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USDOT Integrated Corridor Management (ICM) Initiative

Integrated Corridor Management Analysis, Modeling, and Simulation Experimental Plan for the Test Corridor

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16. Abstract

This document, the AMS Experimental Plan, lays out the scope of analysis that will be conducted through the application of the AMS methodology to the Test Corridor. The specific objectives of the Experimental Plan are:

- Create an AMS framework that identifies strategies, scenarios, and procedures for tailoring AMS general approaches towards the Test Corridor; and
- Specify the AMS framework, based on the analysis and application of existing tools, and integrating existing tools into an internally consistent and flexible system approach that is able to support the Test Corridor ICM functional requirements.

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SI* (MODERN METRIC) CONVERSION FACTORS				
APPROXIMATE CONVERSIONS TO SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa
APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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1.0 Introduction

The concept of Integrated Corridor Management (ICM) is the coordination of individual network operations between parallel facilities that creates an interconnected system capable of cross network travel management. An ICM corridor is defined as a combination of discrete parallel surface transportation networks (e.g., freeway, arterial, transit networks) that link the same major origins and destinations. ICM corridors are defined operationally rather than geographically or organizationally.[1]

In Task 2.3 of the ICM Tools, Strategies and Deployment Support project, Cambridge Systematics developed a methodology for conducting Analysis, Modeling, and Simulation (AMS) for ICM corridors. The AMS Methodologies document provides a discussion of potential ICM analytical approaches for the assessment of generic corridor operations. This document, the AMS Experimental Plan, lays out the scope of analysis that will be conducted through the application of the AMS methodology to the Test Corridor. The specific objectives of the Experimental Plan are:

- Create an AMS framework that identifies strategies, scenarios, and procedures for tailoring AMS general approaches towards the Test Corridor; and
- Specify the AMS framework, based on the analysis and application of existing tools, and integrating existing tools into an internally consistent and flexible system approach that is able to support the Test Corridor ICM functional requirements.

The purpose of the Test Corridor modeling is to perform a pilot study to evaluate:

- Proof of concept for the AMS framework;
- Development and application of interfaces for flow of data between modeling tools; and
- AMS application of a subset of ICM strategies to the test corridor.

This report is organized as follows:

- **Section 2.0** provides the modeling approach and AMS tools for the Test Corridor;
- **Section 3.0** presents ICM strategies and analysis scenarios that will be applied for the Test Corridor;

[1] http://www.fhwa.dot.gov/crt/roadmaps/icmprgmplan.cfm.

- **Section 4.0** presents the calibration and validation methodology for the Test Corridor AMS;
- **Section 5.0** presents the performance measures that will be applied to the Test Corridor AMS; and
- **Section 6.0** summarizes the report and presents the risks and applicability associated with the suggested modeling.

2.0 Modeling Approach

The AMS Methodology document presented three findings based on the analysis of capabilities found in existing AMS tools:

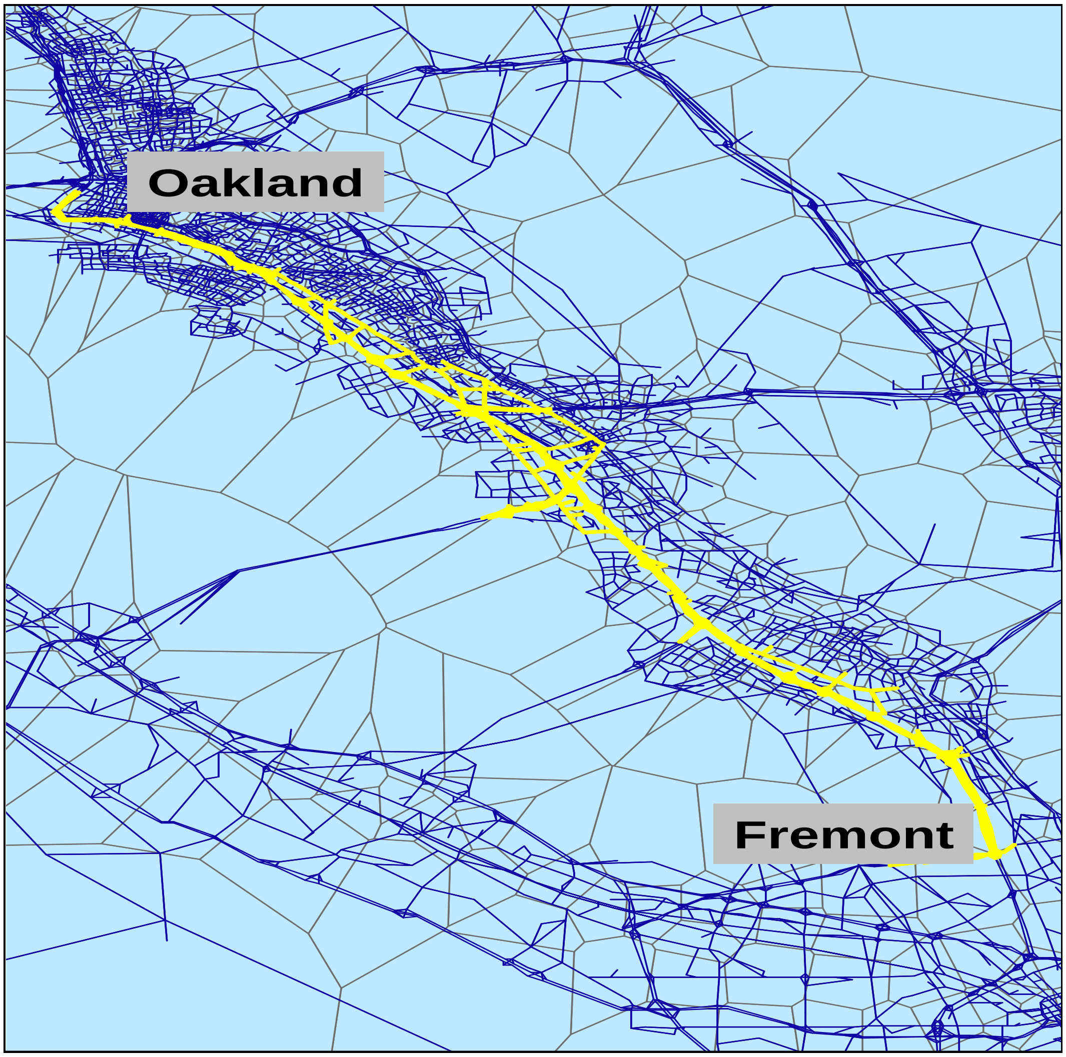
1. Each tool type has different advantages and limitations, and is better than other tool types at some analysis capabilities. There is no one tool type at this point in time that can successfully address the analysis capabilities required by the ICM program. An integrated approach can support corridor management planning, design, and operations by combining the capabilities of existing tools.
2. Key modeling gaps in existing tool's capabilities include: a) the analysis of traveler responses to traveler information; b) the analysis of strategies related to tolling/HOT lanes/congestion pricing; and c) the analysis of mode shift and transit.
3. Interfacing between travel demand models, mesoscopic simulation models, and microscopic simulation models presents integration challenges that can be addressed by identifying interface requirements that focus on: a) maintaining the consistency across analytical approaches in the different tools; and b) maintaining the consistency of performance measures used in the different tool types.

2.1 TEST CORRIDOR SITE

The Test Corridor comprises the I-880 corridor between the cities of Oakland and Fremont, California, with the I-580/I-80 interchange as the northern boundary and SR 237 as the southern boundary, for a distance of about 38 miles or more than 250 lane-miles. The ICM AMS team evaluated a number of candidate Test Corridor sites and selected I-880 based on a number of criteria, including availability of macro-, meso-, and microscopic simulation models, validation and calibration data, ease of modifications to these models, multitude of transportation modes (single-occupancy vehicle (SOV), high-occupancy vehicle (HOV), transit, etc.), multitude of transportation facilities (freeways, arterials, HOV lanes, transit, etc.), and transferability/applicability of results and methods tested on the Test Corridor.

As one of the main arteries of the freeway system in the San Francisco Bay Area, I-880 includes 38 miles of freeway connecting Silicon Valley with the East Bay. I-880 serves the Port of Oakland, Oakland International Airport, and the Oakland Coliseum, as well as a major concentration of residential, office, industrial and warehouse land uses. I-880 serves as both an access route for major interregional and international shippers and a primary intraregional goods-movement corridor. Facilities in the Test Corridor include the I-880 freeway, arterial highways, the Alameda County (AC) bus transit routes, the Bay Area Rapid Transit (BART) rail, and intercity passenger and freight rail lines. An illustration of the Test Corridor is shown in Figure 2.1. The Test Corridor is described in more detail in the "Test Corridor Model Description" document, one of the ICM AMS deliverables.

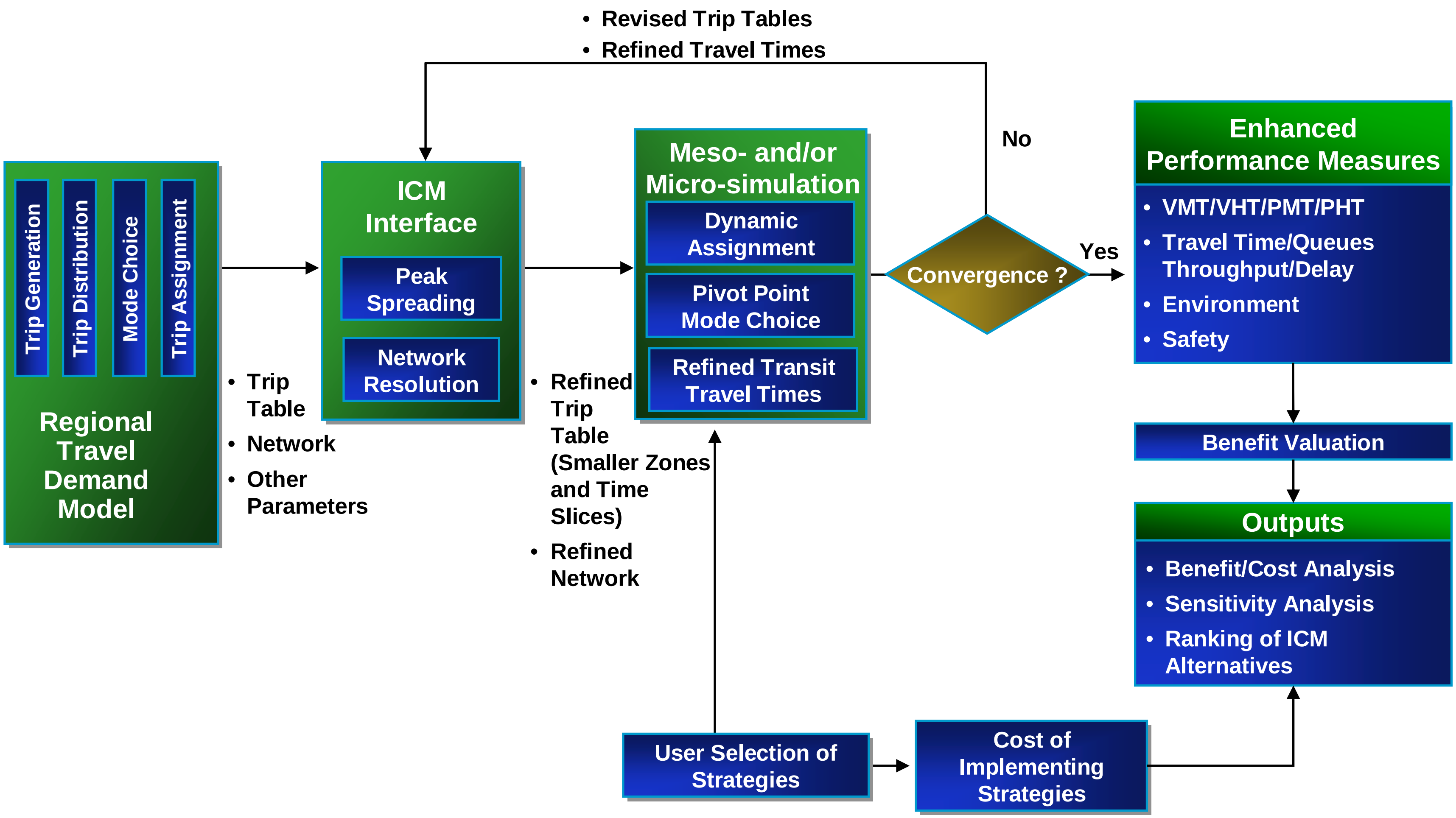
Figure 2.1 Test Corridor



2.2 MODELING APPROACH

The approach adopted for the test corridor analysis applies the AMS Methodology findings and the AMS framework shown in Figure 2.2. The Test Corridor AMS approach encompasses tools with different traffic analysis resolutions. All three classes of simulation modeling approaches – macroscopic, mesoscopic, and microscopic – may be applied for evaluating ICM strategies. This modeling approach provides the greatest degree of flexibility and robustness in supporting

Figure 2.2 Test Corridor AMS Framework



subsequent tasks for AMS support of Pioneer Sites. In this section, the Test Corridor site selected in Task 2.1 is presented and then the AMS Framework for the Test Corridor is described.

The AMS methodology for Test Corridor applies macroscopic trip table manipulation for the determination of overall trip patterns, mesoscopic analysis of the impact of driver behavior in reaction to ICM strategies (both within and between modes), and microscopic analysis of the impact of traffic control strategies at roadway junctions (such as arterial intersections or freeway interchanges.) The methodology also includes a simple pivot-point mode shift model and a transit travel-time estimation module, the development of interfaces between different tools, and the development of a performance measurement and benefit/cost module.

In this AMS framework, macroscopic, mesoscopic, and microscopic traffic analysis tools can interface with each other, passing trip tables and travel times back and forth looking for natural stability within the system. Absolute convergence may not be achieved because of inherent differences at the various modeling levels. This methodology will seek a natural state for practical convergence between different models, and the iterative process will be terminated or truncated at a point where reasonable convergence is achieved.

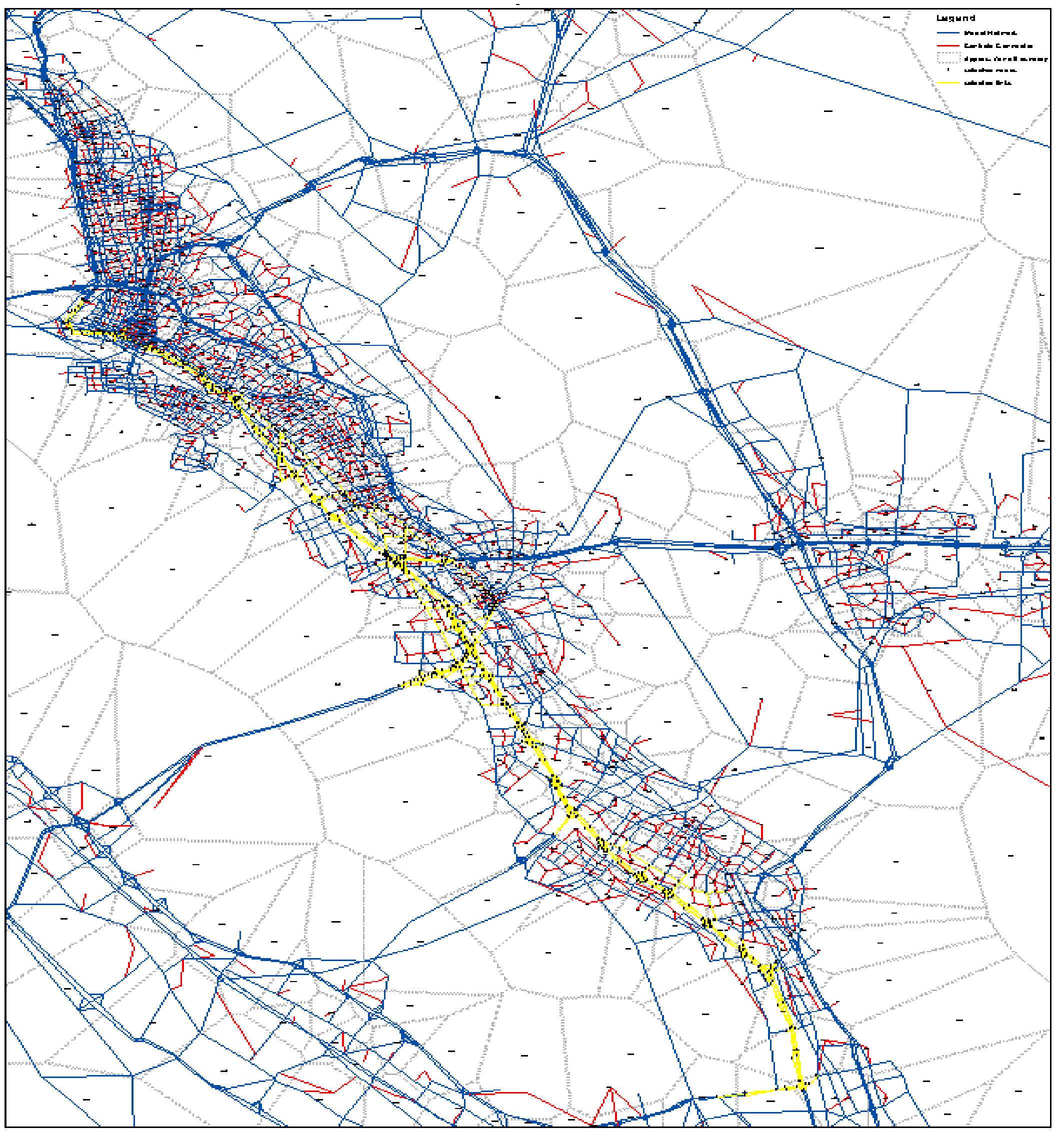
This section describes the various off-the-shelf and custom tools applied for the Test Corridor to conduct the modeling of the ICM strategies.

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; these are mathematical models that forecast future travel demand from current conditions, and future projections of household and employment characteristics.

A validated CUBE travel demand model (TDM) of the Alameda County Congestion Management Agency, depicted in Figure 2.3, will be used to develop the trip tables and networks for the Test Corridor. Subarea trip tables and networks will be developed from the TDM –for use in the simulation model. The travel demand model also will be used as the analysis engine for a simple pivot-point mode-choice model which will analyze mode shifts in response to congestion and to ICM strategies. The output from the mode choice analysis and trip table manipulation will be corridor-based trip tables that take into account trip impacts associated with corridor conditions, current operations, or operational changes. A detailed description of the mode choice model is provided later in this section.

Figure 2.3 Alameda County Travel Demand Model

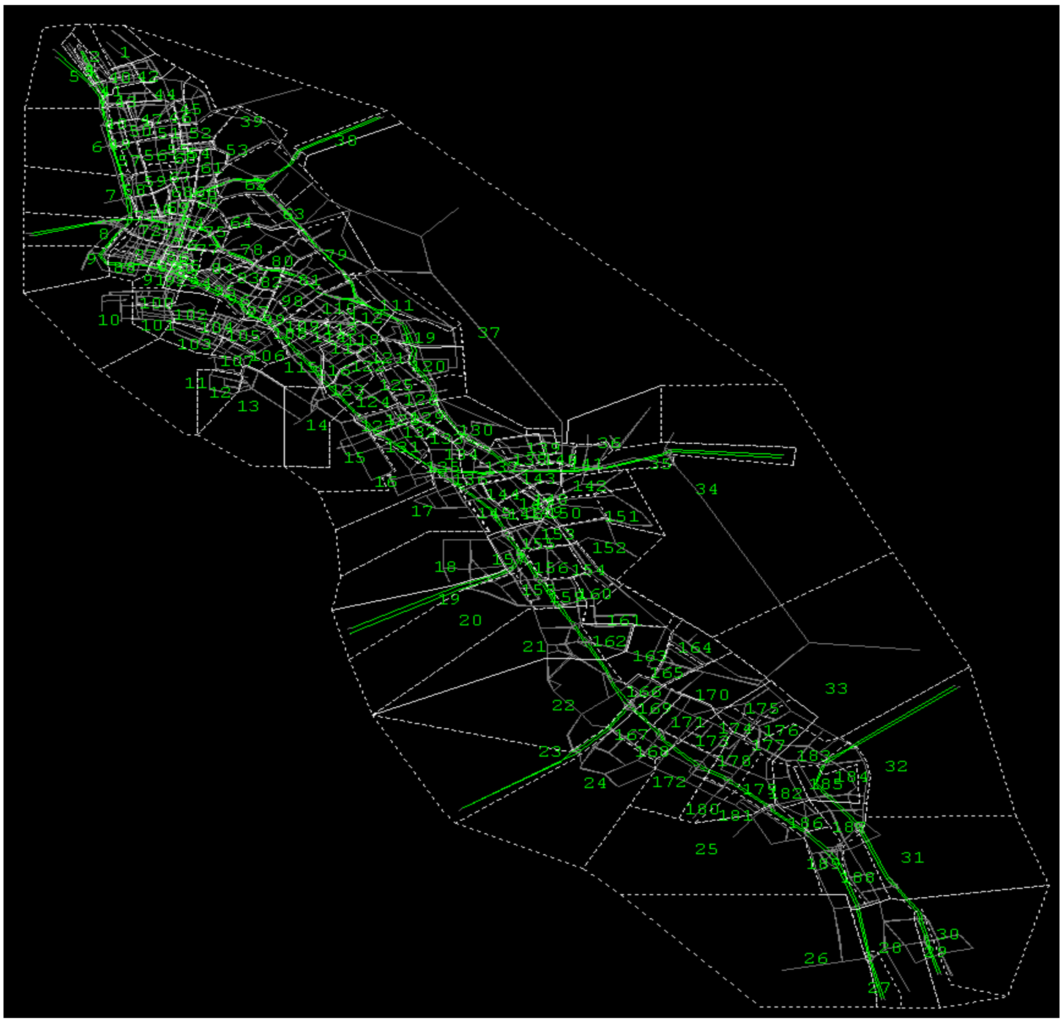


Mesoscopic Simulation Model

Mesoscopic models combine properties of both microscopic and macroscopic simulation models. The mesoscopic models' unit of traffic flow is the individual vehicle, and they assign vehicle types and driver behavior, as well as their relationships with the roadway characteristics. Their movement, however, follows the approach of macroscopic models and is governed by the average speed on the travel link. Mesoscopic models provide less fidelity than microsimulation tools, but are superior to travel demand models, in that, mesoscopic models can evaluate dynamic traveler diversions in large-scale networks.

A DynaSmart-P mesoscopic model of the subarea extending beyond the mainline I-880 corridor will be used for the analysis of ICM strategies of the Test Corridor. The DynaSmart-P network will use a trip table from the travel demand model. The model will be used to support the analysis of the dynamic impact of ICM strategies that may induce shifts of trips from one network to another, such as pricing, and corridor-specific traveler information (pre-trip and e-route.) An illustration of the mesoscopic simulation network is shown in Figure 2.4.

Figure 2.4 Mesoscopic Simulation Network for the Test Corridor

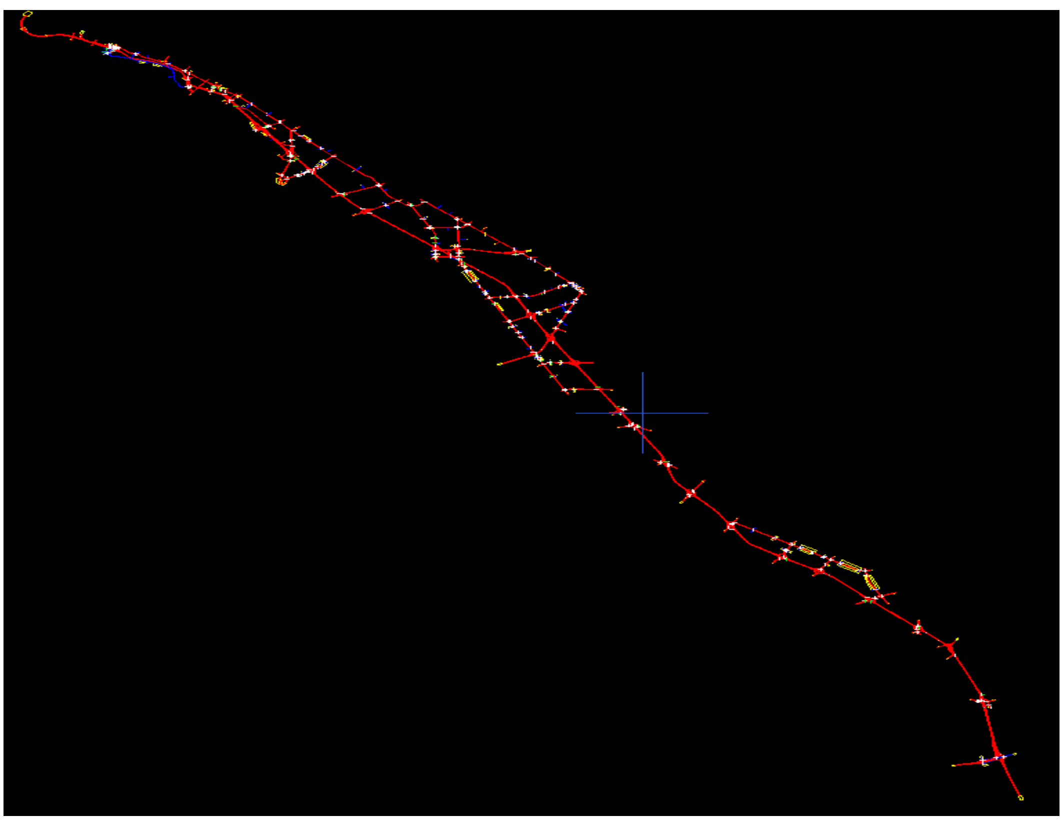


Microscopic Simulation Model

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.

A Paramics microsimulation model for the Test Corridor is being developed for I-880 as part of the California Department of Transportation (Caltrans) Model Corridor study. Depending on the schedule of this parallel effort the Paramics model may be available to support the evaluation of the operational control aspects of the ICM strategies, such as ramp metering and traffic signal coordination strategies. Microscopic simulation analysis can output detailed travel times that can be used to augment the mesoscopic simulation analysis. This augmentation would entail the conversion of operational impacts identified at the microscopic level into adjustment factors at the mesoscopic level. These factors can support the modification of the mesoscopic analysis, such that the impacts of the operational control aspects of ICM strategies can be analyzed in conjunction with the trip management and route shifting aspects of those strategies. An illustration of the Paramics model network for the Test Corridor is shown in Figure 2.5.

Figure 2.5 Microscopic Simulation Network for the Test Corridor



Model Interface

Linkage mechanisms are required to establish consistency between the modeling resolutions of the AMS tools. In general, three types of interfaces are required to allow communications between macroscopic travel demand models, mesoscopic simulation models, and microscopic simulation models:

1. An interface focusing on network features;
2. An interface focusing on the temporal distribution of trips; and
3. An interface focusing on the refinement/aggregation of model traffic analysis zones that generate and attract travel demand.

For example, the interface between a travel demand model and a microscopic simulation model requires that uniform peak-period travel demand from the travel demand model is transformed into a dynamic travel demand that changes every 5 to 15 minutes. This interface further requires that there is compatibility between the zonal structures and networks in the two model types. This interface will be flexible and extensible to be applied as the linkage mechanism between different travel demand, meso, and micro models.

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 Test Corridor can be due to scenario impacts (incidents, etc.) and ICM strategies (such as Traveler Information Systems, ramp metering, etc.) Modeling of mode shift requires input of transit travel times which need to be calculated and provided 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.

The pivot-point mode shift model works with trip tables from the travel demand model, and with more accurate travel times estimated by simulation models. A depiction of the application is shown in Figure 2.6; the work flow in the mode choice model is shown in Figure 2.7.

This approach provides: 1) calculation of transit travel times for each requested level of analysis given the corridor conditions or operations input; 2) incorporation of inputs from each level of analysis to adjust transit travel times per segment and decision point; and 3) generation of outputs that can be incorporated into the other modeling tools as analysis adjustment factors. This approach supports the corridor analysis of transit in an ICM environment and provides the information necessary to account for the interrelation of impacts with the traffic operations in the corridor.

Figure 2.6 Pivot Point Mode Choice Model Application

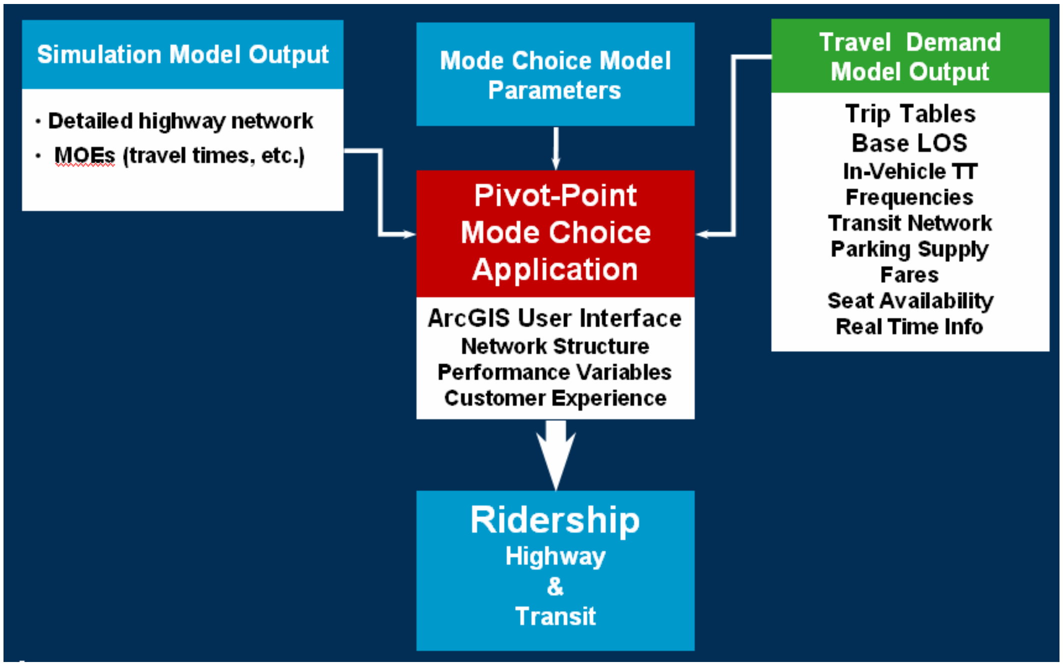
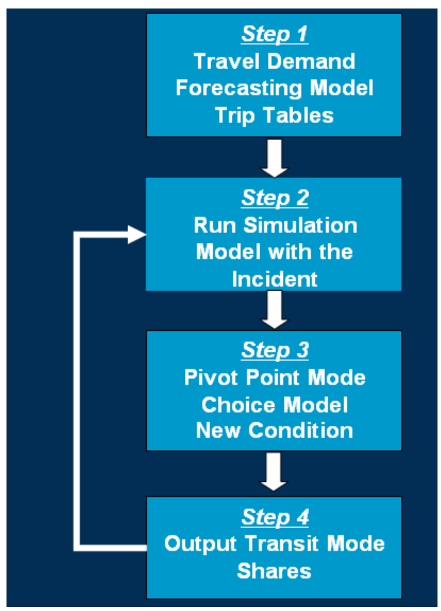


Figure 2.7 Pivot Point Mode Shift Model – Work Flow

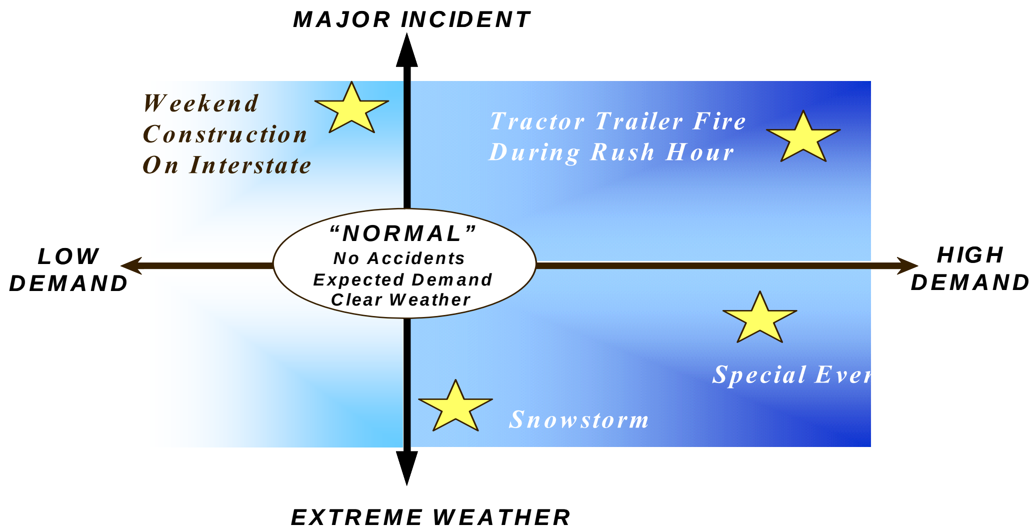


3.0 Analysis Scenarios and ICM Strategies

This section describes the ICM strategies that will be applied to the Test Corridor and the scenarios that will be studied to analyze the impacts of the strategies. The objective of the Test Corridor modeling is to assess the practicality of the proposed AMS Framework. This section describes the strategies and scenarios for which the AMS modeling approach will be tested.

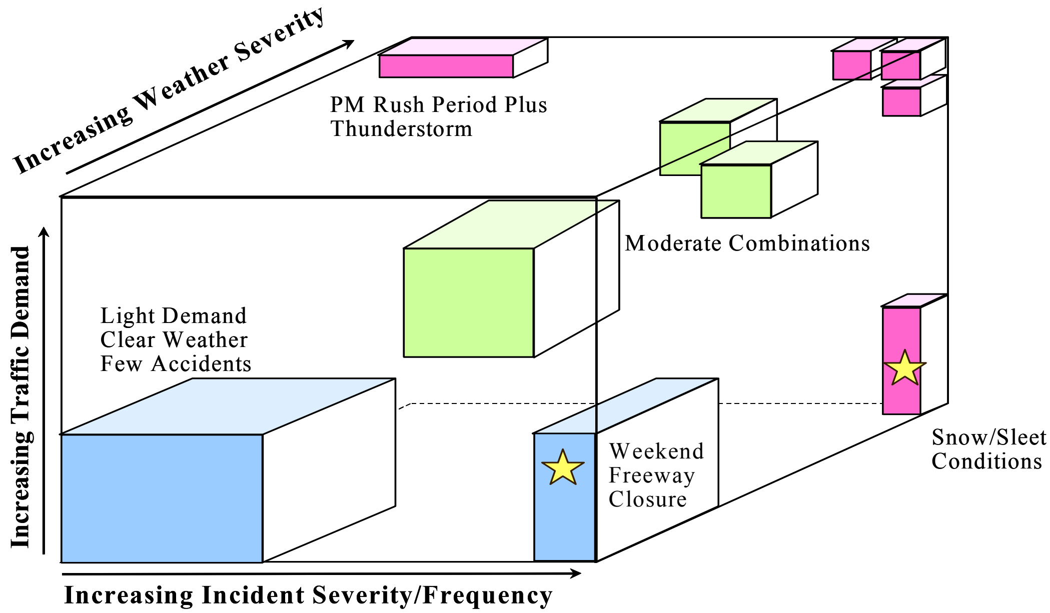
The ICM AMS framework provides tools and procedures capable of supporting the analysis of both recurrent and nonrecurrent corridor scenarios. Nonrecurrent congestion scenarios entail combinations of increases of demand and decreases of capacity. Figure 3.1 depicts how key ICM impacts may be lost if only "normal" travel conditions are considered; the proposed scenarios take into account both average- and high-travel demand, with and without incidents. The relative frequency of nonrecurrent conditions is important to estimate in this process – based on archived traffic conditions, as shown in Figure 3.2.

Figure 3.1 Key Intelligent Transportation System (ITS) Impacts May Be Lost If Only "Normal" Conditions Considered



Source: Wunderlich, K., et al., *Seattle 2020 Case Study*, PRUEVIIN Methodology, Mitretek Systems. This document is available at the Federal Highway Administration Electronic Data Library (http://www.itsdocs.fhwa.dot.gov/).

Figure 3.2 Sources of System Variation
Classifying Frequency and Intensity



Source: Wunderlich, K., et al., *Seattle 2020 Case Study*, PRUEVIIN Methodology, Mitretek Systems. This document is available at the Federal Highway Administration Electronic Data Library (http://www.itsdocs.fhwa.dot.gov/).

3.1 Average- and High-Demand Scenarios

For the test corridor, average- and high-travel demand conditions were determined by analyzing archived data from the PeMS database. Table 3.1 shows average and maximum vehicle miles traveled (VMT) data for the entire region under Caltrans District 4. Typical weekday volumes for Tuesday, Wednesday, and Thursday show that maximum observed VMT is 6 percent higher than average VMT. Figure 3.3 provides an overview of demand patterns on the Test Corridor – the demand is lower on Saturday and Sunday, and during Christmas season. We chose to use "median" instead of "mean" demand to avoid bias from nonworking days. Ranges of travel demand on the test corridor are as follows:

- **Low demand –** <98.5 percent of median VMT, or 42 percent of days in the year;
- **Medium demand –** Between 98.5 percent and 102.5 percent of median VMT, or 29 percent of days in the year; and
- **High demand –** >102.5 percent of median VMT, or 29 percent of days in the year.

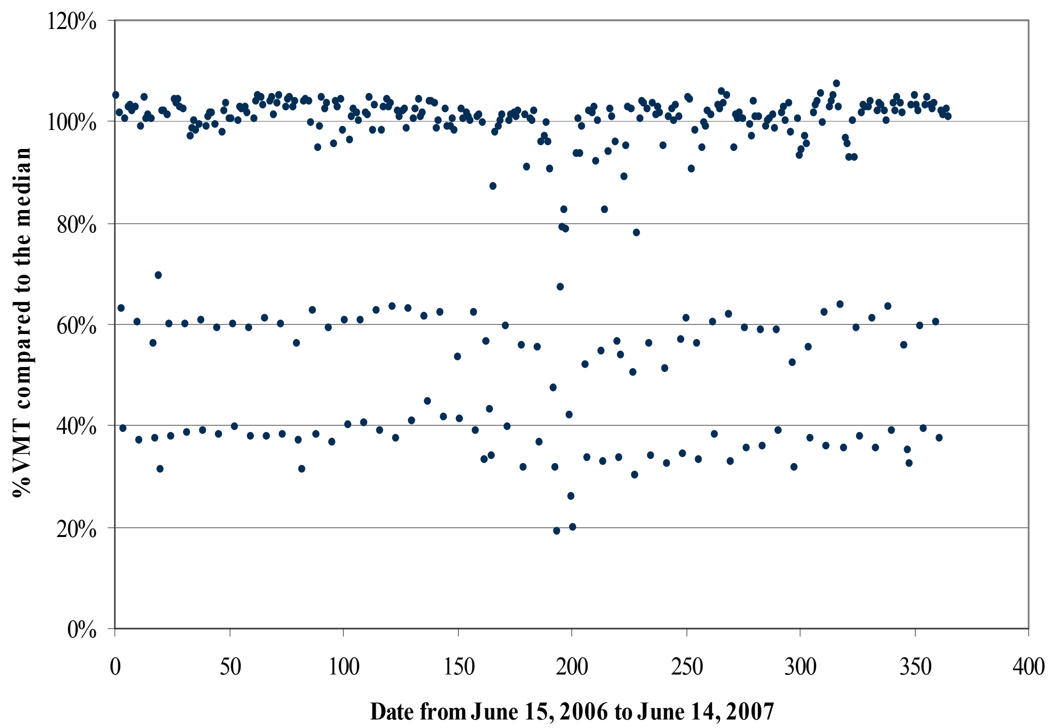
The medians of the high and medium ranges will be used in the analysis. In the Test Corridor AMS we will simulate the median from the medium-demand range (100 percent) and the median from the high-demand range (104 percent).

The average traffic volume scenario will be based on a trip table obtained for the AM peak period from the regional travel demand model.

Table 3.1 Determining High-Volume Scenario from VMT for Caltrans District 4

Day	Minimum	Mean	Maximum	Max/Mean	Max/Mean
Sunday	42,134,910	47,433,782	53,214,009	1.12	
Monday	42,251,727	55,616,955	60,296,132	1.08	
Tuesday	40,632,558	57,784,703	61,054,236	1.06	
Wednesday	53,649,452	58,890,264	62,557,940	1.06	1.06
Thursday	46,971,959	59,607,667	63,807,090	1.07	
Friday	50,495,376	61,664,122	65,244,922	1.06	
Saturday	48,530,858	53,343,231	58,004,132	1.09	

Figure 3.3 Demand Variation on the Test Corridor



3.2 Incident and No-Incident Scenarios

The most likely incident location for the Test Corridor was determined by analyzing incident frequency from the PeMS database. Figures 3.4 and 3.5 show incident locations by frequency on the Test Corridor, northbound and southbound, respectively. A plot of incident frequency on I-880 southbound shows that the maximum number of incidents occur around Postmile 23, as shown in Figure 3.6. This location is shown in Figure 3.7 – between SR 23 and SR 92, an area of increased merging and weaving traffic.

The duration and severity of the incidents was obtained from a combination of the PeMS database and the "TMS Master Plan" study conducted for Caltrans. The PeMS graphic on incident duration is shown in Figure 3.8. Figure 3.9 shows incident duration by percent increments for incidents on the Test Corridor. We used aggregate incident data from June 15, 2006 to June 14, 2007 (including weekdays and weekends for all 365 days).

The nonrecurrent congestion (or incident) scenario includes an incident near Postmile 23 in the northbound direction. The incident will result in two lanes being closed for 45 minutes, starting at 7:15 a.m. This represents the 85th percentile incident with duration of 45 minutes. The Test Corridor at the incident location provides alternative arterial routes and alternative transportation modes, including bus and BART lines.

In addition to identifying high-incident locations and duration of incidents, when designing scenarios that describe operational conditions the analyst should also identify overall incident patterns as they occur on different days of the year. This type of analysis will be conducted in the Test Corridor AMS by separating major from minor incidents. Time and resource-permitting this analysis can be more thorough by focusing on different ranges of numbers of incidents occurring on different days of the year.

Figure 3.4 Incident Locations/Frequency - Test Corridor NB

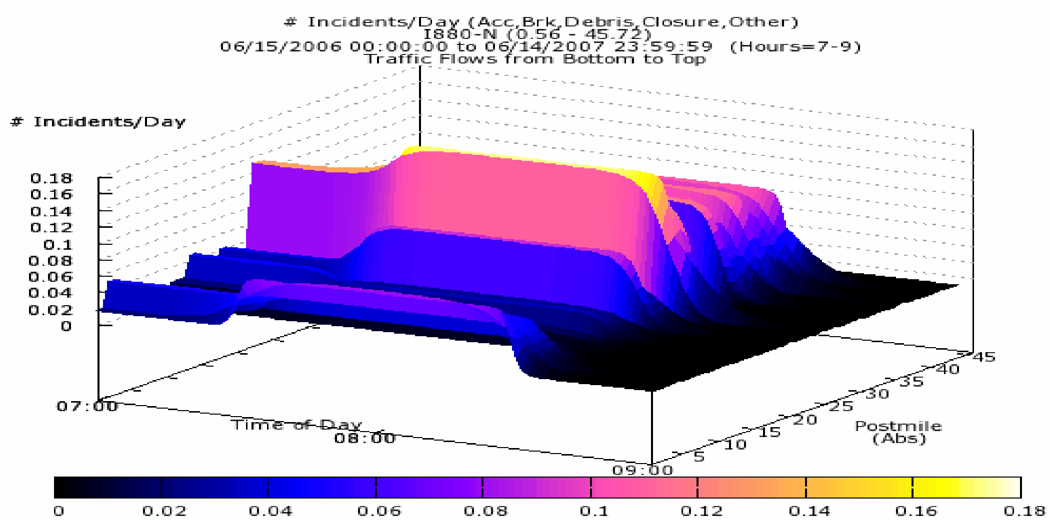


Figure 3.5 Incident Locations and Frequency on Test Corridor
Southbound

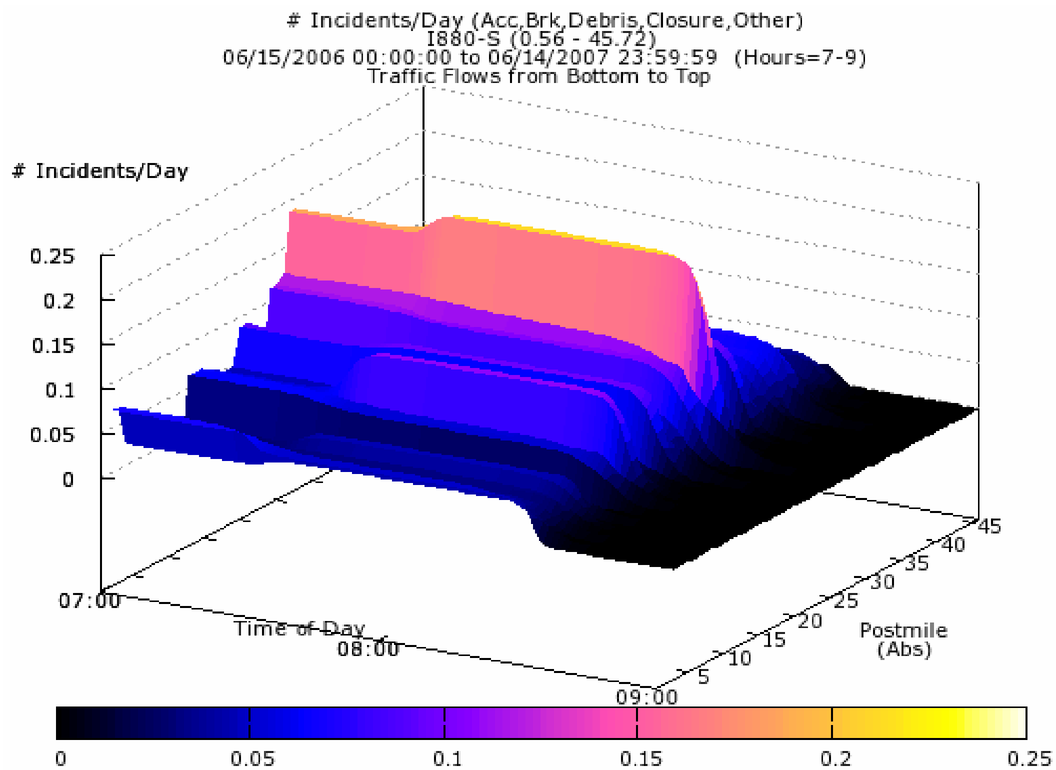


Figure 3.6 Incident Frequency in the Test Corridor
Southbound

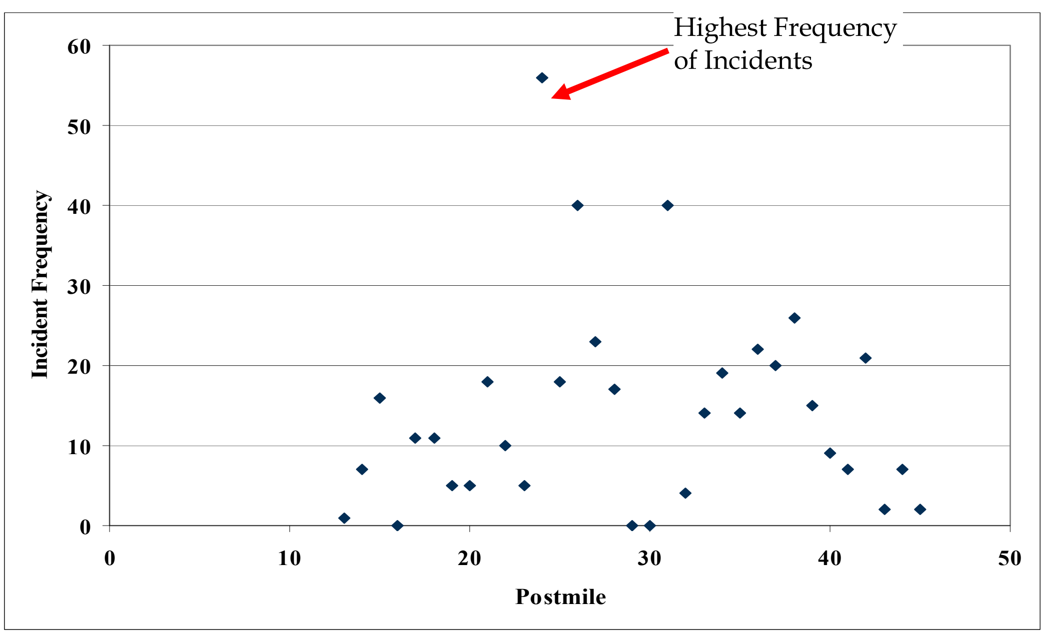


Figure 3.7 Highest Frequency Incident Location in the Test Corridor

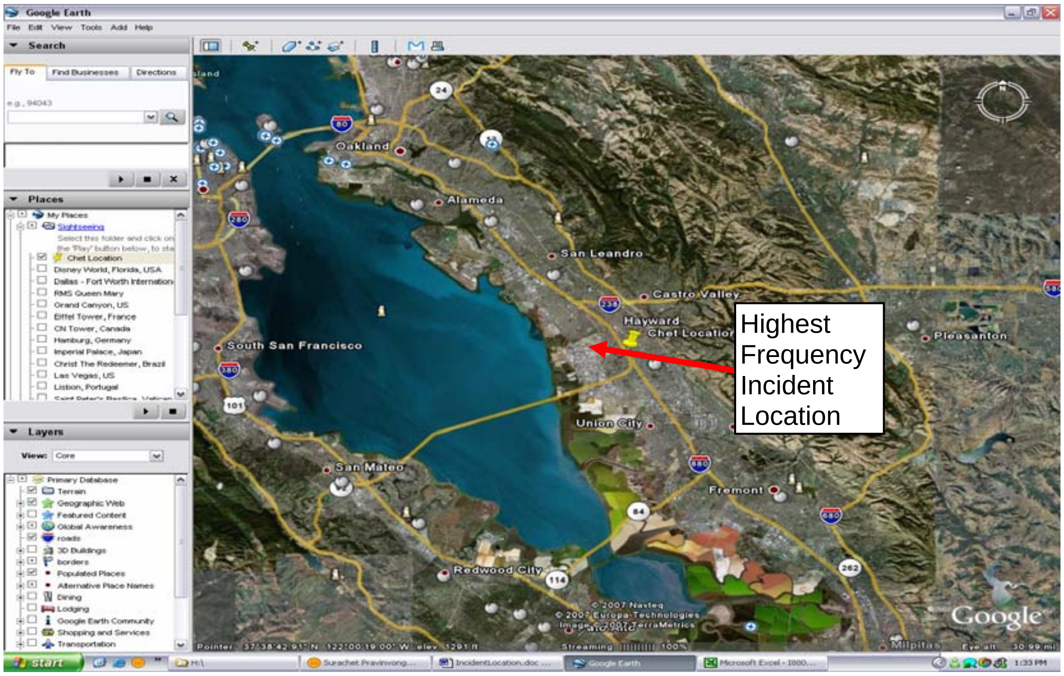


Figure 3.8 Incident Duration from PeMS

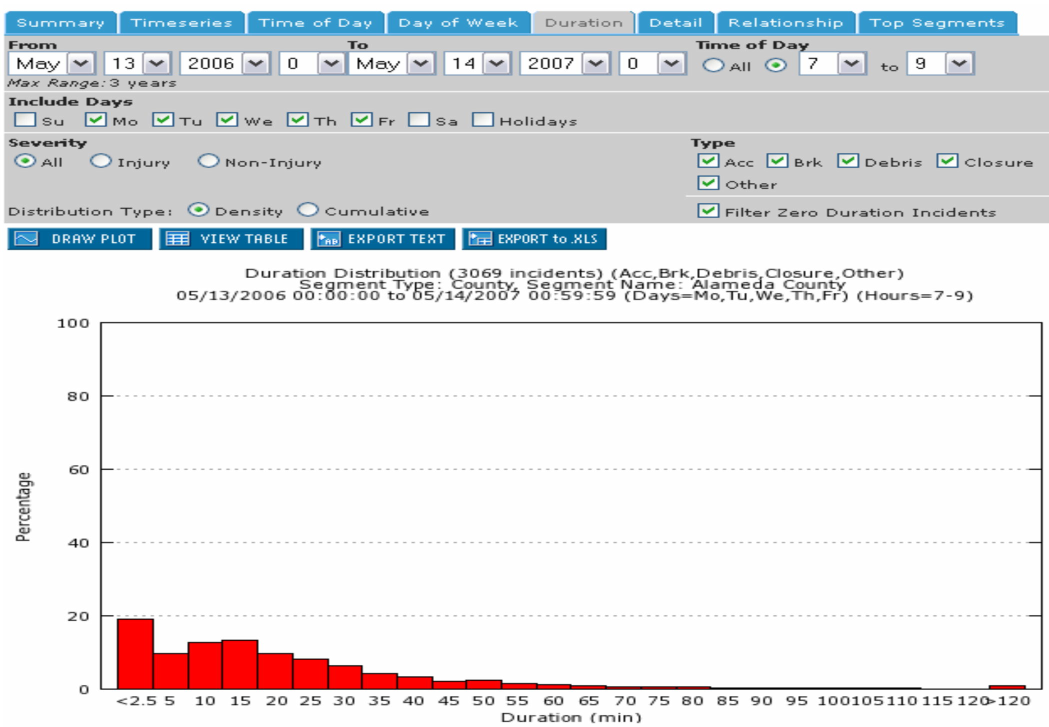
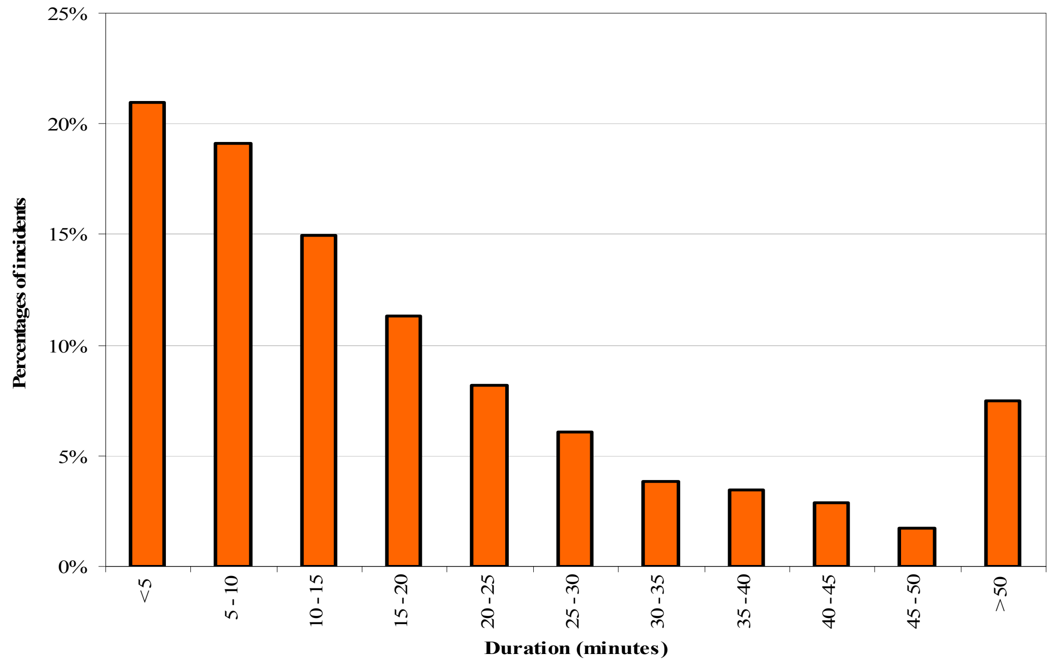


Figure 3.9 Incident Duration on the Test Corridor



3.3 Summary of Analysis Settings

Table 3.2 presents a summary of settings for the Test Corridor analysis.

Table 3.2 Test Corridor – Summary of Analysis Settings

Parameter	Value	Comment
Analysis year	2005	The analysis year is based on the available model year in the regional travel demand model.
Time period of analysis	AM peak – 2 hours (7:00 a.m.-9:00 a.m.)	The analysis period is determined by the peak-hour trip table available in the regional travel demand model. The actual analysis period in the mesoscopic and microscopic simulation models will include an initialization period of 15 minutes and a demand dissipation period of 30 minutes.
Incident location	Postmile 23	Over 55 incidents have occurred around this postmile point between May 2006 and May 2007.
Incident duration	2 lanes closed for 45 minutes starting at 7:15	Obtained from incident duration from the PeMS database and Caltrans "TMS Master Plan" study.

Table 3.3 shows the overall frequency in operational conditions for the Test Corridor, including percentage of days in the year categorized by different incident and demand levels. Major incidents are defined as having duration over 20 minutes, and minor incidents as having duration under 20 minutes.

Table 3.3 Percentages of Days in the Year Categorized by Incident and Demand Levels

	Incident Frequency		
Demand	**Minor Incident (Duration < 20 Minutes)**	**Major Incident (Duration > 20 Minutes)**	**Total**
High	20	9	29
Medium	21	8	29
Low	19	23	42
Total	**61**	**39**	**100**

3.4 ICM STRATEGIES

The remainder of this section identifies site-specific strategies, analysis scenarios, and tools to be used in the analysis of implementation of integrated corridor management on the Test Corridor. This set of ICM strategies can comprehensively test the AMS methodology in terms of traveler responses (route diversion, mode shift, and temporal shift); and in terms of interfaces for flows of data between modeling tools. The Final Report will contain more detailed information on modeling of the Test Corridor. The subset of ICM strategies selected for testing includes the following:

- **Zero ITS baselines –** Four combinations of average-/high-travel demand and presence (or not) of incident with no ITS (no ramp metering and no traveler information.) The incident is defined as a two-lane blockage at the highest incident location for 45 minutes. The travel demand model and DynaSmart-P are used in modeling these scenarios.
- **Traveler information –** Eight combinations of average-/high-travel demand and presence of incident with 1) pretrip traveler information, 2) en-route traveler information, 3) Variable Message Signs (VMS), and 4) combination of 1, 2, and 3. Traveler information on incident location and severity will provide drivers with the opportunity to take alternative arterial routes or drive to a transit station where parking is available. The analysis of these scenarios will be conducted in DynaSmart-P.
- **Mode shift to transit in the presence of an incident –** This scenario focuses on the evaluation of mode shift due to the incident. It will study the impact of parking availability by manipulating parking search time. Parking capacity at different BART stations will be taken into account. In this scenario, travel times from DynaSmart-P will be imported in an external Geographic Information System (GIS)-based, mode-shift pivot point model. An iterative process will be applied to analyze mode choice for each 15-minute period.

- **Ramp metering –** Freeway traffic management can be obtained by controlling the vehicles entering the freeway through ramp metering. The analysis of ramp metering will be conducted using DynaSmart-P to assess regional diversion effects.
- **HOT lane** – High-Occupancy Toll (HOT) lanes provide the potential to optimally use the HOV lanes while generating revenue. Converting the existing HOV lane in the I-880 corridor will be studied using DynaSmart-P. Mode shift effects will be studied using the pivot point mode shift model.
- **Arterial traffic signal coordination –** Evaluation of arterial traffic signal coordination strategies using Synchro, DynaSmart-P, and the pivot-point mode choice model.
- **Combinations –** Applying combinations of traveler information, transit, ramp metering, and HOT lane strategies will be evaluated. A combination of DynaSmart-P, and the pivot-point mode shift model will be used in this analysis.

The strategies and scenarios that will be studied on the Test Corridor are presented in Table 3.4.

Table 3.4 Test Corridor Analysis Scenarios

Scenario	Travel Demand	Incident	ICM Strategy	Description
Zero ITS baseline	Average, high	No, yes	No ITS	Combinations of average-/high-travel demand and presence (or not) of incident with no ITS (no ramp metering and no traveler information.) Incident is defined as a 2-lane blockage at the highest incident location for 45 minutes.
ICM A	Average, high	Yes	Traveler information	DynaSmart-P and the pivot-point mode choice model – pretrip and en-route traveler information at 5% and 20% market penetration; VMS.
ICM B	Average, high	Yes	Mode shift to transit	Impact of incident information on mode shift will be studied using DynaSmart-P, the travel demand model, and the pivot-point mode choice model.
ICM C	Average, high	No, yes	Ramp metering	A ramp metering strategy will be studied using DynaSmart-P and the pivot-point mode choice model.
ICM D	Average, high	No, yes	HOT lane	Evaluation of HOT lane pricing will be studied using DynaSmart-P and the pivot-point mode choice model.
ICM E	Average, high	No, yes	Arterial traffic signal coordination	Evaluation of arterial traffic signal coordination strategies using Synchro, DynaSmart-P, and the pivot-point mode choice model.
ICM F	Average, high	No, yes	Combinations	Combinations of all ICM strategies will be studied using all available models

4.0 Model Calibration

Accurate calibration is a necessary first step for proper simulation modeling. Before modeling ICM strategies, model calibration ensures that base scenarios represent reality, creating confidence in the scenario comparison. It should be noted that even the most detailed microsimulation model still contains only a portion of all of the variables that affect real-world traffic conditions, which can affect the accuracy of the calibration. Details of the methodology that will be used for data calibration are provided below.

4.1 Simulation Model Calibration

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. These parameter adjustments are necessary because no simulation model can include all of the possible factors (both on- and off-street) that might affect capacity and traffic operations. The calibration process accounts for the impact of these "unmodeled" site-specific factors through 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.

4.2 Calibration Approach

Available data on bottleneck locations, traffic flows, and travel times will be used for calibrating the simulation models for the analysis of the Test Corridor. The Test Corridor calibration strategy will be based on the three-step strategy recommended in the FHWA Guidelines for Applying Traffic Microsimulation Modeling Software:[2]

1. **Capacity calibration –** An initial calibration will be 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 performed first, followed by link-specific fine-tuning.
2. **Route choice calibration –** The Test Corridor has parallel arterial streets, making route choice calibration important. A second calibration process will be performed with the route choice parameters. A global calibration is performed first, followed by link-specific fine-tuning.
3. **System performance calibration –** Finally, the overall model estimates of system performance (travel times and queues) are 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.

Calibration Criteria

Calibration criteria presented in Table 4.1 will be applied for the test corridor simulation, subject to the budget and schedule constraints for the Test Corridor AMS.

Table 4.1 Calibration Criteria for the Test Corridor AMS

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

[2] 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.

4.3 Preliminary Model Calibration Results

Preliminary results for the calibration of the Test Corridor DynaSmart-P model are presented in this section.

- Figure 4.1 shows observed versus simulated traffic volumes across 7 consecutive iterations in the calibration process. Progressively the calibration results have become better from Iteration 1 to Iteration 7. For most links with high-traffic volumes (greater than peak-period traffic flows of 2,000), simulated volumes fall within the 15 percent error range (dotted lines in Figure 4.1.)
- Figure 4.2 shows percent error between observed and simulated traffic volumes for the calibrated DynaSmart-P baseline simulation. Again, for most links with high-traffic volumes (greater than peak-period traffic flows of 2,000), simulated volumes fall within the 15 percent error range (dotted lines in Figure 4.1).
- Table 4.2 shows observed, simulated, and free-flow average travel times at 6 segments of the Test Corridor in the southbound direction. Overall, the simulated corridor travel time is within the 15 percent error range.
- Table 4.3 shows observed, simulated, and free-flow average travel times at 7 segments of the Test Corridor in the northbound direction. Overall, the simulated corridor travel time is within a 20 percent error range.

Figure 4.1 DynaSmart-P Calibration
Observed vs. Simulated Volumes

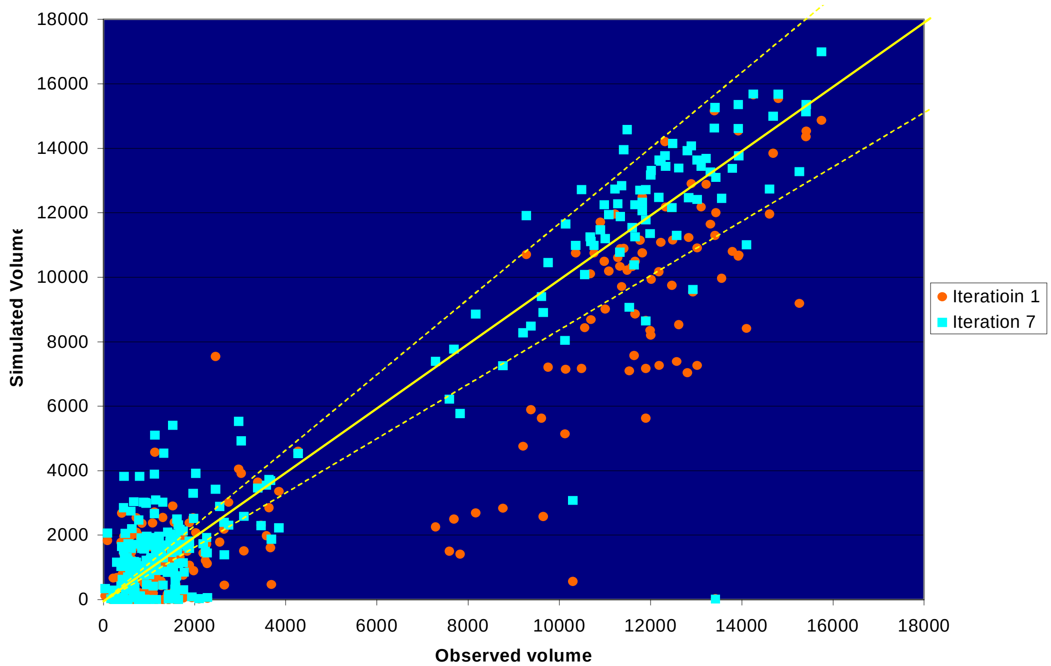


Figure 4.2 DynaSmart-P Calibration
Error in Link Volumes

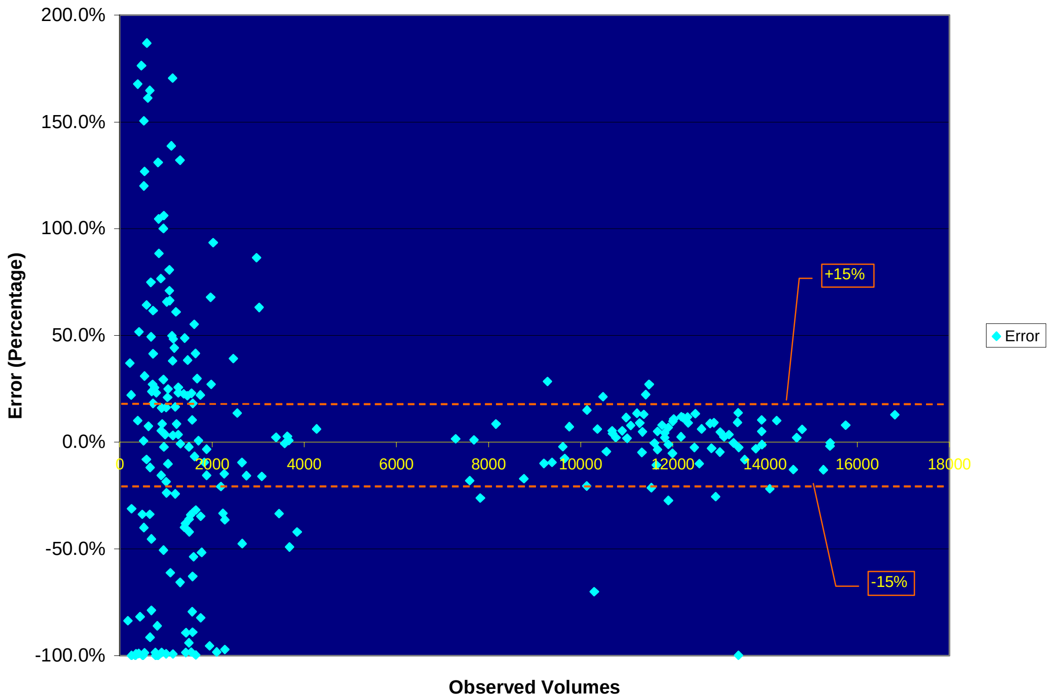


Table 4.2 Travel Time Calibration
Southbound – AM

Segment	Start	End	Observed Time (in Minutes)	Simulated Calibrated (in Minutes)	Free-Flow Travel Time (in Minutes)
1	N. end	29th Avenue	4.90	5.12	4.30
2	29th Avenue	98th Avenue	4.15	4.02	3.60
3	98th Avenue	I-238	8.10	8.79	3.70
4	I-238	SR 92	7.40	10.29	3.90
5	SR 92	SR 84	6.97	10.22	5.73
6	SR 84	Auto mall	6.92	5.51	5.01
Total			**38.44**	**43.95**	**26.24**

Table 4.3 Travel Time Calibration
Northbound – AM

Segment	Start	End	Observed Time (in Minutes)	Simulated Calibrated (in Minutes)	Free-Flow Travel Time (in Minutes)
1	S. end	Auto mall	6.35	5.72	5.94
2	Auto mall	SR 84	5.12	12.18	5.04
3	SR 84	SR 92	11.27	16.37	5.91
4	SR 92	I-238	3.90	5.86	3.30
5	I-238	98th Avenue	6.45	3.97	3.90
6	98th Avenue	29th Avenue	5.37	3.58	3.63
7	29th Avenue	N. end	5.45	5.18	3.93
Total			**43.91**	**52.86**	**31.65**

Some of these calibration results do not meet the calibration criteria presented in Table 4.1 primarily because meeting these criteria was assigned a lower priority given the resource constraints for the Test Corridor AMS. In a real-corridor ICM application continued calibration is needed, including a) calibration for average and non-average conditions, b) meeting calibration targets for aggregate travel times and delay, and c) more explicitly taking into account bottleneck flows including temporal variation throughout the modeled time period.

5.0 Performance Measures

This section details the performance measures to be used in the evaluation of ICM strategies for the Test Corridor. To be able to compare different investments within a corridor, a consistent set of performance measures will be applied. These performance measures:

- Provide an understanding of existing traffic conditions in the study area;
- Demonstrate the ability of ICM strategies to improve corridor mobility, throughput, reliability, and safety based on current and future conditions; and
- Help prioritize individual investments or investment packages within the Test Corridor for short- and long-term implementation.

To the extent possible, the measures will be reported by:

- **Mode –** SOV, HOV, transit, freight, etc.;
- **Facility Type –** Freeway, expressway, arterial, local streets, etc.; and
- **Jurisdiction –** Region, county, city, neighborhood, and corridor-wide.

The performance measures focus on the following three key areas. Additional information on these measures is provided in the "ICM AMS Methodology" document.

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. **Safety –** Captures the safety characteristics in the corridor, including crashes (fatality, injury, and property damage).

Mobility

Mobility describes how well the corridor moves people and freight. The mobility performance measures are readily forecast. Two primary types of measures will be used to quantify mobility in the Test 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 will be computed for the peak period.
2. **Delay –** This is defined as the total observed travel time less the travel time under uncongested conditions, and will be reported both in terms of vehicle-hours and person-hours of delay. Delays will be calculated for freeway mainline and HOV facilities, transit, and surface streets.

Reliability of Travel Time

Reliability captures the relative predictability of the public's travel time. Unlike mobility, which measures how many people are moving at what rate, the reliability measure focuses on how much mobility varies from day to day. For the Test Corridor, travel-time reliability will be calculated using the simulation models by performing multiple model runs for all scenarios.

A combination of the "Buffer Index" and the standard deviation of travel time for the peak period will be used to report travel-time reliability for the Test Corridor. The buffer index is defined as the extra time (or time cushion) that travelers must add to their average travel time when planning trips to ensure on-time arrival. On-time arrival assumes the 95^{th} percentile of travel-time distribution. The buffer index is the difference between the 95^{th} percentile travel time and the average travel time for the peak period divided by the average travel time:

$$BufferIndex = \frac{([95thPercentileTravelTime] - [AverageTravelTime])}{[AverageTravelTime]}$$

Safety

For the safety performance measure, the number of accidents and accident rates from accident databases will be used for the Test Corridor. For the Test Corridor, safety analysis will be conducted qualitatively using expected levels of improvement in safety as a result of deploying mitigation strategies (e.g., major improvement, minor improvement, none, slightly worse, etc.).

Cost Estimation

For the identified mitigation strategies, the analysis team will prepare planning-level cost estimates, including life-cycle costs (capital, operating, and maintenance costs). Costs will be expressed in terms of the net present value of various components.

6.0 Summary

The AMS Methodologies Document (Task 2.3) provided a discussion of potential ICM analytical approaches for the assessment of generic corridor operations. The AMS framework identified strategies and procedures for tailoring AMS general approaches toward individual corridors with different application requirements and modeling characteristics. This document, the Experimental Plan, lays out the scope of analysis that will be conducted through the application of the AMS methodology to the Test Corridor.

The purpose of the Test Corridor modeling is to perform a pilot study to evaluate the following:

- Proof of concept for the AMS framework;
- Development and application of interfaces for flow of data between modeling tools; and
- AMS application of a subset of ICM strategies to the test corridor.

The general methodological approach presented in the AMS framework will require significant tailoring to account for the application of specific software for the macroscopic, mesoscopic, and microscopic modeling. Depending on the scope, complexity, and questions to be answered within a specific corridor, there may be more or less emphasis on each of the three general model types and their interaction.

Potential risks and applicability issues associated with the suggested methodology include:

- The Test Corridor AMS application calls for different levels and forms of model integration of the macro, meso, and micro models. Limitations in all three software programs may present challenges. However, the AMS methodology has been designed in a way that is flexible to the availability of different types of models at different Pioneer Sites.
- While the emphasis of the AMS methodology has been to provide the greatest degree of flexibility and robustness in supporting subsequent tasks for the Test Corridor and AMS support of Pioneer Sites, the actual application to the Test Corridor will evaluate the practicality of the process.
- The Test Corridor modeling emphasizes using available data sources. Depending on the availability of data, accuracy of model calibration can be impacted.
- The proposed methodology includes the development of a simple pivot-point mode shift model and a transit travel-time estimation module to support comparison of network and modal alternatives, and facilitate the analysis of

traveler shifts among different transportation modes. This is custom software where the requirements have to be carefully specified to create a robust program.

- The proposed methodology also includes the development of linkage mechanisms required to establish consistency between the modeling resolutions of the AMS candidate tools. Inaccuracies in the interface that are not weeded out can severely impact the modeling effort.

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