of time (which is distributed randomly for the entire traveler population).

To facilitate the simulation of these behaviors, modeling sensors were placed along the route upstream of the message sign. As drivers approach the message sign, they pass through these sensors, which in turn call up a macro that updates these drivers' route choice decisions. When the macro is activated, new routes are assigned to the percentage of drivers that divert their routes based on the posted information. Depending on the scenario or type of incident that may have occurred, the amount of route diversion will differ throughout the simulation runtime.

Change in Mode En-Route

This is a real possibility on the I-15 corridor considering that BRT is being introduced along the corridor, and there will be direct access to "Bus Transit Hubs" from HOT lanes, as well as from General Purpose lanes. This mode shift was analyzed by evaluating a fixed number of options for a certain percentage of drivers as they approach a Transit Hub. The methodology described for changes in route choice is similar to how the model addresses drivers' reactions, as they approach a message sign near a transit hub exit. In this situation, a macro is used to update drivers' route choice decisions as they near the hub. Drivers at this point have the option of staying on their original route; diverting to a different path (i.e., choose the HOT lanes if they are on the General Purpose Lanes); or shift to a different mode (i.e., BRT). Similar to the variable message sign, depending on the parking availability at the transit hub or the traffic conditions on either the General Purpose or the HOT lanes, drivers will shift modes, and the percentage of drivers diverting will be based on a nested logit-based decision model.

Ramp Metering

The I-15 freeway currently has a number of ramps that are metered in both the northbound and southbound directions. The meters operate on a local occupancy-based algorithm working off the San Diego Ramp Metering Software (SDRMS). One of the future scenarios includes the conversion of Ramp Metering algorithm from locally adaptive to corridor coordinated. The analysis will test a corridor-coordinated ramp metering algorithm implemented under the IMTMS framework. The current ramp metering algorithms implemented in the corridor will be incorporated into the TransModeler utilizing the GIS – Development Kit (DK) framework.

Alternative ramp metering algorithms, as well as new signal timing plans, can be created and customized to fit a particular incident scenario. In TransModeler, when the incident occurs, the appropriate set of metering strategies and signal timing plans can be called up to replace the existing signal and metering operation in order to address the present traffic conditions. The ramp metering algorithm and signal timing plans used will also vary based on the signal coordination plan set to address the particular incident scenario (addressed in the next section on signal coordination).

Signal Coordination on Arterials with Freeway Ramp Metering

In addition to simulating Signal Coordination on Arterials, which involves implementing the QuicNet traffic signal control platform within the simulation model, the ramp metering algorithms will be introduced within this framework to evaluate the best possible strategy to optimize operations on both the freeway and the arterials. The Ramp Metering strategy will be coordinated with the signal timing set-up on the arterials, and the performance of both the corridor and impacted roadway network will be evaluated based on input from the QuicNet system.

HOT Lane Strategies for Improving Traffic Management

The analysis evaluated the impacts of using the managed lanes for congestion mitigation and incident response. Therefore, one of the ICM strategies analyzed involves opening the I-15 managed lanes to all traffic during major incidents. The effect of this strategy is to maximize throughput along the corridor during major incidents.

Reduced Time of Detection, Notification, and Verification of Incidents

The analysis evaluated the impacts of reducing time for detection, notification, and verification of incidents as part of the ICM deployment. Currently, incident management along the corridor is handled by Caltrans and other responders. With the proposed ICM deployment, this system will be streamlined in order to facilitate coordination between various agencies during major traffic incidents. Implementing this strategy will provide coordination between the Traffic Management Center, Caltrans, FasTrak, SANDAG, emergency responders, and law enforcement. The coordination efforts will help the agencies establish clear procedures, decision-making processes, and delegation of responsibilities when responding to incidents. Currently without the ICM strategy in place, all agencies are notified within 30 to 60 minutes of the incident occurrence. With an active ICM deployment and improved coordination among agencies, this notification period can be shortened significantly.

3.3 Analysis Settings

Table 3.7 summarizes the analysis settings for the I-15 Corridor. All analysis scenarios were compared against a Future Baseline scenario. The main difference between the Future Baseline and the different scenarios evaluated is that the future baseline model introduces the different ICM strategies in an uncoordinated approach. In contrast, the different alternative scenarios will make use of a Decision Support System to take advantage of coordination benefits between different ICM strategies.

Table 3.7 San Diego I-15 Corridor
Summary of Analysis Settings

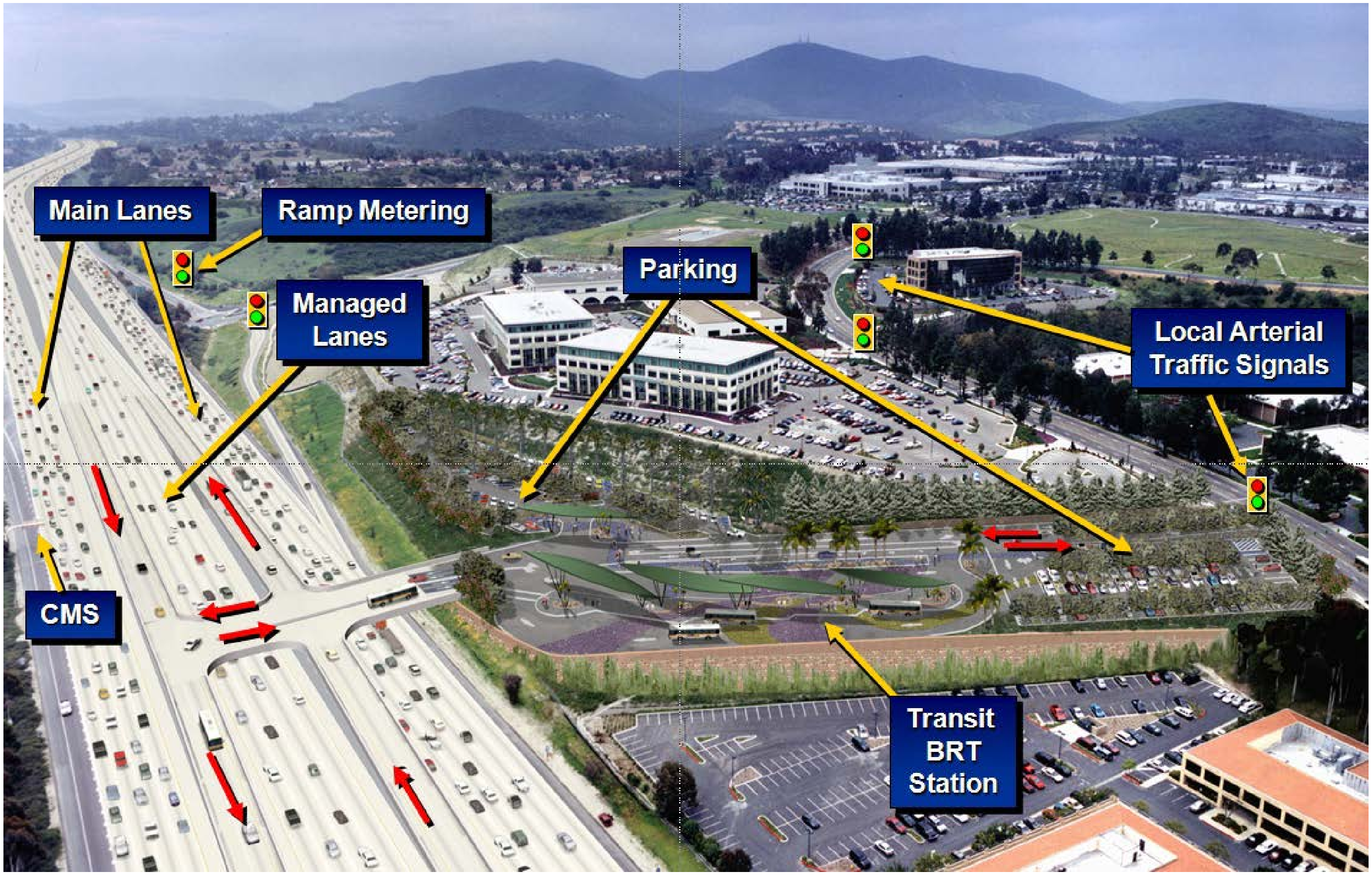
Parameter	Value	Comment
Base year	2003	The base analysis year is based on the available validated model year in the regional travel demand model.
Analysis year	2012	The analysis year is derived from the anticipated finishing of construction of system, and implementation of ICM Strategies.
Time period of Analysis	AM	The analysis of the AM peak period provides the most benefit in terms of assessing the proposed ICM strategies.
Simulation Period	3-6 hours	6 AM-9 AM is the primary analysis period. Future baseline scenarios will run for longer to calculate performance metrics.
Freeway Incident Location	I-15 SB between SR-56 and Scripps Poway Rd	Based on analysis conducted as part of V/C determination, this location experiences high number of incidents and offers the potential for route diversion.
Arterial Incident Location	Carmel Mountain Rd (east of I-15)	Based on 2012 demand projections and calculated Initial Crash Rates (ICRs) for different arterials.
Incident Duration	45 minutes	Chosen to represent a major blockage in the peak period.

The following is a summary of the response strategies for each of the analysis scenarios, as determined by SANDAG. The list shows the scenario with the corresponding strategies that were modeled depending on availability of resources. Table 3.8 lists the set of assumptions for pre-/post-ICM implementation assumptions. These model assumptions are based upon local and regional agency feedback, transportation conditions, and expected traveler behavior. Figure 3.10 shows how the I-15 ICM strategies are expected to operate in conjunction.

Table 3.8 Model Assumptions/Inputs – Stage 2 AMS

Outcome of Strategies		Summary/Notes	Without ICM	With ICM in Place
1.	**Pre-Trip and En-Route Traveler Information**			
1.1	Earlier dissemination of en-route incident and travel time information	Because of quicker notification, en-route traveler information systems will disseminate incident information earlier to travelers. The effect will be that more travelers will be able to alter routes, modes, and departure times. Incident duration stays the same with and without ICM.	10 minutes to dissemination	5 minutes to dissemination; and 30% of travelers (smart phones, 511, radio combined) with traveler information. In the baseline year of 2003, 5% of travelers were assumed to have traveler information.
1.2	Comparative travel times (mode and route)	Information dissemination (pre-trip and en-route) will include travel time comparisons for freeway, general purpose lanes, arterial, and transit. The effect will be that more travelers will choose the best options to maintain consistent trip times.	General purpose lane and mainline travel time	Travelers will make diversion choices at equal intervals of time (for the next time period). The decision choice is based on a generalized cost that feeds into a decision model. The effect will be that as conditions worsen, more travelers will take more alternative options including transit.
2.	**Improved Traffic Management**			
2.1	Freeway ramp metering and signal coordination	Incident location-based strategy to coordinate arterial traffic signals with ramp meters.	SDRMS not coordinated with arterial signals	Corridor ramp metering coordinated with arterial signals under RAMS framework.
2.2	HOT lanes	Existing today, HOT lanes are included in the modeling. Can be opened to all traffic during major incidents. Option of adding additional lane in incident direction using movable barrier.	Maintain HOT lanes during major incidents	Open HOT lanes to all traffic during major incidents to maximize throughput (I-15 managed lanes operations and traffic incident management plans).
3.	**Improved Transit Management**			
3.1	Reduced time of detection, notification, and verification of incidents	Currently, incident management is handled by Caltrans and other responders. The system will be streamlined to provide coordination of major traffic incidents between TMC/Caltrans and FasTrak CSC/SANDAG. Clear-cut procedures and understanding of decision-making process and delegation of authority/responsibility of actions will reduce response times.	All agencies notified within 30-60 mins. Incident clearance in less than 90 minutes.	All agencies notified within 5 minutes. I-15 managed lanes and traffic incident management plans provide a blue print for coordination.

Figure 3.10 ICM Strategies Working in Conjunction (Source: SANDAG, March 2009)



- Daily Operations:
  - Pre-Trip and En-Route Traveler Information;
  - Ramp-Metering and Arterial Signal Coordination;
  - BRT; and
  - Congestion Pricing for Managed Lanes.
- Freeway Incident:
  - Pre-Trip and En-Route Traveler Information;
  - Ramp-Metering and Arterial Signal Coordination;
  - BRT; and
  - Congestion Pricing for Managed Lanes
- Arterial Incident:
  - Pre-Trip and En-Route Traveler Information;
  - Ramp-Metering and Arterial Signal Coordination;
  - BRT; and
  - Congestion Pricing for Managed Lanes.

3.4 Performance Measures

This section provides an overview of the performance measures used in the evaluation of ICM strategies for the I-15 Corridor. To be able to compare different investments within a corridor, a consistent set of performance measures were applied.

The performance measures focused on the following key areas:

1. **Mobility –** Describes how well the corridor moves people and freight;
2. **Reliability –** Captures the relative predictability of the public's travel time; and
3. **Emissions and Fuel Consumption –** Captures the impact on emissions and fuel consumption.

Mobility

Mobility describes how well the corridor moves people and freight. The mobility performance measures are readily forecast. Three primary types of measures were used to quantify mobility in the I-15 Corridor, including the following:

1. **Travel time –** This is defined as the average travel time for the entire length of the corridor or segment within a study corridor by facility type (e.g., mainline, HOV, and local street) and by direction of travel. Travel times are computed for the peak period.
2. **Delay –** This is defined as the total observed travel time less the travel time under uncongested conditions, and is reported both in terms of vehicle-

hours and person-hours of delay. Delays are calculated for freeway mainline and HOV facilities, transit, and surface streets.

3. **Throughput –** Throughput is measured by comparing the total number of vehicles entering the network and reaching their destination within the simulation time period. The measure ensures that the throughput of the entire system can be utilized as a performance measure for all the scenarios. The corresponding VMT, PMT, Vehicle Hours Traveled (VHT), and Person Hours Traveled (PHT) are reported as a macroscopic measure of the general mobility of the corridor.

Reliability and Variability of Travel Time

Reliability and Variability capture the relative predictability of the public's travel time. Unlike mobility, which measures how many people are moving at what rate, the reliability/variability measures focus on how much mobility varies from day to day. For the I-15 Corridor, travel time reliability/variability was calculated using the simulation models by performing multiple model runs for all scenarios. Appendix A of the final report titled, *Integrated Corridor Management Analysis, Modeling, and Simulation for the I-15 Corridor in San Diego, California* describes the methodology used in calculating reliability and variability impacts.

Emissions and Fuel Consumption

The I-15 Corridor AMS also produced estimates of emissions and fuel consumption, associated with the deployment of ICM strategies. The IDAS methodology was used, which incorporates reference values to identify the emissions and fuel consumption rates based on variables such as facility type, vehicle mix, and travel speed. The emissions and fuel consumption rates were based on currently available sources, such as the California Air Resources Board EMFAC. Emissions and fuel consumption were computed by pollutant, mode, and facility type.

Cost Estimation

For the identified ICM strategies, planning-level cost estimates were prepared with inclusions for life-cycle costs (capital, operating, and maintenance costs). Costs were expressed in terms of the net present value of various components and are defined as follows:

- **Capital Costs –** Include up-front costs necessary to procure and install ITS equipment. These costs are shown as a total (one-time) expenditure that includes the capital equipment costs as well as the soft costs required for design and installation of the equipment.
- **Operations and Maintenance (O&M) Costs –** Include those continuing costs necessary to operate and maintain the deployed equipment, including labor costs. While these costs do contain provisions for upkeep and replacement of minor components of the system, they do not contain provisions for wholesale replacement of the equipment when it reaches the end of its useful life. These O&M costs are presented as annual estimates.
- **Annualized Costs –** Represent the average annual expenditure that would be expected in order to deploy, operate, and maintain the ICM improvement, and replace (or redeploy) the equipment as they reach the end of their useful life.

Within this cost figure, the capital cost of the equipment is amortized over the anticipated life of each individual piece of equipment. This annualized figure is added with the reoccurring annual O&M cost to produce the annualized cost figure. This figure is particularly useful in estimating the long-term budgetary impacts of Pioneer Corridor ICM deployments.

The complexity of these deployments warrants that these cost figures be further segmented to ensure their usefulness. Within each of the capital, O&M, and annualized cost estimates, the costs are further disaggregated to show the infrastructure and incremental costs. These are defined as follows:

- **Infrastructure Costs –** Include the basic “backbone” infrastructure equipment necessary to enable the system. For example, in order to deploy a camera (CCTV) surveillance system, certain infrastructure equipment must first be deployed at the traffic management center to support the roadside ITS elements. This may include costs, such as computer hardware/software, video monitors, and the labor to operate the system. Once this equipment is in place, however, multiple roadside elements may be integrated and linked to this backbone infrastructure without experiencing significant incremental costs (i.e., the equipment does not need to be redeployed every time a new camera is added to the system). These infrastructure costs typically include equipment and resources installed at the traffic management center, but may include some shared roadside elements as well.
- **Incremental Costs –** Include the costs necessary to add one additional roadside element to the deployment. For example, the incremental costs for the camera surveillance example include the costs of purchasing and installing one additional camera. Other deployments may include incremental costs for multiple units. For instance, an emergency vehicle signal priority system would include incremental unit costs for each additional intersection and for each additional emergency vehicle that would be equipped as part of the deployment.

Structuring the cost data in this framework provides the ability to readily scale the cost estimates to the size of potential deployments. Infrastructure costs would be incurred for any new technology deployment. Incremental costs would be multiplied with the appropriate unit (e.g., number of intersections equipped, number of ramps equipped, number of variable message sign locations, etc.), and added to the infrastructure costs to determine the total estimated cost of the deployment.

The costs were estimated for each scenario and a benefit-cost ratio was assigned to all the individual performance measures. The annualized benefits for each of the measures mentioned above were calculated using incident frequencies from the freeways and any arterial and transit incident information available.

3.5 Model Calibration

Accurate calibration is a necessary step for proper simulation modeling. Before modeling ICM strategies, model calibration ensures that base scenarios represent reality, creating confidence in the scenario comparison. Each simulation software program has a set of user-adjustable parameters that enable the practitioner to calibrate the software to better match specific local conditions. The calibration process accounts for the adjustment of the calibration parameters included in the software for this specific purpose. Therefore, model calibration involves the selection of a few parameters for calibration and the repeated operation of the model to identify the best values for those parameters. Calibration improves the ability of the model to accurately reproduce local traffic conditions. The key issues in calibration are:

- Identification of necessary model calibration targets;
- Selection of the appropriate calibration parameter values to best match locally measured street, highway, freeway, and intersection capacities;
- Selection of the calibration parameter values that best reproduce current route choice patterns; and
- Calibration of the overall model against overall system performance measures, such as travel time, delay, and queues.

Calibration Approach

Available data on bottleneck locations, traffic flows, and travel times were used for calibrating the simulation model for the analysis. The I-15 Corridor calibration strategy was based on the three-step strategy recommended in the FHWA Guidelines for Applying Traffic Microsimulation Modeling Software:[4]

1. **Capacity calibration –** An initial calibration is performed to identify the values for the capacity adjustment parameters that cause the model to best reproduce observed traffic capacities in the field. A global calibration is first performed, followed by link-specific fine-tuning. The capacity calibration for the I-15 Corridor is performed utilizing volume data collected from the PeMS database for the year 2003 between the periods of September to November.
2. **Route choice calibration –** Because the Pioneer Corridor includes parallel arterial streets, route choice calibration plays a significant role in the overall calibration effort. After capacity calibration, this second calibration process is performed with the route choice parameters. A global calibration is first performed, followed by link-specific fine-tuning.
3. **System performance calibration –** Finally, the overall model estimates of system performance (travel times and queues) is compared to the field measurements for travel times and queues. Fine-tuning adjustments are made to enable the model to better match the field measurements.

Model Calibration Criteria

The calibration criteria presented in Table 3.9 were applied in all ICM AMS.

[4] Dowling, R., A. Skabardonis, and V. Alexiadis, *Traffic Analysis Toolbox Volume III: Guidelines for Applying Traffic Microsimulation Modeling Software*, FHWA-HRT-04-040, Federal Highway Administration, July 2004.

Table 3.9 Model Calibration Criteria

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

Model Calibration Data Requirements

The model calibration methodology requires a diversified set of data, including the following:

- Traffic flows at individual links, as well as on screen-lines across the arterial, freeway and transit components of the ICM Corridor;
- Travel times along critical segments of the ICM Corridor freeway and arterial components;
- O-D surveys, if available, identifying travel patterns along the freeway and arterial components of the ICM Corridor; and
- Any available bottleneck observations along critical segments of the ICM Corridor freeway and arterial components.

In addition to this information, for the I-15 Corridor in San Diego, the following data requirements were identified for model calibration purposes, as well as for building and verifying future base line and alternative models:

- PeMS data for base year 2003;
- Traffic studies within the defined study area for year 2003 (counts and travel times);
- Truck percentages on corridor;
- Arterial signal timings and ramp metering algorithms;
- Signal optimization with QuicNet Framework – Logic and Synchro Files; and
- Queuing/bottleneck graphs included in ConOps for year 2003.

Model Calibration Results

Details of the Model Calibration Results are available in a separate report titled *Integrated Corridor Management Analysis, Modeling, and Simulation for the I-15 Corridor in San Diego, California.* A summary of the results can also be found in Appendix A of this document.

Analysis Results

The results for the I-15 corridor Stage 2 AMS are presented in the final report titled *Integrated Corridor Management Analysis, Modeling, and Simulation for the I-15 Corridor in San Diego, California*. Results are presented for different operational conditions, ICM strategies, and performance measures employed in the analysis, including:

- ***Twelve operational conditions***, represented by combinations of high/medium/low demand with future baseline/freeway incident/arterial incident.
- ***ICM strategy alternatives***, including pre-ICM and post-ICM, pretrip and en-route traveler information, ramp metering, congestion pricing for managed lanes, arterial traffic signal coordination, en-route mode shift, and combinations of these strategies.
- The analysis produced ***performance measures*** for all operational conditions and for all ICM strategies tested. Performance measures include mobility, reliability, fuel consumption, and emissions reported across different transportation modes, facility types, and jurisdictions.

The summary tables for these results are included as Appendix B of this document for ease of reference.

ICM Benefits and Costs

ICM benefits were calculated using the AMS performance measures results associated with the baseline and each of the ICM alternatives for the AM peak period by determining the differences in performance measures between the alternative and baseline. This represents one-half of the daily benefit/disbenefit resulting from the deployment of a particular ICM strategy. The monetized benefits are combinations of four performance measures, including travel time, travel time reliability, fuel consumption, and emissions.

The analysis then assumed that ICM implementation during the AM peak period produces approximately the same impact as the PM peak period. AM and PM peak-period impacts were added to produce daily impacts or benefits. Daily benefits were converted into annual benefits by multiplying times 260 workdays.

Benefits were monetized by multiplying:

- Hours of delay saved times $24 per hour (an average value of time for the test corridor area).
- Hours of travel time reliability saved times $24 per hour. This is a conservative value of reliability – typically travel time reliability is valued at 2.5 to 3 times the average value of travel time.

- Gallons of fuel saved at $4.00 per gallon.
- Emissions saved at the emission cost per mile per speed category.

Overall, deployment of ICM on the I-15 Corridor was estimated to produce a 10-year benefit of approximately $116 million.

The initial capital cost for the ICM deployments on the I-15 corridor is estimated at $7.55 million, with an additional $0.53 million per annum in operating and maintenance costs. Assuming a 10-year life cycle for all components, the total annualized cost for all ICM deployments for the I-15 corridor is $1.42 million, which translates to $12.0 million in total life-cycle costs.

4.0 Stage 3A AMS

This chapter describes the Stage 3 Pre-Deployment AMS activities in support of pre- and post-deployment of the proposed ICM system for the I-15 corridor. The previous chapter in this document described the Stage 2 AMS efforts that were used to guide the development of the site's proposed ICM system. During the first phase of Stage 3 AMS (Stage 3A), the tools and methodologies developed in Stage 2 were revisited and further evaluated in order to improve the capability of the site-specific tools to represent and evaluate the ICM system prior to deployment. In the second phase of Stage 3, the tools and methodologies that result from the pre-deployment analysis will be used to support post-deployment evaluation of the site's ICM system.

The key objectives of Stage 3A AMS include the following:

- Identify and facilitate further enhancements to tools, data, and methods developed from the Stage 2 AMS activities;
- Ensure that the future scenario models developed in Stage 2 accurately reflect expected demands and traffic conditions along the corridor prior to deployment;
- Conduct modeling analysis of enhanced tools in order to assess the impacts of the ICM strategies proposed for the corridor;
- Provide guidance for the site's future ICM deployment and support for the integration of the AMS tools and methods developed with their ongoing corridor management practices;
- Support Demonstration Site-specific evaluation efforts;
- Manage the successful transition of modeling leadership responsibilities from the AMS contractor to the ICM Demonstration Site staff and organizations; and
- Provide technical documentation of ICM AMS tool development, data collection and analysis, model calibration and validation methods, and analytical methods deployed to both represent and evaluate ICM impacts.

To achieve these objectives, Stage 3A includes the following tasks in order to evaluate the impacts and readiness of the proposed ICM system. Subsequent sections of the document provide further detail on each of the following Stage 3A AMS tasks:

- Enhance tools to reflect with ICM and without ICM corridor management;
- Perform pre-deployment baseline calibration and validation;
- Conduct pre-deployment alternatives analysis; and
- Preparation of the pre-deployment AMS assessment report and briefing.

Three main hypotheses were investigated in this Stage 3A AMS work, including:

1. Assessing the validity of the future base year 2013 flow rates;
2. Testing the ability of TransModeler to faithfully model the ALINEA ramp metering algorithm and its effects; and
3. Assessing the ability of the model to discern between coordinated and uncoordinated diversion timings.

4.1 Enhanced Tools to Reflect Corridor Management With ICM and Without ICM

This section describes the task items related to coordination and support of the alteration of analysis tool inputs, analytical methodology, and enhancements to analytical software to reflect pre-deployment and post-deployment corridor management technologies and strategies. The Cambridge Systematics team coordinated with SANDAG to confirm, refine, and validate the parameters/assumptions that served as the basis for the control strategies, currently present in the models produced from the Stage 2 AMS efforts. Table 3.8 details the model parameters used in both the "with ICM" and "without ICM" models. These parameters establish the expected driver behavior and incident detection, response, and clearance times "with" and "without" ICM. SANDAG and local stakeholders reviewed the model parameter assumptions to ensure that they sufficiently capture travel characteristics for the corridor and system response times according to the capabilities of their transportation management systems.

Traveler Information Parameters

Model Parameter Setting for Latency for the Dissemination of Traveler Information

After discussions with the site representatives and local stakeholders, latency for the dissemination of traveler information was determined to be set at 5 minutes for agency notification and 5 minutes for dissemination of traveler information afterwards. The total time for dissemination of the information from the time of the incident would be set at a maximum of 10 minutes. No sensitivity analysis was therefore deemed necessary for changing or adjusting existing model parameter assumptions related to the dissemination of traveler information.

Traveler Information Sensitivity Analysis – Volpe Center Survey Support

Sensitivity analysis using traveler information parameters was conducted in order to support the Volpe Center in developing their travel surveys to be used in the evaluation effort. This task evaluated the sensitivity of motorists to traveler information and the frequency by which such information is disseminated en-route. Results from the sensitivity analysis were used to support the development and administration of travel surveys for the evaluation effort. The sensitivity analysis results guided the survey developers to target their surveys to specific facility types, locations, and/or driver groups along the I-15 corridor.

Time to Initiate Flush and/or Responsive Signal Timing Plans

One of the proposed ICM strategies is a responsive signal operations plan for certain major arterials within the corridor. More details about the proposed signal operations can be found later in this chapter. In order to accurately model the impacts of ICM on these responsive signals, certain model parameters had to be confirmed. One of these parameters is the time to initiate the responsive signal timing plan after an incident or a special event occurs during high travel demand.

According to the site representatives and local stakeholders, the time to initiate can feasibly be between 5 to 15 minutes. However, the operational impact of a 5-minute activation time versus 15 minutes is unknown. A sensitivity analysis can therefore provide further insight into the impacts of the various potential signal plan activation times. The 2012 incident models were used to run the sensitivity analysis and test how the proposed signal operations respond to incident conditions. The responsive signal operations planned for the region was incorporated into the model by revising signal timing plan operations for the arterials included in the program. The sensitivity analysis evaluated the impacts of varying the time to initiate the responsive signal plan (within the range of 5 and 10 minutes). The results of the sensitivity analysis helped determine an optimal time by which the responsive signal should be activated after an incident occurs.

I-15 Model Extensions: Kearny Villa Road and SR 163

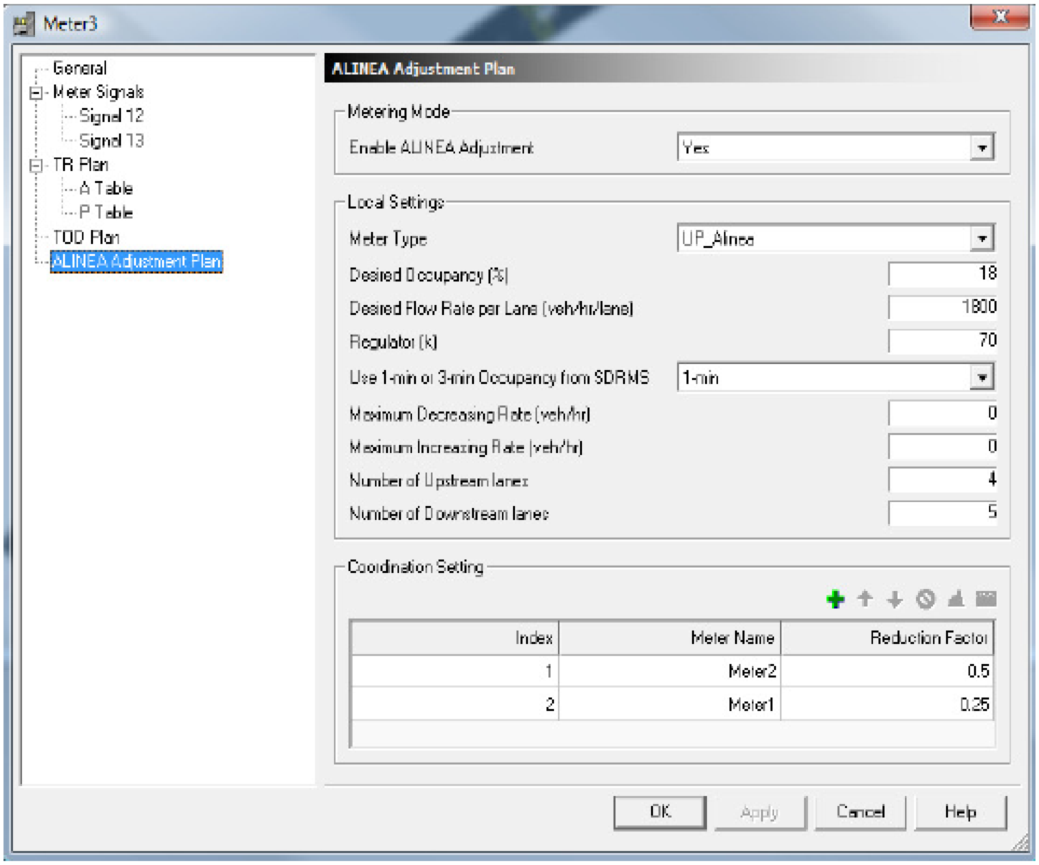
Through the recommendation of SANDAG and local stakeholders, the I-15 model network was modified towards the southern section of the corridor to include an additional parallel route option along Kearny Villa Road. The network modifications included the extension of Kearny Villa Road from Mira Mesa Boulevard to its junction with SR-163. Additionally, the I-15 freeway mainlines and managed lanes were extended to include the junction of SR-163 with I-15. The network modifications were applied to all future year model scenarios.

Improved Ramp Meter Algorithm

The San Diego Ramp Metering System (SDRMS) is the ramp metering operations platform currently in use along the Corridor and the rest of the San Diego region. However, a new corridor-wide ramp metering system was developed to be implemented with the future ICM deployment. The new corridor-wide ramp metering system was developed and tested by Caltrans and the University of California, San Diego. After evaluating several ramp metering algorithm options for the Corridor, the Caltrans and UC San Diego team determined that a modified version of ALINEA is the preferred algorithm for the new corridor-wide ramp metering system. This modified version features a feed-backward occupancy-based controller over (any) two consecutive ramps. In this system, the occupancy measured at the downstream zone (at the ramp located in the downstream direction) is used to calculate the allowable on-ramp rate for the upstream detector.

Using the research and documentation developed by the Caltrans and UC San Diego research team, the CS team developed and tested a TransModeler compatible plug-in. Figure 4.1 presents a screenshot of the plug-in. The corridor-wide ramp metering was used to evaluate the impacts of the proposed ramp metering algorithm and will be active in subsequent alternative analysis scenarios.

Figure 4.1 Plug-in for ALINEA Corridor-wide Ramp Metering System (Source: SANDAG, December 2011)



4.2 Pre-Deployment Baseline Calibration and Validation

This section provides the methodology and results of the Pre-Deployment AMS Calibration and Validation for the I-15 Corridor, which will be referred to as the Reasonableness Assessment throughout this document. Because a full calibration effort of the 2003 Baseline Model was previously conducted during Stage 2 AMS and due to resource constraints the expectation in this task was that no full model calibration effort would take place. Work in this task included model reviews, assessment of the need to recalibrate the model, modifications to model inputs, a limited number of model runs to produce calibration statistics, and production of the model calibration report. Specifically, the objective of the Reasonableness Assessment is to review the Future Year Baseline simulation model, assess the need to recalibrate, and modify the model inputs accordingly in order to ensure that the model sufficiently replicates and simulates observed travel conditions on the field during the pre-deployment stage of ICM. This section provides information regarding the Reasonableness Assessment methodology, data inputs, and results.

Purpose of the Reasonableness Assessment

The Stage 2 AMS model calibration efforts, detailed in the *Integrated Corridor Management: Analysis, Modeling, and Simulation for the I-15 Corridor in San Diego, California Final Report*, were conducted for year 2003, prior to the start of construction activities along the I-15 Corridor. All future models for year 2012 were created using the 2003 calibrated model as a base. During the Stage 2 AMS effort, the 2003 baseline model calibration effort was deemed comprehensive and sufficient. Therefore it was determined that the Stage 3 AMS efforts will not include any full recalibration of the 2003 baseline model. However, in order to ensure that the future year models adequately represent observed travel conditions along the I-15 corridor, a Reasonableness Assessment was conducted. This assessment serves to verify and ensure that the future year baseline or daily operations model is consistent with current travel conditions along the corridor in the years 2010-2011. This helped validate the capability of the model to accurately represent traffic conditions and congestion patterns by opening day of the proposed ICM deployment in 2013.

The Reasonableness Assessment Methodology

The Reasonableness Assessment Methodology involved the comparison of the I-15 Future Baseline Model volumes and speeds (including bottleneck locations) with field observed data. In order to perform this assessment, the methodology included four steps, as detailed in the following sections.

Step 1: Data Collection

The first step in the Reasonableness Assessment was to obtain the necessary data inputs. The data inputs for this assessment included field observed volumes and speeds along the freeway mainline and ramps of the I-15 Corridor. The data collection effort also established the time frame for when such data should be collected or observed. For consistency, this assessment mirrored the data collection methodology featured in the ICM Stage 2 Analysis Plan, *Integrated Corridor Management: Analysis, Modeling, and Simulation for the I-15 Corridor in San Diego, California.* In the Stage 2 AMS, one of the main sources used for freeway data was Caltrans' PeMS database. The PeMS database includes collected and archived data for loop detectors across the State of California's major highways and freeways.

During Stage 2 AMS, 2003 PeMS data were extracted for use in the 2003 Baseline Model calibration. This process included obtaining volume and speed data for all mainline and ramp PeMS detectors along the I-15 Corridor. In order to capture traffic conditions on "typical days," only data from Tuesdays, Wednesdays, and Thursdays in the months of September and October of 2003 were used. Data collected from these "typical" weekdays in September and October were then aggregated into hourly increments for the AM Peak Period (5:00 – 11:00 AM). In order to keep the Reasonableness Assessment methodology consistent with the data collection effort established for the 2003 Baseline Model, hourly PeMS data (volume and speed information) were extracted for the same weekday types and months for year 2011. Where year 2011 data were unavailable, data from year 2010 were used.

Step 2: Reasonableness Assessment Criteria

The Reasonableness Assessment methodology employed similar elements of the model calibration criteria detailed in the *FHWA Guidelines for Applying Traffic Microsimulation Modeling Software*. The Reasonableness Assessment included two types of data comparisons:

- **Volume Comparison –** The first part of the assessment determined whether the 2012 baseline model reasonably replicates year 2010 or 2011 PeMS volume data. The criteria for comparing hourly flows between model and observed values are summarized on Table 4.1.
- **Travel Speeds and Bottlenecks –** The reasonableness of the future model's speeds were based on a visual audit comparing speed contour diagrams from PeMS data with model speed data. Speed contour diagrams depict typical weekday speeds along the I-15 Corridor during the AM peak period between the hours of 6:00 AM and 9:00 AM.

Table 4.1 Reasonableness Assessment Criteria and Acceptance Targets

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

To fulfill the visual audit criteria in a typical full-scale calibration effort, the model output would be compared against the PeMS speed contours to assess whether the model output sufficiently replicates the temporal and geographical extents of bottlenecks along the corridor. Because of the on-going construction along the I-15 corridor this comparison would be difficult to conduct when comparing the 2012 model output against current field conditions While the future baseline model represents the I-15 road geometry on opening day of ICM when all construction will have been completed, the road geometry on the field, at the time of this assessment, is representative of the corridor it its current construction stages. Because of the differences in road geometry, it is not possible for the model to provide an accurate representation of the current freeway bottleneck spatial and temporal extents along I-15. For this reason, the visual audit criteria needed to be revised for the Reasonableness Assessment. Speed contour diagrams were still used to show that bottlenecks are occurring in the same geographical location as on the field and that link speed-flow relationships, as well as queuing patterns appear reasonable in the model.

Step 3: Model vs. Observed Data Initial Comparison

The third step of the Reasonableness Assessment involved comparing the Future Baseline Model outputs/performance measures against field volume and bottleneck data along the I-15 Corridor. The criteria established in Step 2 were then utilized to determine whether the Future Baseline Model results adequately replicate the field data. The initial comparison between the Stage 2 future baseline model volumes and PeMS counts showed that the forecasts underestimated future demands by about 15 percent. Additionally, speed and bottleneck comparisons also showed that the Future Baseline model was not replicating the bottlenecks as shown by PeMS data. Therefore, additional adjustments to the network and travel demand were deemed necessary. These adjustments are detailed in Step 4.

Step 4: Travel Demand and Network Adjustments

Based on the results of the initial comparison conducted in Step 3, additional work was needed in order to adjust the travel demand forecast for 2012. Additionally, this effort served to identify any necessary model network geometries and traffic control differences that may have impacts on the results of the Reasonableness Assessment.

The 2012 forecasts used for the future baseline model were developed in 2008 at the beginning of the national economic downturn. The future forecasts were then adjusted to account for the expected impacts that the economy may have on travel demand growth along the corridor. These future forecasts, however, underestimated the travel growth along the corridor by a difference of about 15 percent. Therefore, it was determined that the forecasted demands needed to be adjusted in order to better reflect more recent demand patterns as shown by PeMS data.

The first step in adjusting the forecasted demands was to identify the model links with the greatest volume differences against observed volumes. After these links were identified, the next step was to determine how much to adjust the volumes by and where these changes needed to be applied. In order to determine how these adjustments were to take place, three considerations were taken into account:

- **Identify locations with great volume differences** – One consideration was to determine whether volume differences of 15 percent or greater were occurring across the entire span or within specific localized areas along the corridor. The comparison results showed that these differences were concentrated along specific segments of the corridor. Therefore, adjustments were concentrated to these particular areas.
- **Identify any erroneous or inconsistent PeMS data** – Another consideration was to identify any PeMS link detector data that showed inconsistent or erroneous flow calculations. An example of PeMS data inconsistencies is shown on Figure 4.2. The figure shows PeMS detector counts in the southbound direction during the AM peak period along the freeway mainline and ramps at three interchanges of I-15. In this example, the PeMS detector count issue occurs at Center City Parkway (highlighted in red). The flow on the mainline at Center City Parkway should equal about 20,000 vehicle-trips based on the upstream flows from the mainline and on-ramp detector counts at the Citracado Parkway Interchange. However, as shown on the figure, the mainline count at Center City Parkway totals about 24,000 vehicle-trips. This equates to a 4,000 vehicle-trip difference that is unaccounted for. Additionally, if there were 24,000 vehicle-trips at Center City Parkway and an additional 3,600 vehicles trips entered the freeway from the Center City Parkway on-ramp to I-15 SB, the total number of vehicle-trips along the I-15 southbound mainlines by Via Rancho Parkway should be closer to about 27,000 vehicle-trips. However, according to PeMS, the mainline count at Via Rancho Parkway is 18,000 vehicle-trips. Therefore the detector data from Citracado Parkway must be producing inconsistent flow observations and were therefore eliminated from the count

comparison. Additional PeMS detector counts where similar issues occurred were also eliminated from the link count comparison.

Figure 4.2 PeMS Data Inconsistency Example (Source: Cambridge Systematics, Inc., December 2011)

	6 - 7 AM		7-8 AM		8-9AM	
	PeMS	Model	PeMS	Model	PeMS	Model
I15SB OFF	100	25	210	126	227	144
I15 ML	6103	4772	5985	5528	6366	5379
I15 SB ON	332	523	748	487	450	395

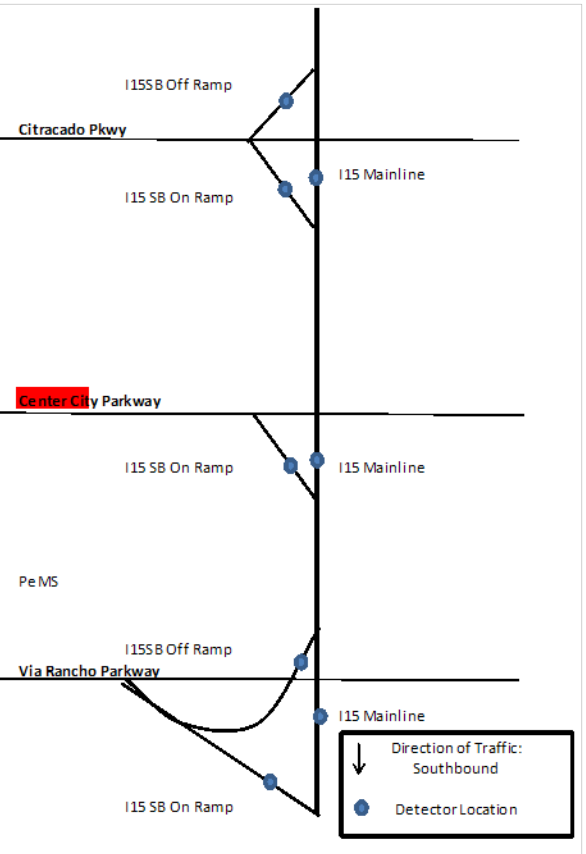
Citracado Pkwy

	6 - 7 AM		7-8 AM		8-9AM	
	PeMS	Model	PeMS	Model	PeMS	Model
I15 ML	8296	5301	8528	6003	7831	5771
I15SB OFF	1053	1451	1401	1092	1158	879

Center City Parkway

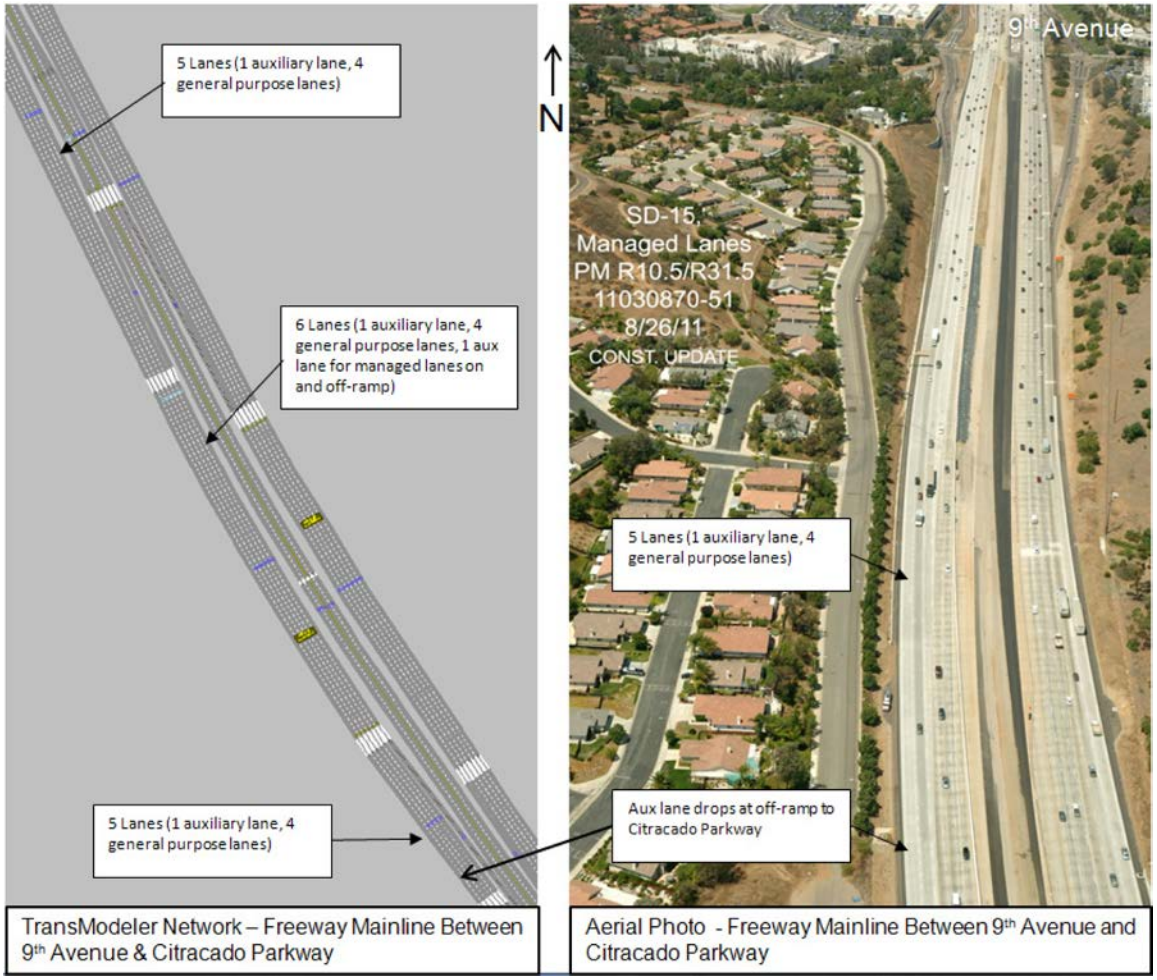
	6 - 7 AM		7-8 AM		8-9AM	
	PeMS	Model	PeMS	Model	PeMS	Model
I15SB OFF	207	203	416	238	327	254
I15 ML	6095	6530	6480	6858	5944	6402
I15 SB ON	1436	1559	1584	1571	1400	1558

Via Rancho Parkway



- **Identify network/geometry differences between the model and on the field** – As discussed in the previous step, freeway bottleneck temporal and geographical extents on the field may appear differently from the model due to differences in road geometries. The future baseline model represents the corridor just prior to opening day of the ICM deployment on I-15. Therefore the model network assumes that all construction projects, such as the I-15 Managed Lanes, Bus Rapid Transit stations, and other interchange reconstruction projects have been completed and are fully operational. However, during the time that the PeMS field data was collected (September 2011 or 2010) several of these projects were still under construction. The most recent aerial photographs of the corridor (taken August 2011) were therefore obtained in order to identify where these road geometry differences occur. Figure 4.3 provides an example of the geometric differences between the current field and the future baseline model.

Figure 4.3 Example of Geometric Differences between the Current Field and the Future Baseline Model (Source: SANDAG, December 2011)



Summary of Reasonableness Assessment Results

Link Count Comparisons

A total of 83 freeway mainline and ramp PeMS link counts were compared against the modeled count output from the simulation runs. Table 4.2 provides a summary comparison over all links. The results shown on Table 4.2 indicate that the Future Baseline Model adequately meets both volume reasonableness checks. Ninety-two percent of links with flows greater than 2,000 vph are within 15 percent of the observed volumes, and the sum of all model link flows is within 2 percent of the sum of observed link counts.

Table 4.2 06:00 – 09:00 Link Count Summary – Reasonableness Assessment

Reasonableness Assessment Criteria and Measures	Model versus Observed	Percentage
Within 15%, for Flow > 2,000 veh/h (for > 85% of links)	24 (26) {pass counts (total)}	92%
Within 5%, sum of all link flows	710,111 (682,453) {model flow (observed counts)}	2%

Delay, Speed and Bottleneck Comparisons

The second component of the reasonableness assessment criteria listed in Table 4.1 is the visual audit of model speeds and bottlenecks. Model versus field-observed speeds and bottlenecks can be compared using speed contour diagrams. Tables 4.3 through 4.6 compare the speed contours of the I-15 freeway generated using PeMS speed data versus model outputs. Tables 4.5 and 4.6 indicate that during the AM peak period, congestion along the corridor occurs primarily in the southbound direction. In the northbound direction, there is not much congestion to start with, and thus the investigation focused in the southbound direction.

Comparisons of the PeMS and model speed contour plots show that the model is unable to sufficiently represent the bottleneck temporal extents, as prefaced in this document. As previously mentioned, replicating the current bottlenecks shown by 2010 to 2011 PeMS data using the 2012 baseline model is not feasible due to differences in road geometry. For instance, according to the PeMS speed contour shown on Table 4.5, one of the major bottlenecks that occur along I-15 southbound during the AM peak period begins at Via Rancho Parkway and stretches upstream to Valley Parkway. In the model, this congestion is primarily concentrated near the 9th Avenue Interchange. Comparisons of aerial photographs at these interchanges with the model lane configurations showed that there are several road geometry differences between the field and the model – these differences are illustrated in Figure 4.2. The aerial photographs show that a total of five mainline lanes (four general purpose lanes and one auxiliary lane) currently exist along the southbound direction from 9th Avenue to Citracado Parkway. However, in the model, the mainline lane configuration in this same location varies between five and six lanes, as shown in Figure 4.2. The figure also shows that while the model includes access points to and from the I-15 Southbound Managed Lanes near the Citracado Parkway Interchange, these on- and off-ramps were still under construction as of August 2011. The additional mainline lanes and managed lanes access points that are incorporated into the 2012 Future Baseline Model network provide additional capacity that is currently not available on the field. For this reason, the Via Rancho Parkway to Valley Parkway bottleneck extents cannot be replicated in the model.

Comparing the southbound PeMS speed contour (Table 4.5) and the model speed contour (Table 4.6), the model is able to replicate the bottleneck locations. However, it is unable to match the temporal extent and severity of the bottlenecks on the field as shown by the PeMS data. A quick comparison of capacity vs. demand at many of these locations will show that the bottlenecks would have appeared more prominently if the model represented the 2010 to 2011 roadway geometries on the field. For instance, for the Via Rancho Parkway bottleneck shown in Figure 4.2, if the simulation model network only had the four general purpose lanes shown in the aerial photograph in Figure 4.2, the model demand in this section would closely approach the capacity at this location and a bottleneck of greater severity would have appeared in the model. Therefore, without the additional capacity provided by the managed lanes and the additional auxiliary lane, a more severe bottleneck would have appeared in this freeway section during the simulation.

Table 4.3 6:00 – 9:00 AM Northbound Observed Speed Contours (PeMS, 2010)

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
Segment Ids	37331	14409	37333	28810	37335	10859	37337	37340	37341	13640	8809	721	12957	669	28588
Time Period (a.m.)	1.2	2.4	5.4	6.6	8.1	9.3	10.3	11.4	12.3	13.1	13.9	15.2	15.8	16.4	19.1
6:00	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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 4.4 6:00 – 9:00 AM Northbound Simulation Model Speed Contours

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
Segment Ids	14410	14409	37333	28810	37335	10859	37337	37340	37341	13640	8809	721	12957	669	28588
Time Period (a.m.)	1.2	2.4	5.4	6.6	8.1	9.3	10.3	11.4	12.3	13.1	13.9	15.2	15.8	16.4	19.1
6:00-6:05	51.8	64.0	64.2	63.8	64.3	63.2	65.7	58.5	64.3	63.1	62.3	63.5	65.9	68.1	67.0
6:05-6:10	51.8	60.5	62.1	60.7	63.4	63.7	65.5	61.3	64.1	66.3	65.1	63.7	61.8	66.5	62.2
6:10-6:15	54.9	66.2	63.5	63.1	61.2	61.6	64.7	63.8	65.9	66.8	66.4	63.9	64.2	65.0	63.5
6:15-6:20	54.8	60.7	61.0	60.9	64.2	65.4	63.9	60.0	61.4	63.3	65.7	65.8	66.4	65.9	64.2
6:20-6:25	53.3	61.2	62.8	64.0	65.3	61.3	65.7	61.7	66.0	64.9	64.9	63.9	63.6	66.6	68.2
6:25-6:30	57.3	62.6	62.4	65.1	62.1	61.7	64.6	61.7	64.9	67.2	65.3	66.3	65.1	65.4	64.4
6:30-6:35	54.9	64.0	65.2	63.4	62.4	63.8	61.9	59.3	66.2	64.5	64.8	65.7	64.2	65.5	66.1
6:35-6:40	55.5	62.4	63.1	63.5	63.3	62.7	67.8	60.9	62.0	61.7	66.4	66.2	62.7	66.6	65.1
6:40-6:45	52.8	63.8	65.1	63.9	62.7	66.8	66.0	57.2	65.2	65.2	64.9	64.7	65.6	67.3	60.9
6:45-6:50	50.2	63.8	64.4	63.4	62.8	67.6	64.2	63.1	63.0	64.7	64.0	64.5	64.9	66.0	65.4
6:50-6:55	54.7	63.2	64.7	64.1	64.6	63.8	65.1	61.3	70.1	66.1	64.3	66.3	65.7	64.4	67.8
6:55-7:00	56.8	60.9	61.2	57.4	63.9	64.4	64.4	60.7	64.4	65.2	65.5	65.5	65.9	66.2	63.8
7:00-7:05	49.5	63.5	59.6	59.8	59.9	64.1	65.8	60.0	63.4	62.8	64.3	67.2	63.7	66.5	65.2
7:05-7:10	46.4	63.6	59.4	63.9	60.5	63.9	64.4	61.4	62.9	64.6	61.3	64.3	65.2	64.7	66.5
7:10-7:15	44.3	62.3	55.2	61.6	59.2	64.5	64.1	53.7	60.6	63.9	62.9	63.5	63.0	63.2	64.4
7:15-7:20	44.6	61.5	59.6	59.6	58.5	63.4	62.9	56.3	63.3	62.8	65.9	64.8	64.4	64.4	65.1
7:20-7:25	41.4	62.9	61.8	63.3	61.2	64.1	66.7	58.3	62.6	64.3	62.2	62.5	63.9	63.3	61.5
7:25-7:30	36.5	61.5	61.6	64.4	58.6	62.3	65.4	61.1	63.2	65.1	65.1	66.3	63.3	66.1	61.6
7:30-7:35	38.7	61.2	59.4	57.7	61.5	63.1	66.7	51.5	63.2	64.8	64.3	65.6	63.1	65.8	60.5
7:35-7:40	38.0	61.6	58.8	62.6	55.2	64.8	63.7	61.5	61.4	65.7	64.7	66.4	64.1	66.2	61.5
7:40-7:45	37.5	63.3	56.5	65.1	57.9	66.1	66.6	51.3	63.2	65.4	63.2	63.6	63.2	65.3	63.1
7:45-7:50	33.9	60.1	58.6	64.7	56.2	66.6	64.5	53.7	63.9	62.8	65.3	65.3	64.8	64.9	64.7
7:50-7:55	38.2	60.9	61.1	63.3	62.3	65.0	64.9	52.2	63.0	66.1	64.1	62.9	63.7	63.3	63.1
7:55-8:00	37.5	59.0	61.7	62.4	57.8	64.5	65.8	60.6	65.5	65.4	64.2	62.7	64.4	65.6	60.9
8:00-8:05	40.9	63.0	55.0	62.3	59.6	65.4	63.5	55.0	60.6	63.1	62.8	65.0	64.1	65.1	52.7
8:05-8:10	40.0	62.2	60.2	63.9	55.5	65.3	64.4	55.9	63.4	65.3	63.5	65.5	65.4	65.1	54.1
8:10-8:15	42.5	58.1	56.7	64.3	61.8	65.6	65.5	53.6	60.0	64.6	63.2	63.8	63.4	65.2	53.4
8:15-8:20	38.4	55.7	59.6	58.7	57.0	62.5	66.4	56.3	61.3	64.0	63.0	64.1	65.8	65.0	62.9
8:20-8:25	39.6	58.6	61.2	63.1	62.8	64.1	63.4	55.6	61.0	65.0	64.5	63.6	63.0	65.1	61.3
8:25-8:30	37.2	56.0	60.2	64.2	62.4	65.2	66.4	58.9	63.2	63.2	63.3	63.7	63.4	66.8	61.9
8:30-8:35	41.2	60.7	61.0	62.9	61.5	63.3	65.4	51.5	63.3	66.3	63.0	62.5	63.4	64.6	63.0
8:35-8:40	39.3	53.5	63.3	63.3	60.7	62.9	65.1	58.2	64.2	66.1	63.9	63.1	65.3	65.0	59.9
8:40-8:45	40.7	60.5	61.2	60.8	61.1	62.8	64.1	60.5	66.8	64.4	63.2	63.5	62.1	65.5	62.6
8:45-8:50	35.8	56.5	57.4	63.7	62.4	65.0	66.4	54.8	63.7	67.1	63.6	64.1	63.2	64.9	62.0
8:50-8:55	35.2	50.5	61.4	61.1	58.7	64.7	64.9	54.1	60.5	63.4	63.9	67.0	63.0	64.4	63.8
8:55-9:00	36.1	42.3	58.9	61.1	59.5	64.4	66.7	58.1	61.9	63.9	61.0	63.4	63.1	66.0	64.5

Table 4.5 6:00 – 9:00 AM Southbound Observed Speed Contours (PeMS, 2010)

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	9.8
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 4.6 6:00 – 9:00 AM Southbound Simulation Model Speed Contours

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	37556	37498	37596	14645	37338	13664	13653	13646	8810	722	562	37580	37586	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
6:00-6:05	62.9	63.2	63.6	41.4	55.0	39.5	61.1	54.6	52.9	58.9	62.8	64.2	62.4	60.9	53.2	64.9
6:05-6:10	62.7	62.9	63.9	40.1	56.9	41.6	64.0	46.5	52.8	58.7	63.3	62.3	61.8	59.7	57.8	65.2
6:10-6:15	61.9	62.5	65.4	40.2	57.6	51.4	64.1	50.1	59.2	59.1	60.4	64.2	63.1	59.4	50.3	68.4
6:15-6:20	60.8	63.2	64.4	44.3	54.2	38.0	62.7	52.9	53.3	59.0	62.0	62.0	60.7	60.3	57.0	63.9
6:20-6:25	63.2	61.6	65.6	39.6	51.7	36.6	63.4	52.1	52.5	55.8	63.1	61.0	62.5	60.1	56.4	65.7
6:25-6:30	62.0	64.8	65.9	33.1	46.5	40.1	63.2	56.1	53.0	60.5	63.0	66.2	63.1	60.9	55.4	65.2
6:30-6:35	62.7	63.2	64.3	30.5	55.1	39.7	62.2	48.1	57.2	60.4	62.2	62.4	62.7	58.5	55.5	66.9
6:35-6:40	61.9	62.5	65.1	36.8	57.2	50.9	64.3	57.2	49.9	56.5	61.8	62.9	63.4	62.2	51.5	65.8
6:40-6:45	62.6	60.8	64.6	37.5	51.4	37.0	61.7	51.7	48.4	59.2	60.3	63.0	61.7	60.1	51.5	63.4
6:45-6:50	60.9	63.8	64.4	37.3	54.1	35.3	63.5	49.0	54.8	58.2	62.3	62.1	61.8	60.0	52.4	63.5
6:50-6:55	61.7	62.3	64.0	39.0	40.1	47.0	63.2	55.4	56.9	58.0	62.8	60.5	60.9	59.3	56.0	69.4
6:55-7:00	62.7	63.0	64.8	39.6	52.6	40.1	62.9	54.1	46.9	58.1	62.5	64.2	63.0	58.8	53.7	64.5
7:00-7:05	62.8	62.2	65.0	41.7	53.3	48.7	61.8	55.7	52.2	58.8	62.3	62.1	60.8	56.8	44.0	64.6
7:05-7:10	62.0	64.1	65.9	35.7	47.2	50.3	65.3	51.5	47.0	56.4	62.7	63.3	60.9	57.8	36.8	63.1
7:10-7:15	62.5	63.2	65.7	32.0	51.2	39.8	64.3	47.2	43.7	56.5	60.0	61.1	60.7	59.8	41.2	64.5
7:15-7:20	62.5	63.4	63.8	29.5	37.6	51.9	62.2	54.8	47.7	57.9	62.6	61.6	61.2	60.0	46.5	64.8
7:20-7:25	62.5	64.4	64.3	29.2	31.9	43.0	64.1	54.7	60.6	57.5	62.7	63.3	62.4	58.3	35.2	65.1
7:25-7:30	63.3	63.5	64.8	27.2	23.0	49.6	62.4	46.1	55.2	58.7	61.2	64.9	60.9	60.1	33.5	65.3
7:30-7:35	63.7	64.2	64.6	27.0	22.4	56.9	63.1	45.7	54.9	58.4	62.5	63.4	61.8	59.6	34.8	63.3
7:35-7:40	61.3	62.4	65.0	24.8	28.2	51.4	60.7	52.5	55.8	59.7	63.6	61.4	61.3	58.7	38.5	64.8
7:40-7:45	60.8	61.5	64.9	26.0	39.0	53.7	66.9	48.9	56.0	60.6	64.0	63.8	63.4	60.2	49.0	67.1
7:45-7:50	63.9	62.9	65.0	24.6	44.3	53.6	66.9	53.5	54.1	57.2	62.1	63.7	62.7	58.0	39.7	66.4
7:50-7:55	62.6	65.2	64.6	24.3	47.7	42.1	62.7	50.7	54.2	59.0	61.0	62.3	61.4	58.8	30.9	65.3
7:55-8:00	63.2	64.8	62.9	29.2	42.3	55.9	64.3	54.8	55.3	57.7	64.1	63.8	61.3	60.1	33.8	62.8
8:00-8:05	62.3	62.3	62.4	25.3	34.8	43.7	63.9	54.1	53.0	59.0	62.2	62.2	61.2	58.3	31.6	64.5
8:05-8:10	62.8	62.9	66.7	28.4	36.5	42.4	62.4	54.9	45.2	57.7	25.1	62.4	62.3	56.3	49.8	63.3
8:10-8:15	62.3	62.4	65.4	29.0	41.1	47.4	64.8	51.1	58.3	58.4	13.6	62.5	60.4	58.2	51.7	65.8
8:15-8:20	61.9	63.2	65.2	27.0	53.4	52.9	64.4	54.2	53.7	59.6	13.6	62.9	61.8	59.3	46.4	62.8
8:20-8:25	63.2	63.8	65.4	27.5	48.4	45.7	61.1	53.2	56.1	58.0	14.8	64.2	61.2	59.9	33.2	64.5
8:25-8:30	62.6	61.3	66.2	24.7	46.5	44.7	63.2	54.5	60.7	53.9	15.9	61.6	62.1	59.7	31.8	66.7
8:30-8:35	62.7	61.8	65.5	25.5	41.2	35.2	64.5	53.1	46.2	61.3	26.2	62.7	62.6	58.5	34.1	63.1
8:35-8:40	63.5	63.1	65.9	24.2	45.3	48.4	61.8	60.6	49.9	62.5	22.6	64.5	61.4	59.2	46.6	64.4
8:40-8:45	62.1	63.3	65.1	22.3	46.2	52.5	64.9	56.2	60.2	58.9	19.2	61.8	61.9	57.7	49.3	64.3
8:45-8:50	62.2	64.4	64.8	24.3	58.5	51.5	64.1	48.9	44.3	61.4	22.6	63.9	62.6	62.3	46.6	64.2
8:50-8:55	62.5	61.5	64.3	24.8	49.6	46.2	63.9	53.9	48.9	60.1	21.0	62.3	60.0	57.3	45.3	65.4
8:55-9:00	61.6	63.8	65.4	23.5	50.6	48.3	65.7	50.7	56.7	58.1	18.6	65.0	61.4	59.6	53.1	66.0

Without revising the future year model road geometries to reflect the conditions on the field in 2010 to 2011, the model will be unable to accurately portray the current bottleneck duration and spatial extents. Achieving a more accurate representation of 2010 to 2011 bottlenecks could be made possible by building a new simulation model of the corridor for interim year 2011. However, this effort would require a significant amount of resources – and these resources are not available at this point. Furthermore, an interim year 2011 model would only serve to satisfy the Reasonableness Assessment and would remain unused for the remaining tasks of the Stage 3 AMS effort.

Overall Conclusion

Ensuring that the model accurately represents the current traffic conditions on the field is an important component of the Reasonableness Assessment. The main objective of the assessment is to ensure that the model can accurately predict and represent road geometries, demands, and operational conditions on the ground in year 2013, prior to the opening day of the proposed ICM deployment. By making the appropriate adjustments to the forecasted demands, the future baseline model is better able to represent the expected travel demand and traffic conditions in year 2013. The adjusted travel demands have also made it possible for the model to portray the 2010 to 2011 bottlenecks in the same location as shown on the field – there are differences in the temporal and spatial extents of these bottlenecks between 2010 and 2011 PeMS data and the simulation model, but these differences are due to differences in capacity and road geometry. Furthermore, traffic volume comparisons show that the enhanced future baseline model is capable of adequately representing the pre-deployment corridor operational conditions and corridor management strategies in the I-15 Corridor. Overall, work under the reasonableness assessment task advanced the capability of the San Diego I-15 Corridor model to be rapidly deployed in the Post-Deployment analysis phase.

4.3 Pre-deployment Alternatives Analysis

This section provides an overview of the AMS efforts associated with the Pre-deployment Alternatives Analysis. Chapter 3 provided an overview of the methodologies, tools, and strategies involved in developing the proposed ICM system under different scenarios that included incidents, with or without ICM, and under varying levels of travel demand. Once the models built through the Stage 2 AMS efforts have been refined using the sensitivity analysis and the Reasonableness Assessment detailed in Sections 4.1 and 4.2, the models were used for additional testing and analysis that served to assess the impacts of the proposed ICM deployment.

These potential ICM deployment-related alternatives were identified through feedback and input of the Site coordinators and local agencies. These alternatives include evaluating the impacts of enhanced or improved ICM strategies incorporated into the proposed system. The alternatives analysis served to assess the performance of various components of the ICM system under different scenarios and events. The methodologies, tools, and strategies incorporated into the Pre-deployment Alternatives Analysis are documented in this section, including information regarding the alternative scenarios identified for analysis and the methodologies and the modeling efforts associated with each alternative scenario.

Pre-Deployment AMS Alternatives Analysis Scenarios

During Stage 2 AMS several models and scenarios were developed in order to determine the optimum combination of strategies to support the site's proposed ICM system. The baseline models were modified in the Reasonableness Assessment effort (described in Chapter 4.2) to be made consistent with volumes and speeds observed in years 2010 and 2011. Travel demand was then modified to accommodate forecasted demand in year 2013, which is the estimated opening year for the ICM deployment in the corridor.

In Stage 3 AMS, alternative analysis scenarios were developed for the purpose of assessing the performance of the proposed ICM system under different conditions reflecting refinements and improvements to ICM strategies. Through the input of the site coordinators and stakeholders, three alternative scenarios were identified. Each of the three scenarios builds upon future baseline model scenarios, as referenced in Table 4.7. This table also indicates the ICM strategies active in each model alternative or scenario. A description of the three alternatives is as follows:

Table 4.7 San Diego I-15 – AMS Stage 3A Baseline and Alternatives Models

	Stage 3A Baseline AMS Alternatives (Under High Demand)		Stage 3A Alternatives (With Revised Parameters/Strategies, Under High Demand)		
ICM and other Planned Strategies	**ICM A – Daily Operations**	**ICM B – Freeway Incident**	**ICM D – Daily Operations Corridor-wide Ramp Metering**	**ICM E – Freeway Incident Responsive System**	**ICM F – Freeway Incident Suboptimal Performance**
Traveler Info *(Pre-Trip and En-route)*	☑	☑	☑	☑	☑
Transit – BRT	☑	☑	☑	☑	☑
Ramp Metering	☑	☑	☑	☑	☑
Arterial/Ramp Coord.	☑	☑	☑	☑	☑
Incident Signal Plans		☑		☑	☑
Improve Incident Response Times		☑		☑	☑
Managed Lane Open to Traffic *(Major Incidents)*		☑		☑	☑
Route Choice *(Congestion Pricing for Managed Lane and Updated Travel Time Info)*	☑	☑	☑	☑	☑

☑ Indicates which ICM strategies are evaluated by the model alternative scenario.

☐ Indicates strategies and/or parameters revised as a result of Stage 3A AMS activities.

- **ICM D (Daily Operations) with Corridor Ramp Metering –** The ICM D alternative evaluated the impacts of Caltrans District 11's proposed new corridor-optimized ramp metering system. This alternative was compared with the performance of ICM A, the 2012 Daily Operations model with the current ramp metering system, the SDRMS. The corridor ramp metering will be active for all subsequent ICM alternative scenarios.

- **ICM E (Freeway Incident) with Responsive Signal Operations –** The ICM E alternative tested the performance of the proposed responsive signal operations on parallel arterials during a major incident on the freeway. The responsive signal operations were active for both ICM E and ICM F alternatives analysis scenarios.
- **ICM F (Freeway Incident) under Suboptimal ICM Performance –** The ICM F alternative tested the suboptimal implementation of one or more of the strategies incorporated into the site's proposed ICM system. The purpose of the test was to evaluate the impacts and performance of the system under this particular scenario.

This section provides further information on the three alternative scenarios, including information on any project details and ICM strategies involved. The section also lays out the modeling and analysis efforts that were employed for each of the alternative scenarios, and presents analysis results.

ICM D – Daily Operations with Corridor Ramp Metering

The San Diego Ramp Metering System (SDRMS) is the ramp metering operations platform currently in use along the Corridor and the rest of the San Diego region. However, a new corridor-wide ramp metering system was developed to be implemented with the future ICM deployment. The ICM D alternative simulated the impacts of the new corridor ramp metering system during the daily operations of the morning peak period. The performance of ICM D was compared to the results of ICM A or the Daily Operations model with SDRMS. Inputs to the model included metering logic, metering rate plans, and ramp metering layout/configuration details.

The new corridor-wide ramp metering system was developed and tested by Caltrans and the University of California, San Diego. After evaluating several ramp metering algorithm options for the Corridor, the Caltrans and UC San Diego team determined that a modified version of ALINEA was the preferred algorithm for the new corridor-wide ramp metering system. This modified version features a feed-backward occupancy-based controller over (any) two consecutive ramps. In this system, the occupancy measured at the downstream zone (at the ramp located in the downstream direction) is used to calculate the allowable on-ramp rate for the upstream detector. Using the research and documentation developed by the Caltrans and UC San Diego research team, the CS team developed a TransModeler compatible plug-in in order to evaluate the impacts of the proposed ramp metering algorithm. The corridor-wide ramp metering will also be active in subsequent alternative scenarios, ICM E and ICM F.

Table 4.8 presents a comparison between the simulation model runs for the ICM D (new ALINEA ramp metering system) and ICM A (existing SDRMS) both for normal, non-incident operational conditions; the reported results are for a five-hour AM peak period. The new ALINEA ramp metering system demonstrates superior performance in the simulation when compared to the existing system: 1) total vehicle- and person hours traveled (VHT and PHT) improve by 5 percent; 2) 3,144 vehicle- or 4,107 person-hours are saved in the AM peak period as a result of implementing the new system; 3) total delay improves by 7 percent; and 4) 2,155 vehicle-hours of delay are saved in the AM peak period. **Overall the proposed new ramp metering scheme is shown in the simulations to be effective at reducing congestion in the I-15 corridor. Furthermore, the implementation of ALINEA in the I-15 simulation model is working as expected, which a key element of getting ready for Post-Deployment analysis.**

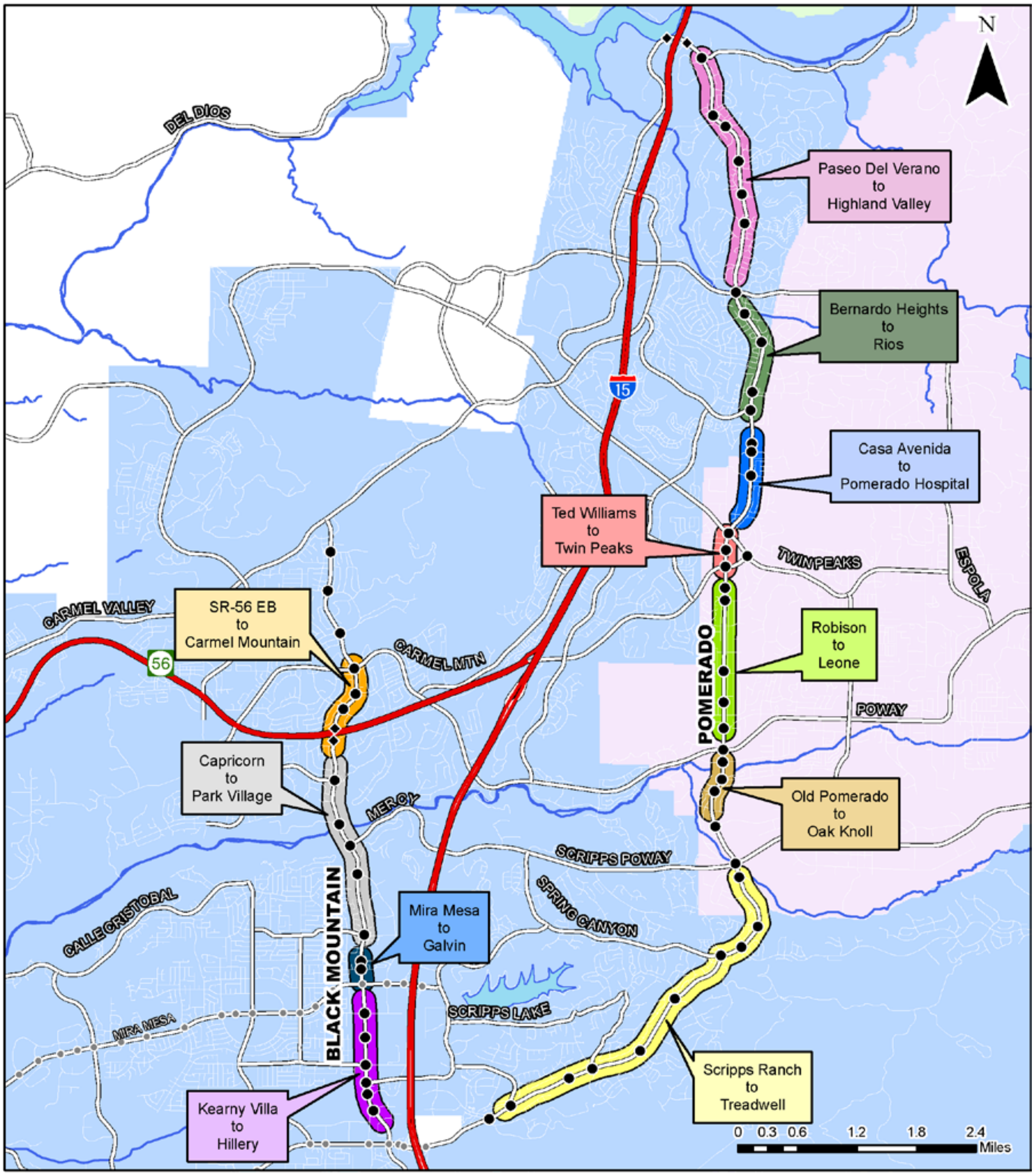
Table 4.8 Comparison between ICM D (New ALINEA Ramp Metering System) and ICM A (Existing SDRMS)

Road Type	ALINEA	SDRMS	Difference	Percentage of Difference
VMT (Vehicle-Miles)				
SB 1-15	675,232	680,012	-4,780	-1%
SB Managed Lanes	176,311	176,131	180	0%
NB 1-15	429,756	432,600	-2,843	-1%
NB Managed Lanes	152,592	152,225	367	0%
Arterials	176,696	180,716	-4,020	-2%
Total	**2,008,536**	**2,022,423**	**-13,887**	**-1%**
VHT (Vehicle-Hours)				
SB 1-15	16,845	20,524	-3,680	-18%
SB Managed Lanes	2,825	2,912	-87	-3%
NB 1-15	7,062	7,136	-74	-1%
NB Managed Lanes	2,404	2,397	7	0%
Arterials	14,575	15,043	-468	-3%
Total	**64,256**	**67,400**	**-3,144**	**-5%**
Delay (Hours)				
SB 1-15	3,717	6,594	-2,877	-44%
SB Managed Lanes	29	103	-74	-72%
NB 1-15	91	109	-17	-16%
NB Managed Lanes	0	0	0	0%
Arterials	11,095	11,487	-393	-3%
Total	**28,206**	**30,361**	**-2,155**	**-7%**

ICM E – Freeway Incident with Responsive Signal Operations

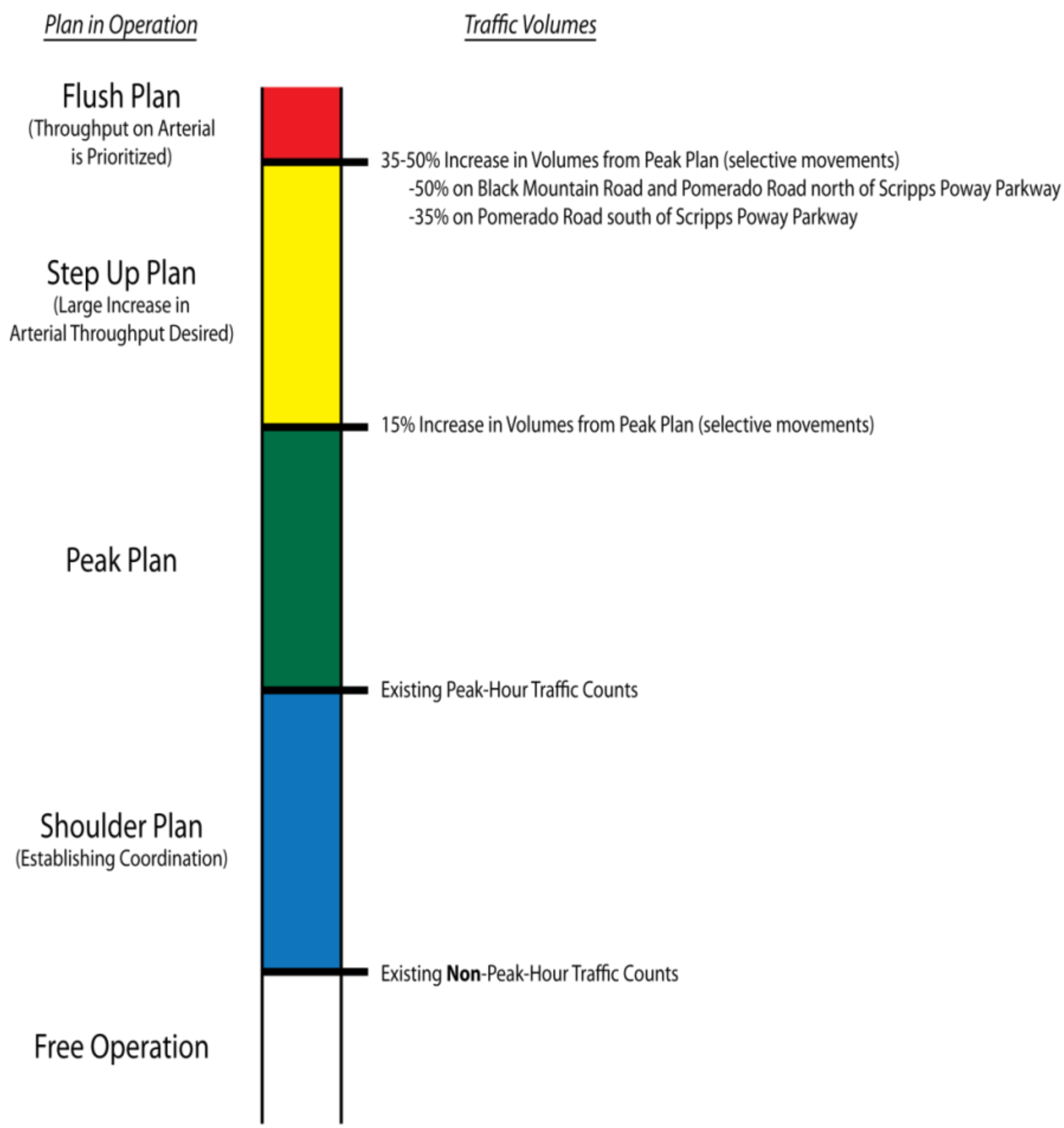
A Responsive Signal Operations System for major arterial routes parallel to the I-15 Corridor is currently in its planning stages. The proposed signal operations system will be placed along the arterial segments illustrated in Figure 4.4. Each arterial group defined in this figure will be programmed with certain volume thresholds that define which specific signal timing plans will be activated for that group during various operating conditions throughout the day. While these thresholds are defined based on historical travel patterns in the area, the system is meant to be reactive and is therefore designed to activate the appropriate signal timing plan based on these thresholds and real-time travel conditions.

Figure 4.4 I-15 Responsive Signal Operations Arterial Groups (Source: SANDAG, December 2011)



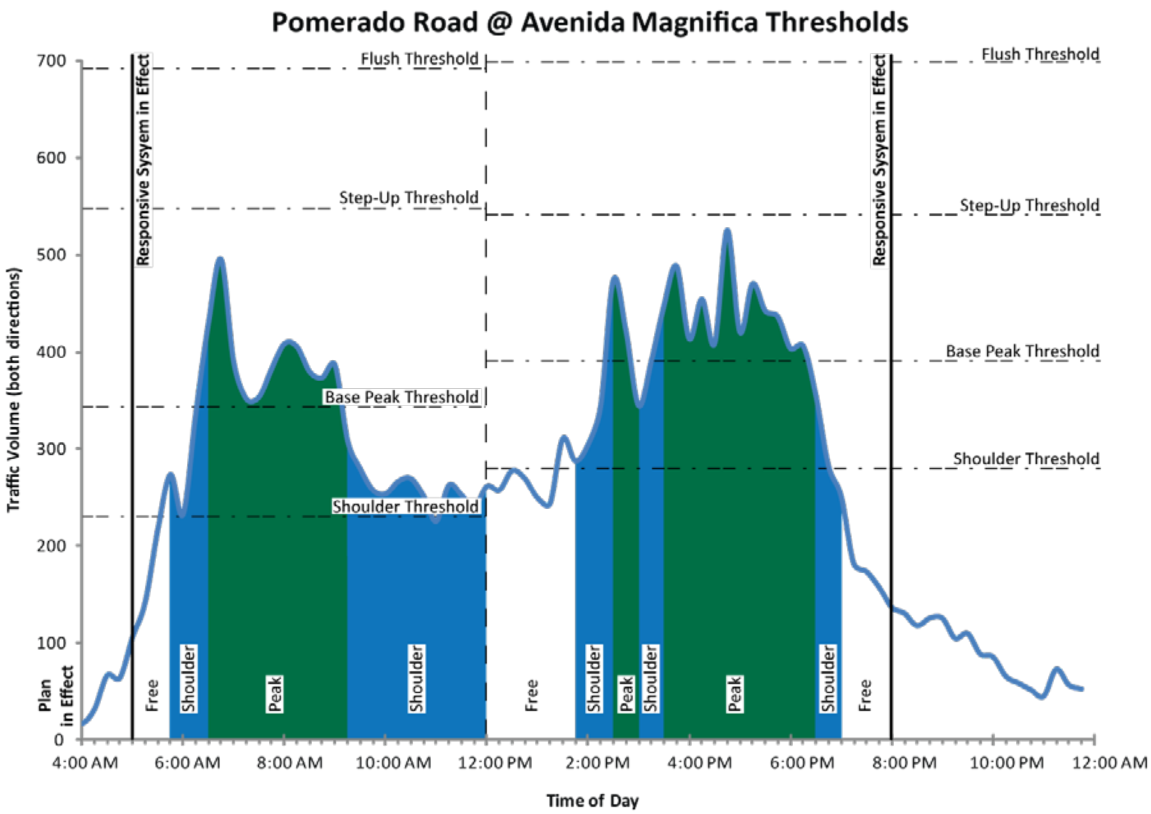
An example of the responsive signal operations concept is illustrated in Figure 4.5. As shown in the figure, the system can accommodate several types of signal timing plans including peak and off-peak signal timing plans, as well as additional plans that would address atypical traffic conditions that may occur during instances of nonrecurring congestion. These signal timing plans are sometimes called “flush” signal plans. The “flush” signal timing plans are coordinated to allow smooth progression through different jurisdictions. The intended effect of these signal plans is to reduce arterial delays, especially during incidents and/or special events.

Figure 4.5 Responsive Signals Concept (Source: Cambridge Systematics, Inc., December 2011)



In order to determine the volume thresholds for all the signalized intersections within the proposed arterial groups, data will be collected during incident and non-incident travel conditions at various times of the day to create volume threshold graphs, such as the one shown in Figure 4.6. As previously mentioned, in the responsive signal operations system, the appropriate timing plan will be activated for an arterial group when the collective volumes of all its signalized intersections reach a certain volume threshold.

Figure 4.6 Example Volume Threshold Chart (Source: Cambridge Systematics, Inc., December 2011)



In order to simulate the responsive nature of the proposed signal operations, several steps were involved, including the following:

- **Data Collection –** Data inputs include signal timing operations; volume threshold graphs for all arterial groups; and parameter values for the responsive signal operations, such as transition time to a new signal timing plan once a threshold has been reached.
- **Network edits –** The model needed to include additional detectors along the arterials incorporated into the responsive signals operations program.
- **Program scripts/plug-ins –** New scripts were needed in order to automate a process or rules by which new signal timing plans can be activated for a group of signalized intersections when model detectors detect a volume threshold has been reached.

ICM F – Freeway Incident under Suboptimal ICM Performance

The ICM F alternative tested the possible effects of suboptimal implementation of one or more of the strategies incorporated into the Site's proposed ICM system. There are several ICM strategies that must be coordinated with each other in order to optimize a response during both recurring and nonrecurring forms of congestion along the Corridor. The purpose of the ICM F alternative is to evaluate the impacts and performance of the system when one of these strategies fails to be initiated during an incident. The performance of the ICM F alternative was compared to the ICM E alternative, which represents a freeway incident scenario when all ICM strategies are actively working in coordination with each other.

The failure of one potential ICM strategy was considered for the ICM F alternative scenario. Specifically, **the suboptimal implementation of ICM E Arterial Responsive Signal Operations was tested in model scenario ICM F**. In this scenario, in all arterial groups flush signal operations during an incident were activated 45 minutes after the incident occurred as opposed to 15 minutes in alternative ICM E.

The I-15 simulation model was run with similar base characteristics for alternatives ICM E and F: the AM peak period model was run with a major incident on southbound I-15, where from 7:00 to 7:30 AM four lanes were closed (and two were open); and from 7:30 to 8:00 AM three lanes were closed (and three were open). The mitigation strategies tested included: 1) existing conditions with no special incident signal flush plans, 2) ICM E with responsive signal timings engaged 15 minutes after the incident, and 3) ICM F with responsive signal timings engaged 45 minutes after the incident. Simulation results were reported for three hours in the AM peak during the impact on traffic conditions by the incident.

The I-15 deployment team had developed thresholds and timings for parallel facilities, including Pomerado and Black Mountain Road, and these settings were used in the simulation. No thresholds and flush timings were developed initially for east-west routes connecting the I-15 freeway to the parallel arterials used by travelers to route away from the incident. However, it became clear in conducting the analysis that it is necessary to develop and provide flush thresholds and timings for east-west routes connecting the freeway to parallel arterials so as to accommodate route diversion and incident avoidance. In the absence of such east-west flush timings, large queues are expected to develop along east-west signals, especially at signalized intersections at on- and off-ramps. The AMS team developed flush timing plans for connecting routes affected by the modeled incident, including Camino Del Norte and Mira Mesa; these plans can be used by the I-15 development team. **It is recommended that such east-west flush thresholds and timings plans are developed for all major connecting routes between the I-15 freeway and major parallel arterials.**

Table 4.9 shows analysis results for alternatives ICM E and ICM F. The table presents a comparison of system performance between responsive signal operations and existing nonresponsive operations under a major incident with flush plans initiated 15 minutes (ICM E) and 45 minutes (ICM F) after the incident occurred. In alternative ICM E, total vehicle- and person-hours traveled (VHT and PHT) improve by three percent when compared to the baseline. This represents 1,295 vehicle- or 1,675 person-hours saved in the AM peak period (3 hours), which is a significant improvement. In alternative ICM E, total delay improves by 5 percent, or 1,193 vehicle hours saved in the AM peak period. **Overall, the proposed responsive signalization scheme is shown to be effective at reducing congestion during a major incident – as long as timing thresholds and signal timings are also developed for east-west routes connecting the I-15 freeway to parallel arterials.** In alternative

ICM F, travel time and delay benefits are reduced by approximately one-half if responsive signal timings are activated (not 15 but) 45 minutes after the incident occurs.

Table 4.9 Comparison of System Performance between Responsive Signal Operations and Existing Nonresponsive Operations under a Major Incident with Flush Plans Initiated 15 Minutes (ICM E) and 45 minutes (ICM F) after the Incident Occurred

Road Type	Responsive (15 Minutes)	Responsive (45 Minutes)	Existing (Non Responsive)	Difference Responsive (15 Minutes) vs. Existing	Percent Difference Responsive (15 Minutes) vs. Existing
VMT (Vehicle-Miles)					
SB 1-15	385,845	382,000	375,713	10,132	3%
SB Managed Lanes	135,997	141,850	138,113	-2,115	-2%
NB 1-15	288,178	288,235	291,252	-3,074	-1%
NB Managed Lanes	109,954	109,956	112,576	-2,622	-2%
Selected Arterials	135,334	137,230	135,264	70	0%
Entire Network	**1,313,810**	**1,317,771**	**1,311,903**	**1,907**	**0%**
VHT (Vehicle-Hours)					
SB 1-15	15,085	14,906	16,632	-1,547	-9%
SB Managed Lanes	4,206	4,238	4,212	-6	0%
NB 1-15	4,916	4,794	4,860	56	1%
NB Managed Lanes	1,862	1,859	1,891	-29	-2%
Selected Arterials	7,656	8,574	7,285	372	5%
Total	**46,839**	**47,466**	**48,134**	**-1,295**	**-3%**
Delay (Hours)					
SB 1-15	7,000	6,999	8,569	-1,568	-18%
SB Managed Lanes	1,490	1,412	1,422	68	5%
NB 1-15	150	38	57	93	163%
NB Managed Lanes	88	77	71	18	25%
Selected Arterials	4,923	5,802	4,581	342	7%
Total	**21,935**	**22,614**	**23,128**	**-1,193**	**-5%**

Summary

The objective of the Stage 3A AMS efforts is to ensure that the Stage 2 models and methodologies can sufficiently replicate and evaluate corridor conditions and the proposed ICM strategies prior to deployment. In Stage 3A, the AMS contractor and the Demonstration site staff confirmed, refined, and validated the parameters and assumptions that serve as the basis for the control strategies currently present in the Stage 2 models. These updated and enhanced models and methodologies can provide further insight on ICM implementation and other operational benefits that will help guide the Stage 3 demonstration projects, future ICM deployments, as well as the post-deployment AMS activities.

This ***Pre-Deployment AMS Assessment Report for the I-15 Corridor*** describes the various tasks associated with the refinement and additional analysis of the Stage 2 models and methodologies in order to support the successful implementation of ICM.

Chapter 2 provides a brief description of the I-15 Corridor in San Diego, California, and the methodology used for the overall AMS effort. This chapter describes the overall modeling framework used for the analysis and provides detailed information about the assumptions used to conduct peak-spreading, model route and mode shift, as well as rules used in modeling the effects of better traveler information be it pre-trip, en-route, or using Dynamic Message Signs.

Chapter 3 summarizes the AMS work completed as part of the Stage 2 analysis, including analysis scenarios, ICM strategies, modeling assumptions, summary of analysis settings, performance measures, the model calibration effort, and Stage 2 analysis results. **Appendix A** provides more information on model calibration results, and **Appendix B** provides summaries of analysis results from Stage 2 AMS.

Chapter 4 lays out the methodology, model enhancements, model reasonableness assessment, and analysis results for the AMS work completed as part of the Stage 3 pre-deployment analysis, including:

- **Analysis tool enhancements** including model network improvements and changes, revisions to ICM strategies, traveler information sensitivity analysis performed in support of the Volpe Center in developing travel surveys, and improvements to the ramp metering algorithm used in the model.

- **Pre-deployment baseline model calibration and validation**. A Reasonableness Assessment was conducted to ensure that the future baseline model is capable of accurately representing road geometries, demands, and operational conditions in the year 2013 when the proposed ICM system is deployed. The changes made and the lessons learned through this assessment contribute to the continuous improvement of the AMS methodology throughout the various stages of the ICM Initiative. Through this effort, new and more current field data were collected and several network and demand adjustments were completed in order to improve the existing future baseline model. The revised demands allowed for the future baseline model to better represent the expected travel demand and traffic conditions in year 2013 and will help avoid the need for a full recalibration effort of the models during the next stage of ICM. Overall, we believe that the refined model is capable of adequately representing the pre-deployment corridor operational conditions and corridor management strategies in the I-15 Corridor.

- **Pre-deployment alternatives analysis**. Stage 3A alternative scenarios were run using a revised model network and with 2013 travel demands. The three alternatives analyzed include:

    - **ICM D (Daily Operations) with Corridor Ramp Metering –** The ICM D alternative evaluated the impacts of ALINEA, Caltrans District 11's proposed new corridor-optimized ramp metering system. This alternative was compared with the performance of ICM A, the 2012 Daily Operations model with the current ramp metering system, the SDRMS. The proposed new ramp metering scheme is shown in the simulations to be effective at reducing congestion in the I-15 corridor. Furthermore, the implementation of ALINEA in the I-15 simulation model is working as expected, which a key element of getting ready for Post-Deployment analysis.
    - **ICM E (Freeway Incident) with Responsive Arterial Signal Operations –** the ICM E alternative tested the performance of the proposed responsive signal operations on parallel arterials during a major incident on the freeway.
    - **ICM F (Freeway Incident) under Suboptimal Arterial Signal Operations – i**n ICM F in all arterial groups flush signal operations during an incident were activated 45 minutes after the incident occurred as opposed to 15 minutes in alternative ICM E. Overall, the proposed responsive signalization scheme is shown to be effective at reducing congestion during a major incident – as long as timing thresholds and signal timings are also developed for east-west routes connecting the I-15 freeway to parallel arterials. In alternative ICM F, travel time and delay benefits are reduced by approximately one-half if responsive signal timings are activated (not 15 but) 45 minutes after the incident occurs.

Overall,

- We believe that the refined model is capable of adequately representing the pre-deployment corridor operational conditions and corridor management strategies in the I-15 Corridor;
- The San Diego site AMS capability can represent the ICM strategies planned to be implemented;
- The Stage 3A AMS results are consistent with Stage 2 AMS, a fact that provides additional reality and credibility to the AMS results; and
- Although these results are not statistically significant (because of inadequate spatial and temporal coverage and consistency in volume and speed data for both freeways and arterials), they are intuitive and do confirm the analysis hypotheses that the implementation of ICM in the I-15 Corridor is expected to produce positive benefits to the traveling public.

Appendix A. Stage 2 AMS Model Calibration Results

This appendix summarizes the model validation and calibration results for the I-15 Corridor in San Diego, California. The model validation and calibration methodology used a diversified set of data, including the following:

- Traffic flows at individual links along the I-15 corridor;
- Speed profiles along critical segments of the corridor; and
- Queue observations along critical segments of the corridor freeway and arterial components.

Link Count Comparisons – Typical Day

A total of 110 freeway link counts on the I-15 corridor was compared against the modeled count output from the TransModeler simulation runs. Two criteria were used to validate the model for each of three hourly time periods comprising the peak period of 6:00 AM to 9:00 AM: 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.

06:00–07:00 AM Link Count Validation

A summary of the link count validation statistics for the first modeled hour, 06:00-07:00, is presented in Table A.1.

Table A.1 06:00-07:00 AM Link Count Summary

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	252,291 (264,021) {model flow (observed counts)}	4.4%

07:00–08:00 AM Link Count Validation

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

Table A.2 07:00-08:00 AM Link Count Summary

Criteria and Measures	Model Versus Observed	Percentage
Within 15%, for Flow > 2,000 veh/h (for > 85% of links)	33 (35) {pass counts (total)}	94%
Within 5%, sum of all link flows	277,783 (292,133) {model flow (observed counts)}	4.9%

08:00–09:00 AM Link Count Validation

A summary of the link count validation statistics for the third modeled hour, 08:00-09:00, is presented in Table A.3.

Table A.3 08:00-09:00 AM Link Count Summary

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	263,735 (264,320) {model flow (observed counts)}	0.2%

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.

Speed Profile Comparisons – Typical Day

Observed speed contours were developed based on the PeMS database for September to October 2003. These observed speed contours were compared against simulation model-generated speed contour profiles. The PeMS database provided 5-minute speed data between 6:00 AM and 9:00 AM 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 A.4 and A.5, respectively. Corresponding speed contours for the southbound I-15 corridor, from the PeMS database and from the calibrated simulation model, are shown in Tables A.6 and A.7, respectively.

In the southbound direction PeMS data suggest heavy congestion north of Lake Hodges during the AM 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.

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.

Table A.4 06:00-09:00 AM Northbound Observed Speed Contours at Five-Minute Intervals 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 A.5 06:00-09:00 AM Northbound Simulation Model Speed Contours at Five-Minute Intervals

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 A.6 06:00-09:00 AM Southbound Observed Speed Contours at Five-Minute Intervals
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 A.7 06:00-09:00 AM Southbound Simulation Model Speed Contours at Five-Minute Intervals

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

Baseline Model Validation Results – Incident Day

This section provides a summary of the simulation model calibration results for an incident day on I-15. 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 AM and ending at 6:51 AM. Traveler information for diversion is dispersed starting at 6:40 AM and ending at 7:30 AM. Figure A.1 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 A.8 through A.12 show speed contours for PeMS baseline with no incident (Table A.8), PeMS baseline with incident (Table A.9), Model baseline with no incident (Table A.10), Model baseline with incident and no diversion information to travelers (Table A.11), and Model baseline with incident and diversion information to 20 percent of travelers (Table A.12). **Qualitative expectations are met**: a) modeled congestion is more with incident than without, as 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 AM to 7:30 AM) congested speeds (red or under 30 mph) in PeMS occupy **53** five-minute periods/segments (Table 5.10), while model incident-congested speeds occupy **50** five-minute periods/segments (Table A.11). **The difference of three periods/segments is well within the 25-percent range recommended by the U.S. DOT.**
3. **Extent of queue propagation: should be within 20 percent**. The bulk of incident-caused (6:40 AM to 7:30 AM) congestion (red or speeds under 30 mph) in PeMS extends for **seven** freeway segments upstream of the incident (Table A.10 – up to Rancho Bernardo), while model incident caused congestion extends for **five** freeway segments upstream of the incident (TableA.12– up to Camino del Norte). **The difference of two segments is not within the 20-percent range recommended by the U.S. DOT – 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.
4. **Diversion flows: Increase in ramp volumes where diversion is expected to take place**. Table A.13 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 AM and 7:00 AM; c) parallel arterial volumes increase upstream of the incident between 6:00 AM and 8:00 AM 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.

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).

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.***

Figure A.1 I-15 Transportation Network Showing Incident Location and Affected Links
(Source: SANDAG, September 2010)

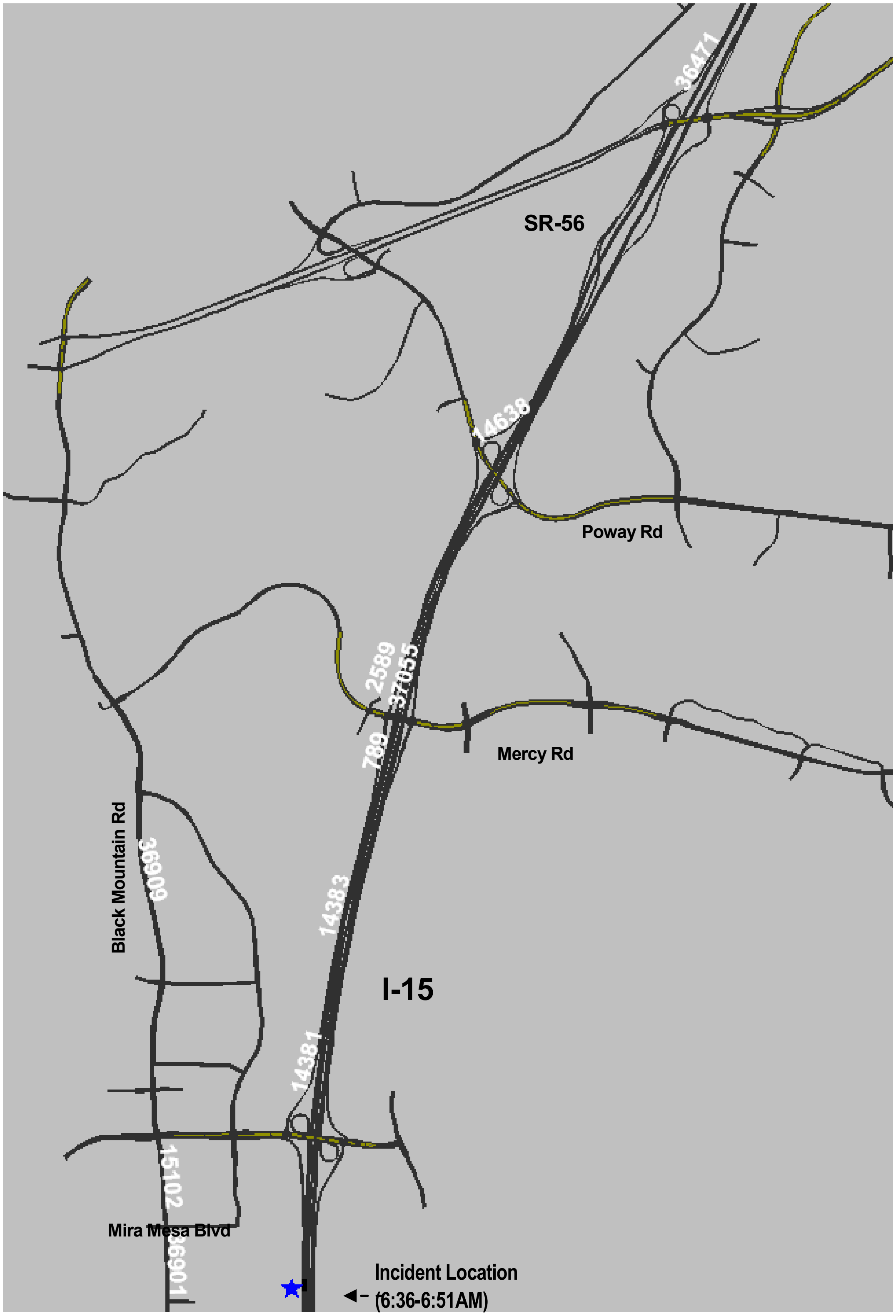


Table A.8 PeMS Baseline Without Incident

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	9.8
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 A.9 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 A.10 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	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	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	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.11 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	13.2	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 A.12 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	12.9	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

Table A.13 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)			VHT (Vehicle-Hours)
	Between Mercy Rd Ramps (#789)	Between Mercy Rd and Mira Mesa (#14383)	To SR 56 (#36471)	To Poway Rd (#14638)	To Mercy Rd (#2589)	To Mira Mesa Blvd (#14381)	Black Mountain Rd (#36909)	Black Mountain Rd (#15102)	Black Mountain Rd (#36901)	
6:00-7:00 AM										
A. Flow-baseline no incident	8,294	9,146	577	132	433	817	395	300	416	8,154.6
B. Flow-baseline w/incident w/o traveler information	7,546	8,399	578	127	404	781	378	282	391	8,309.7
C. Flow-baseline w/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 AM										
D. Flow-baseline no incident	7,816	8,815	597	122	371	937	914	441	675	12,040.1
E. Flow-baseline w/incident w/o traveler information	7,677	8,682	546	112	340	940	856	467	682	12,735.7
F. Flow-baseline w/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 B. Stage 2 AMS Results

This appendix contains the analysis results summary tables from the final report *Integrated Corridor Management Analysis, Modeling, and Simulation for the I-15 Corridor in San Diego, California.*

Table B.1 Year 2012 Baseline With and Without ICM – High Demand
06:00 to 11:00 AM

	2012 Baseline Without ICM			2012 Baseline With ICM		
Corridor	**VMT**	**VHT**	**Delay**	**VMT**	**VHT**	**Delay**
SB I-15	595,100	10,147	42	588,230	9,934	15
SB HOT Lanes	154,858	2,470	0	155,476	2,479	0
Total SB	749,958	12,618	42	743,706	12,413	15
NB I-15	449,048	7,285	5	447,989	7,269	3
NB HOT Lanes	101,120	1,570	0	101,301	1,575	0
Total NB	550,168	8,855	5	549,289	8,844	3
Arterials	211,975	8,802	4,600	209,763	8,531	4,370
Entire Network	**1,808,386**	**43,183**	**11,619**	**1,799,407**	**42,546**	**11,219**

Table B.2 Year 2012 Baseline With and Without ICM – Medium Demand
06:00 to 11:00 AM

	2012 Baseline Without ICM			2012 Baseline With ICM		
Corridor	**VMT**	**VHT**	**Delay**	**VMT**	**VHT**	**Delay**
SB I-15	583,500	9,795	12	576,639	9,669	11
SB HOT lanes	152,105	2,418	0	153,399	2,438	0
Total SB	735,605	12,213	12	730,037	12,107	11
NB I-15	439,085	7,097	1	441,093	7,095	0
NB HOT Lanes	99,360	1,542	0	99,943	1,553	0
Total NB	538,446	8,639	1	541,036	8,648	0
Arterials	207,459	8,013	3,907	208,099	7,910	3,775
Entire Network	**1,774,532**	**41,345**	**10,547**	**1,771,601**	**40,876**	**10,161**

Table B.3 Year 2012 Baseline With and Without ICM – Low Demand
06:00 to 11:00 AM

	2012 Baseline Without ICM			2012 Baseline With ICM		
Corridor	**VMT**	**VHT**	**Delay**	**VMT**	**VHT**	**Delay**
SB I-15	443,988	7,153	5	442,175	7,120	5
SB HOT lanes	113,556	1,774	0	113,608	1,767	0
Total SB	557,544	8,927	5	555,782	8,888	5
NB I-15	331,236	5,189	0	330,964	5,170	0
NB HOT Lanes	75,428	1,162	0	74,269	1,142	0
Total NB	406,663	6,351	0	405,233	6,312	0
Arterials	155,090	4,659	1,665	155,098	4,629	1,637
Entire Network	**1,339,560**	**27,233**	**4,769**	**1,336,876**	**27,163**	**4,759**

Table B.4 Freeway Incident Alternative With and Without ICM – High Demand
06:00 to 11:00 AM

	Freeway Incident Without ICM			Freeway Incident With ICM		
Corridor	**VMT**	**VHT**	**Delay**	**VMT**	**VHT**	**Delay**
SB I-15	590,404	12,590	1,732	581,925	11,805	1,199
SB HOT lanes	156,914	2,591	47	185,142	3,097	24
Total SB	747,319	15,180	1,779	767,067	14,902	1,223
NB I-15	447,675	7,298	12	448,585	7,326	26
NB HOT Lanes	101,769	1,581	0	101,036	1,569	0
Total NB	549,444	8,879	12	549,621	8,895	26
Arterials	211,577	9,301	5,110	210,352	8,633	4,464
Entire Network	**1,804,699**	**46,167**	**13,759**	**1,824,095**	**45,265**	**12,603**

Table B.5 Freeway Incident Alternative With and Without ICM – Medium Demand
06:00 to 11:00 AM

	Freeway Incident Without ICM			Freeway Incident With ICM		
Corridor	**VMT**	**VHT**	**Delay**	**VMT**	**VHT**	**Delay**
SB I-15	581,573	12,266	1,691	570,422	11,204	1,072
SB HOT lanes	153,494	2,522	43	183,398	3,204	84
Total SB	735,067	14,789	1,734	753,820	14,408	1,156
NB I-15	439,908	7,116	2	439,100	7,097	1
NB HOT Lanes	98,656	1,531	0	99,535	1,544	0
Total NB	538,563	8,647	2	538,634	8,641	1
Arterials	206,609	8,266	4,192	206,441	7,989	3,908
Entire Network	**1,771,505**	**44,031**	**12,469**	**1,790,709**	**43,309**	**11,514**

Table B.6 Freeway Incident Alternative With and Without ICM – Low Demand
06:00 to 11:00 AM

	Freeway Incident Without ICM			Freeway Incident With ICM		
Corridor	**VMT**	**VHT**	**Delay**	**VMT**	**VHT**	**Delay**
SB I-15	444,434	7,471	235	446,042	7,462	216
SB HOT lanes	115,268	1,805	0	129,454	1,808	0
Total SB	559,703	9,276	235	575,496	9,269	216
NB I-15	331,035	5,186	0	331,798	5,188	0
NB HOT Lanes	74,141	1,140	0	74,667	1,132	0
Total NB	405,176	6,327	0	406,464	6,320	0
Arterials	155,597	4,658	1,658	155,067	4,640	1,653
Entire Network	**1,340,750**	**27,613**	**5,046**	**1,357,844**	**27,536**	**4,986**

Table B.7 Arterial Incident Alternative With and Without ICM – High Demand
06:00 to 11:00 AM

	Arterial Incident Without ICM			Arterial Incident With ICM		
Corridor	**VMT**	**VHT**	**Delay**	**VMT**	**VHT**	**Delay**
SB I-15	593,075	10,174	78	586,627	10,094	90
SB HOT lanes	154,596	2,463	0	155,853	2,492	0
Total SB	747,670	12,637	78	742,480	12,586	90
NB I-15	448,346	7,325	19	447,092	7,290	9
NB HOT Lanes	101,084	1,571	0	102,862	1,598	0
Total NB	549,430	8,896	19	549,953	8,888	9
Arterials	211,499	9,008	4,803	209,469	8,621	4,465
Entire Network	**1,805,083**	**43,797**	**12,210**	**1,798,396**	**43,226**	**11,745**

Table B.8 Arterial Incident Alternative With and Without ICM – Medium Demand
06:00 to 11:00 AM

	Arterial Incident Without ICM			Arterial Incident With ICM		
Corridor	**VMT**	**VHT**	**Delay**	**VMT**	**VHT**	**Delay**
SB I-15	584,110	9,986	89	577,772	9,937	111
SB HOT lanes	152,277	2,422	0	152,784	2,431	0
Total SB	736,387	12,408	89	730,557	12,368	111
NB I-15	440,507	7,147	9	439,715	7,115	1
NB HOT Lanes	100,157	1,557	0	99,875	1,548	0
Total NB	540,664	8,704	9	539,590	8,664	1
Arterials	206,520	8,522	4,419	207,116	8,372	4,243
Entire Network	**1,778,353**	**42,636**	**11,621**	**1,768,638**	**42,023**	**11,150**

Table B.9 Arterial Incident Alternative With and Without ICM – Low Demand
06:00 to 11:00 AM

	Arterial Incident Without ICM			Arterial Incident With ICM		
Corridor	**VMT**	**VHT**	**Delay**	**VMT**	**VHT**	**Delay**
SB I-15	448,048	7,295	38	440,671	7,132	11
SB HOT lanes	113,506	1,777	0	115,502	1,809	0
Total SB	561,554	9,072	38	556,173	8,941	11
NB I-15	331,899	5,225	1	331,974	5,193	1
NB HOT Lanes	74,145	1,139	0	75,342	1,158	0
Total NB	406,044	6,364	1	407,316	6,351	1
Arterials	155,379	5,006	2,003	155,461	4,875	1,869
Entire Network	**1,343,790**	**28,108**	**5,487**	**1,339,970**	**27,763**	**5,250**

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