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MEMORANDUM

To:	ALA I-580 Technical Corridor Team
From:	Rick Dowling, Allen Huang, Kym Sterner
Project:	MTC/Caltrans I-580 Corridor System Management Plan Technical Support
Subject:	**Travel Demand Forecasting And Traffic Operations Analysis Methodology (FINAL)**
Date:	September 12, 2008 (revised September 27, 2008)
File:	c:\work\proj\061016b mtc i-580\task order 4 method\final traffic anal.doc

1. Introduction

This memorandum provides a detailed overview of the recommended travel demand forecasting and traffic operations analysis methodology that will be used to provide technical support to the development of the ALA 580/238 corridor system management plan.

A meeting was held with the MTC and Caltrans04 corridor technical team on September 10, 2008 to review the August 25 draft of this memorandum. This final version reflects the agreements reached at that meeting plus additional comments sent to us on September 23, 2008. Major changes are highlighted in yellow. A new section has been added at the end giving point-by-point responses to the comments received.

1.1. Purpose of the Corridor System Management Plan

The basic purpose of a Corridor System Management Plan (CSMP) is "to preserve the mobility gains of urban corridor capacity improvements over time".[1]

"CSMP's provide for the integrated management of travel modes and roadways so as to facilitate the efficient and effective mobility of people and goods within California's most congested transportation corridors. Each CSMP presents an analysis of existing and future traffic conditions and proposes traffic management strategies and transportation improvements to maintain and enhance mobility. CSMP's will address State Highways, local roadways, transit, and other transportation modes. The corridor management planning strategy is based on the integration of system planning and system management." [2]

[1] California Transportation Commission, Corridor Mobility Improvement Account Program Guidelines, Adopted November 8, 2006
[2] Caltrans http://www.dot.ca.gov/dist3/departments/planning/corridorplanning.html

"Development of each CSMP involves a six-step process:

1. Defining the Corridor System Management Plan transportation network including, but not limited to, State Highways, major local streets and roads, intercity rail service, regional rail service, primary regional transit service, and key regional bicycle facilities
2. Summarizing existing travel conditions along the corridor.
3. Evaluating existing system management practices along the corridor.
4. Forecasting future travel conditions along the corridor, including modal performance.
5. Preparing a corridor management strategy, including proposed detection and monitoring strategies, needed capital improvement projects, and the roles and responsibilities of each jurisdiction in the corridor management process.
6. Acceptance by the applicable regional transportation planning agency." [3]

1.2. Status of the ALA-580/238 Corridor System Management Plan

The status of the development of the ALA-580/238 CSMP is given in the table below. Milestones 1 and 2 are complete. Milestones 3 and 4 are in progress. Work has not yet begun on Milestones 5 – 8.

Milestone	Completion Date	Status
1. Corridor Defined	June 2007	Complete
2. Corridor Team Assembled	January 2008	Complete
3. Preliminary Performance Assessment	September 2008	In Progress
4. Detection in Place	December 2008	In Progress
5. Comprehensive Performance Assessment	March 2009	
6. Causality Identified	March 2009	
7. Microsimulation Model and Scenario Test	June 2009	
8. Plan Complete/Adopted	September/December 2009	

1.3. Purpose of the Technical Support to the ALA-580/238 CSMP

The purpose of the technical support is to provide the technical analysis and numerical performance measure results to aid the corridor technical team and the corridor stakeholders in selecting and prioritizing traffic operation and demand management strategies for preserving the mobility improvements in the I-580/238 corridor.

1.4. Alternatives to be Evaluated

The alternative strategies to be evaluated for the CSMP will be determined later in consultation with the corridor technical team and the corridor stakeholders. At this early point in time it appears that the ALA-580/238 CSMP will focus on freeway management strategies taking into account of the potential synergies of arterial management strategies. However the primary emphasis will be on the evaluation, testing, and prioritization of freeway management strategies with a lesser emphasis on arterial management strategies. Arterial management strategies will be evaluated only to the extent that they can support the freeway management strategies without drawing freeway traffic onto city streets and county roads. This policy reflects the local sensitivities of adjacent cities in the corridor that have expressed a strong desire to keep freeway traffic on the freeway through the concrete steps they have taken to discourage freeway traffic from using city streets.

[3] Caltrans http://www.dot.ca.gov/dist3/departments/planning/corridorplanning.html

The ALA-580/238 CSMP is likely to include the capacity improvement, freeway management, arterial management, and transit improvement components listed in Exhibit 1. The proposed analysis methodology and modeling approach are designed to provide the necessary performance measures required to evaluate these types of improvements. Note that arterial management strategies are included only to the extent that they support freeway management and do not attract freeway traffic onto surface streets.

1.5. Performance Measures

The technical work for the ALA-580/238 CSMP will produce the performance measures called for in Caltrans' "Guidelines for Completing CSMP Milestones". According to these guidelines the performance assessment should aim to address the entire corridor; however, it should have at least two freeway components:

1. Development of Corridor-wide Performance Measures, and
2. Identification of Bottlenecks in Corridor.

The Guidelines state that Corridor-wide performance measures should address several outcomes; mobility, reliability, safety, productivity, and preservation using the following measures:

- Mobility – Delay, Travel Time
- Reliability – Variation of travel time or the Buffer Index
- Safety – Accidents, accident rates
- Productivity – Lost lane miles of capacity due to congestion
- Preservation – Number and locations of distressed (pavement condition) lane miles

The "Guidelines" further state that the identification of the major bottlenecks should include an estimate of the extent of the queues forming behind each bottleneck. (Although not explicitly called for in the Guidelines, the consultant will also estimate delay for each bottleneck.)

The "Guidelines" also state that, "To the extent possible, the performance assessment should also include a discussion of transit performance on the corridor and on major arterials selected as part of the corridor definition milestone. The degree to which such measures are desired should be discussed with the stakeholder group, who in turn, should be required to provide needed data to perform such assessments. Of particular interest would be travel times on parallel arterials, transit travel times, transit ridership, and frequency of service."

In accordance with the Guidelines, performance data for traffic and transit on local streets under existing conditions will be computed only where local agency stakeholders actually provide the necessary input data (such as: intersection turn movement counts, lane geometry and signal timing for signalized intersections; accident data and pavement condition data for street links; and on-time and peak load point surveys for transit).

1.6. Corridor Study Limits

The corridor study limits include the I-238/I-580 freeways from the I-880 freeway interchange in San Leandro to the I-205 interchange in Tracy (Postmile: ALA 238 14.47/16.69, ALA 580 0.393/R30.807), the ramps connecting the freeways to the surface street system, the intersections at the foot of the ramps, the streets feeding the ramps, and arterial streets parallel to the freeways and located within one mile of the freeways.

These corridor study limits are shown in Exhibit 2. The study limits include large portions of the cities of Dublin, Pleasanton, Livermore, and Hayward. This will be called the "**Super Corridor**". Travel demand changes and traffic operations changes within the Super Corridor will be studies at the planning model level of detail. General changes in vehicle-miles travelled, vehicle-hours travelled, delay, and link level demand/capacity ratios will be reported. However queuing analyses and hot spot analyses will not be conducted at the Super Corridor level.

The recommended demand model will greatly exceed the study limits for the Super Corridor, incorporating all of the Bay Area in the demand analysis. The impacts of regional highway and transit improvements in other corridors in Alameda County and throughout the Bay Area will be taken into account in the forecasting of demand by mode for the ALA-580/238 corridor. The demand model outputs however will be tabulated and reported only for those road and transit links falling within the study limits identified in the exhibit.

The more detailed traffic operations analysis will focus on a narrower area, the "**Thin Corridor**". The traffic operations analysis will be limited to the ALA-580/238 freeways, their ramps, the surface street intersections at the foot of the ramps, plus one signalized intersection beyond the intersection at the foot of the ramps (if the signalized intersection is located within ½ mile of the ramp intersection). Detailed traffic operations analyses consisting of hot spot and queuing analyses will be conducted within the Thin Corridor.

1.7. Purpose of This Memorandum

The purpose of this memorandum is to describe in detail the overall travel demand forecasting and traffic analysis procedures to be applied to the evaluation of existing conditions and the assessment of alternative traffic operation and demand management strategies for the ALA-580/238 CSMP. The corridor technical team will review and comment on this memorandum. A revised memorandum will be issued and used as the template for all further technical analyses for the corridor CSMP. The scope of work for following tasks may be modified based on modifications to this memorandum.

The more detailed aspects of the microsimulation approach (specifically model coding conventions, validation tests and acceptance criteria) will be described in a follow-up memorandum on the microsimulation approach. This latter memo will be primarily of interest to microsimulation modelers.

Exhibit 1: Likely Components of ALA-580/238 CSMP

Capacity Improvement Components
Add Lane Auxiliary Lane Truck Climbing Lane Ramp Lane Additions
Freeway Management System Components

Surveillance
  Traffic
  Infrastructure
Ramp Control
  Ramp Metering
  Ramp Closures
  Priority Access
Lane Management
  HOV facilities
  Reversible Flow Lanes
  Pricing (real time tolling, HOT lanes)
  Lane Control
  Variable Speed Limits
  Emergency Evacuation
Special Event Transportation Management
  Occasional Events
  Frequent Events
  Other Events
  Temporary Transportation Management Centers
Information Dissemination
  Dynamic Message Signs (DMS)
  In-vehicle Systems (IVS)
  Highway Advisory Radio (HAR)
Enforcement
  Speed Enforcement
  High Occupancy vehicles (HOV)
  Ramp Meter Enforcement
Incident Management Systems
  Surveillance and Detection
  Mobilization and Response
  Information Dissemination
  Clearance & Recovery

Arterial Management Components
Traffic Control to Protect Streets from Freeway Traffic Lane Management to Protect Streets from Freeway Traffic Information Dissemination to Protect Streets from Freeway Traffic Enforcement to Protect Streets From Freeway Traffic
Transit Improvements
BART Extension to Livermore Express Bus ACE Train Improvements Park & Ride Lots

Source: http://www.itsoverview.its.dot.gov/ with additions by Dowling Associates
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Exhibit 2: ALA-580/238 Corridor Study Limits (The "Super Corridor")

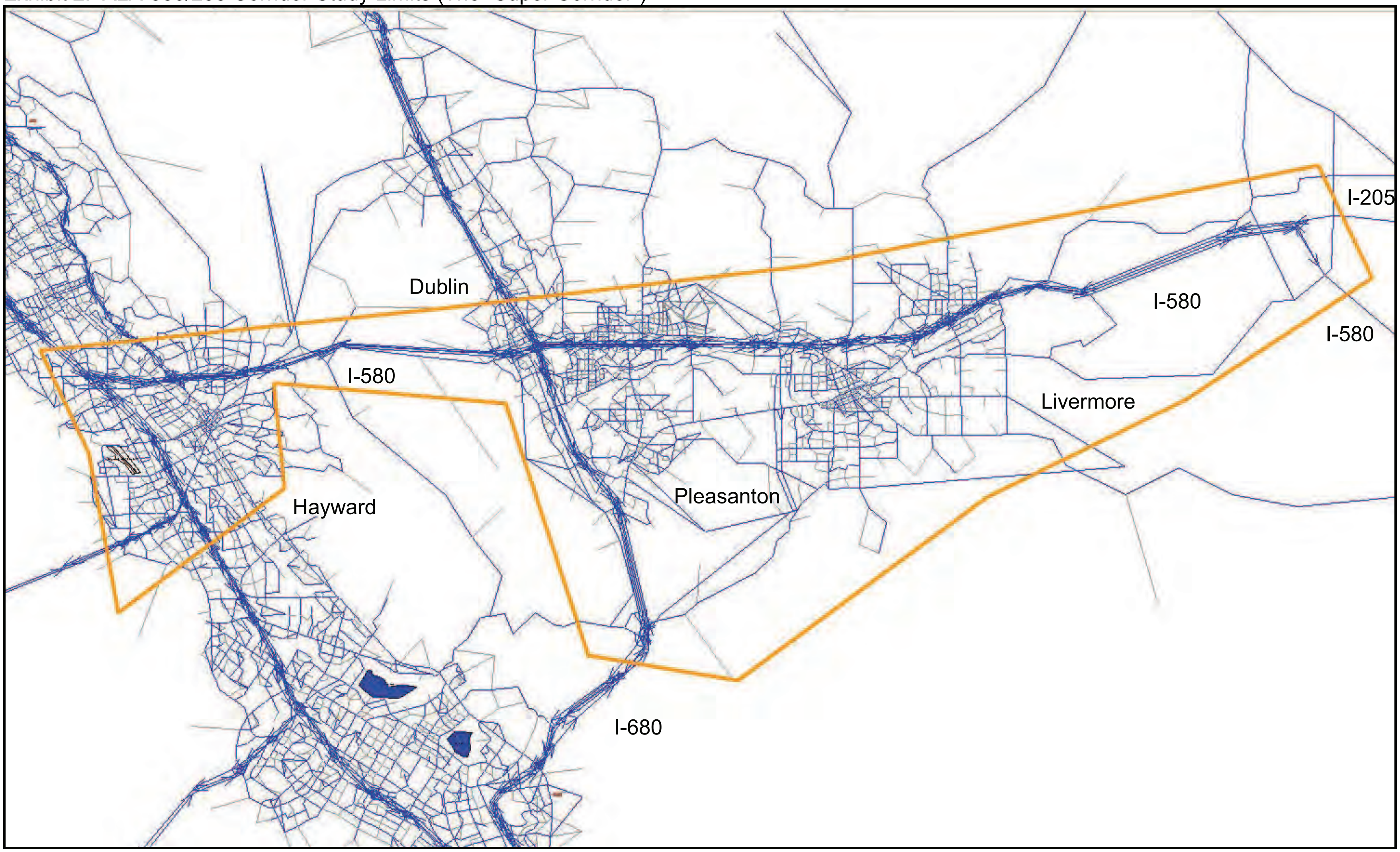
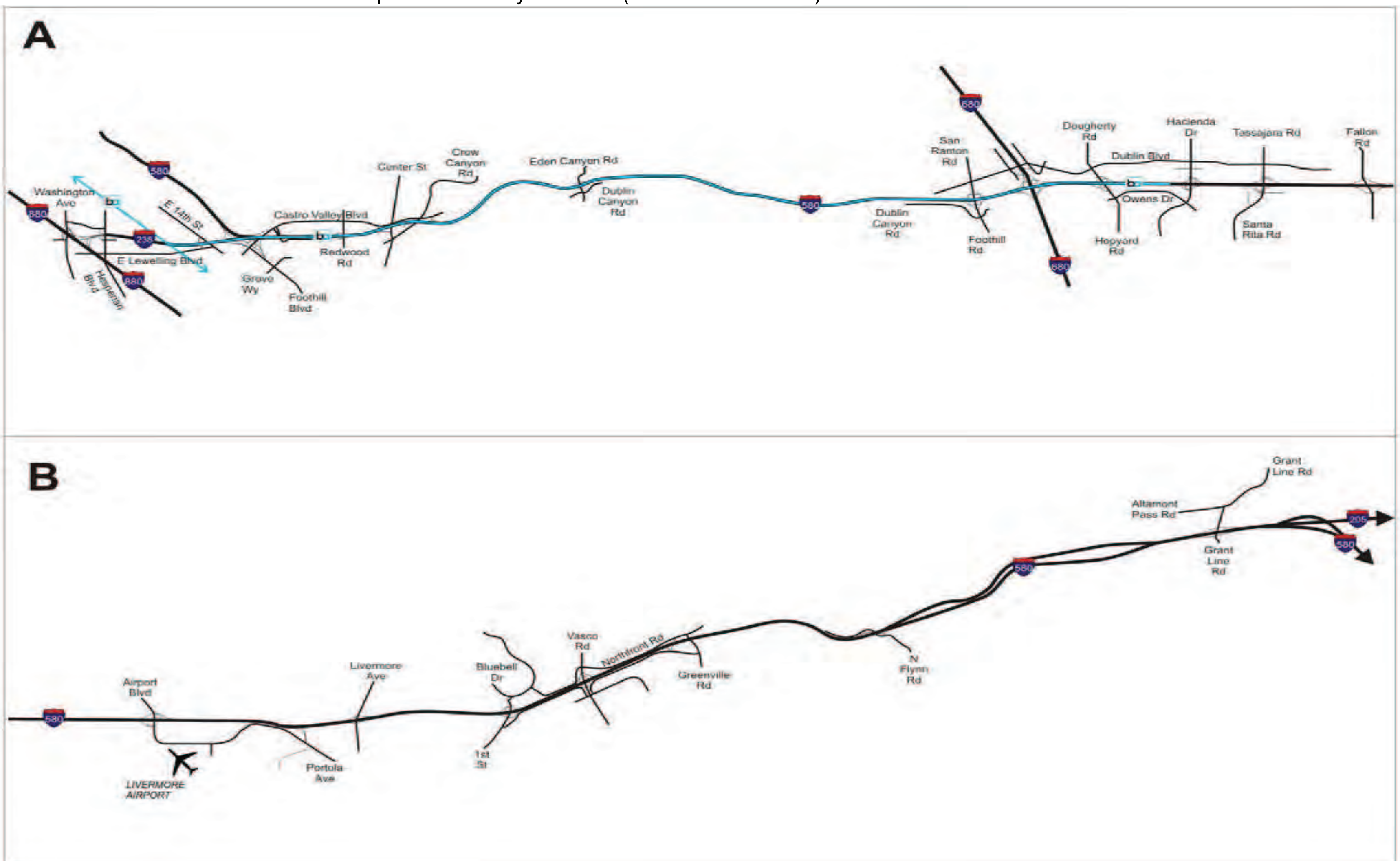


Exhibit 3: ALA-580/238 CSMP Traffic Operations Analysis Limits (The "Thin Corridor")



2. TRAVEL DEMAND FORECASTING METHODOLOGY

This section describes the recommended travel demand forecasting methodology.

An origin-destination (OD) estimator will be used to estimate existing freeway ramp origin-destination (OD) table from ramp counts. This estimated 2008 OD table will then be growth factored up to future year freeway mainline and ramp OD using a county-wide travel demand model.

Intersection peak hour turning movement counts will be forecasted to future turn volumes using growth factors obtained from the county-wide travel demand model.

Transit patronage and diversions between surface streets and freeways, and other corridors will be forecasted using the county-wide travel demand model.

2.1. Recommended Travel Demand Model

The best available travel demand model for the corridor is the Alameda County CMA Countywide travel demand model. It has superior zonal and network detail to the MTC model, is a clone of the MTC model, and was very recently updated with new land use and network data sets. The ACCMA model and its datasets will be the primary tool used to develop forecasts for the corridor and to identify mode shifts and spatial shifts for traffic between freeway and surface streets in the corridor that might be caused by the proposed CSMP strategies.

The ACCMA model operates within the TP+/Cube software environment and is directly consistent with the most current regional MTC model land use and network assumptions. This includes ABAG Projections 2005 land use information and MTC 2005 Regional Transportation Plan (RTP) programmed roadway network improvement assumptions.

The land use and networks are currently being updated to ABAG Projections 2007 and a maximum forecast year of 2035. We proposed to used this updated model data set to develop the forecasts for the I-580 corridor..

The ACCMA Model covers the entire nine county Bay Area with a special focus on Alameda County, using over 2,600 traffic analysis zones. The roadway network is represented by 10 different facility types (freeway to freeway connectors, freeways, expressways, collectors, freeway ramps, dummy, major arterial, metered ramp, special 1, and special 2) in 6 different area types (core, central business district, urban business district, urban, suburban, and rural).

The model contains land use and transportation network datasets for the years 2000, 2015, and 2035.

Trips are modeled using 7 trip purposes (home-work, home-shop/other, home-social/recreation, non-home based, home-grade school, home-high school, and home-college).

Unlike the MTC model, the ACCMA model includes San Joaquin County as a set of internal zones and network.

Internal-external, and external-external trips are forecasted in the ACCMA model based on growth factors obtained from Caltrans' Statewide Travel Demand model.

The MTC model trip distribution method is used in the ACCMA model to distribute person-trips.

Mode choice follows the MTC model for non-home-based work trips. For Home-based work trips the ACCMA model splits the trips between SOV, SR2 (shared ride 2 person), SR3+ (shared ride 3 or more persons), transit, bike, and walk modes.

The ACCMA model produces AM and PM peak period OD tables for single occupant vehicles (SOV), two-person shared ride vehicles (SR2) three person or more shared ride vehicles (SR 3+), trucks, and transit passengers.

Truck trips are generated and distributed separate from the other trip types. No mode choice is applied to them.

OD tables and traffic forecasts are produced for a one-hour AM peak hour, a one-hour PM peak hour, a 2-hour PM peak, a 4-hour PM peak period, and for all-day. Transit patronage is predicted only for all-day.

The ACCMA model will be used to forecast future peak hour turning movements at the surface street intersections and the future peak period origin-destination (OD) table for the freeway ramps.

2.2. Recommended Analysis Time Periods

It is recommended that the same analysis time periods be used in this study as were used by Caltrans 04 to evaluate the performance of the I-580 freeway before and after the westbound ramp meters were turned on east of I-680. These time periods are:

- 24-hours Average Weekday
- AM peak 4-hour (5:00 AM to 9:00 AM)
- PM peak 5-hour (2:30 PM to 7:30 PM)

2.3. Recommended Forecast Horizon Years

It is recommended that the traffic analysis for the ALA-580/238 CSMP focus on one existing year and two forecast years.

- 2008 (Existing Conditions)
- 2015 (Short Term Baseline Forecast)
- 2035 (Long Term Baseline Forecast)

The 2008 existing conditions analysis will be used to establish a base for developing growth factors and comparing future corridor demands to current corridor demands. It will also be used for validating the microsimulation model(s).

The 2015 short term baseline forecast will provide the setting for evaluating short term improvements to the ALA-580/238 corridor. This baseline forecast will include all programmed improvements expected to be in place by circa 2015.

The 2035 long term baseline forecast will include the same improvements as were assumed in the 2015 baseline forecast plus any additional programmed improvements that are expected to be in place by 2035 (could be no additional improvements beyond those identified for 2015).

2.4. Recommended Refinements to ACCMA Model

It is recommended that various refinements be made to the ACCMA model to improve its ability to model the I-580/238 corridor, to better interface the demand model with microsimulation models of the corridor, and to verify the validity of the ACCMA model for the corridor.

Update Network Coding to 2008

The ACCMA model roadway year 2005 network within the immediate vicinity of the corridor will be compared to the recent aerial photos and field surveys, and updated to 2008. The network in the immediate vicinity of the ALA-580/238 freeways will be checked to verify that it accurately represents roadway conditions, including facility type, number of lanes, speeds and capacities. Turn penalties will be checked to verify that they represent existing turn prohibitions.

Freeway ramp link capacities for the AM and PM peak periods will be adjusted to match Caltrans ramp metering rates for eastbound I-580 (to reflect existing conditions) and for westbound I-580 for baseline future conditions.

Turn prohibitors coded in the model will be reviewed to determine if any modifications may be desirable to improve traffic loading at the intersections in the immediate vicinity of the ALA-580/238 freeways.

Surface street intersections to be included in the detailed traffic operations analysis will be coded with a node attribute that allows the model software to automatically output turn movement volumes. These volumes can then be imported into an Excel data base spreadsheet for post-processing. The Excel spreadsheet format and template will allow direct importing of modeled turn movement volumes into SYNCHRO for intersection LOS analysis.

Expansion of ACCMA Model Time Periods to Desired Study Time Periods

The ACCMA model currently has trip generation factors for Daily, AM 1-hour, PM 1-hour, PM 2-hour and PM 4-hour traffic demands. These factors will be extended to 4-hour AM and 5-hour PM based on 2000 BATS survey data. Link capacities will be increased to 4-hour values for the AM assignment process, and to 5-hour values for the PM assignment process. The revised model will output, Daily traffic and transit ridership, AM 4-hour traffic, and PM 5-hour traffic volumes.

Estimation of 2008 Regional Demand

The ACCMA model 2005 land uses will be updated to 2008 by interpolating the 2005 and 2015 land use forecasts contained in the model to the year 2008. The model will then be used to estimate the 2008 regional vehicle trip tables.

Demand Model Corridor Validation Check

The model estimates of AM peak period (4-hour) and PM peak period (5-hour) traffic volumes will be compared to the May 2008 counts for the ALA-580/238 freeway mainline and freeway ramps.

Large link and system-wide differences between the model and the counts (greater than 50% of the counts) will be investigated to determine if simple network, land use, or trip generation rate estimation errors might be corrected to solve the discrepancies. Minor, link specific differences will be carried through and applied to the forecast volumes produced by the model.

Minor differences between the model estimated surface street link volumes in the immediate vicinity of the freeway interchanges and available counts (after they have been growth factored up to 2008 and expanded to peak period volumes) will be added to future link forecasts produced by the model.

Preliminary "shake-out" tests will be made of the model for 2015 and 2035 to verify reasonableness of model forecasts. Network and land uses may be touched up to reduce unreasonable results for the forecast years.

The model estimated 2008 AM and PM peak period average vehicle occupancies (AVO) and number of peak period truck trips will be compared to available count data from other sources and adjusted (if necessary) to improve agreement between model and truck/AVO counts.

2.5. Interfacing Demand Model with Microsimulation Models

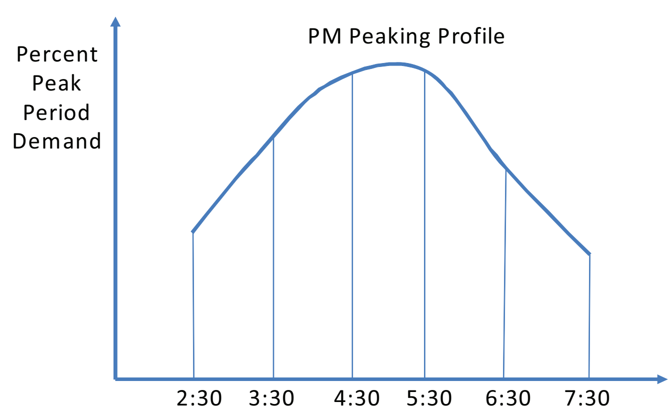
The ACCMA model will interface with the microsimulation models in several ways.

Estimation of Existing OD for Freeway

The ACCMA model will provide the AM Peak 4-hour, and the PM Peak 5-hour 2008 vehicle trip origin-destination (OD) tables (SOV, SR2, SR3+, truck) to be used by the freeway microsimulation model. The OD tables will be for freeway mainline and ramp-to-ramp OD's.

These trip tables (one table for AM, one for PM) will be fitted to the 2008 freeway ramp and mainline traffic counts using Cube's built-in OD estimation routine. Adjustments to the total vehicle trip table for each peak period will be proportioned to the SR2, SR3+, and truck trip tables. The rationale for selecting this approach is explained in a later section of this chapter.

Within period "peaking profiles" will be developed from the May 2008 count data to convert peak period demands (from the ACCMA model) to one-hour demands for each hour of each period (used in the freeway microsimulation model). These peaking profiles will be applied within the freeway microsimulation model.



Forecasting Future OD for Freeway

The ACCMA model will provide the OD cell-by-cell specific growth increments to be applied to the traffic-count-fitted 2008 OD tables for the freeway to estimate 2015 and 2035 baseline demands for the freeway microsimulation model.

Forecast OD = Fitted 2008 OD + Future Increment

Future Increment = Model Forecast − Model 2008

Subject to: Forecast OD >= 0

The future increment in each cell of the OD tables will be allowed to be negative, but it will not be allowed to reduce the future value of the cell to less than zero. Thus individual cell values of the OD tables will be allowed to take on values lower than existing conditions.

Forecasting Future Turn Moves For Surface Streets

The ACCMA model will provide the AM peak hour and PM peak hour intersection approach growth increments to add to the counted or estimated year 2008 intersection turning movements to obtain 2015 and 2035 baseline forecasts for the surface street microsimulation model(s). The NCHRP 255 method will be used to convert (Furness) approach growth increments to forecasted turning movements

Forecast Demand = Existing Count + Future Increment

Future Increment = Model Forecast − Model 2008

Subject to: Forecast Demand >= 0 (forecast demand will be allowed to drop below existing conditions)

If the future increment is exceptionally negative (more than 50% of existing), then the negative increment will be reviewed to determine if it is a legitimate result of the strategy being evaluated or is a potential modeling error. If it is possibly a modeling error, the modeling will be reviewed to see if a cause of the error can be identified and corrected.

Feedback Between Microsimulation and Demand Modelsl

The predicted congestion locations and the extent of congestion will be qualitatively verified for ACCMA and the microsimulation models to ensure that they are showing congestion in about the right places and of about the right amount.

The microsimulation predicted travel times will NOT be fed back to the ACCMA model, since its mode choice and link capacities were not originally calibrated for such a process.

Similarly, the microsimulation model predicted volumes able to pass through the corridor will NOT be used to constrain the demand estimates produced by the ACCMA model for future conditions, since these are volumes, not demand, and the ACCMA model was not originally calibrated to produce constrained volumes.

2.6. Baseline Roadway/Transit Network Improvements 2015

The highway and transit network improvements for the baseline 2015 ACCMA model run need to be determined by the Corridor Technical Team. For information purposes, the current project lists for ACTIA and ACTA are listed in Exhibit 4 and Exhibit 5

Exhibit 4: Summary of ACTIA Projects

ACTIA PROJECT NAME	Measure B 2000 Commitment (1998$)	Project Status	Begin Construction	End Construction
ACE Rail Capital Improvements	$10.0 M	Various	2002	2016
BART Extension to Warm Springs	$165.5 M	Design/ROW	2009	2013
BART Fruitvale Transit Village	$3.5 M	Completed	2002	2004
BART Oakland Airport Connector	$65.8 M	Design/ROW	2008	2011
Downtown Oakland Streetscape	$5.0 M	Design/Construction	2007	TBD
Dumbarton Corridor Improvements	$14.7 M	Environmental	2012	2015
E. 14th/Hesperian/150th Improvements	$830,000	Design/ROW	2009	2010
Hesperian/Lewelling Widening Stage 1/2	$1.0 M	Completed/Planning	2004/2008	2004/2010
I-238 Widening	$66.0 M	Construction	2006	2010
I-580 Auxiliary Lanes	$10.0 M	Various	2008	2012
I-580 Corridor BART to Livermore Studies	$8.7 M	Planning	TBD	TBD
I-580 Interchange Improvements in Castro Valley	$9.2 M	Construction	2008	2010
I-680 SMART Lane	$25.8 M	Design	2008	2010
I-680/I-880 Cross Connector Studies	$1.0 M	Planning	TBD	TBD
I-880/Broadway-Jackson Interchange	$6.0 M	Planning	TBD	TBD
I-880/State Route 92 Reliever Project Phases 1/2	$19.5 M	Planning/Planning	2011/TBD	2013/TBD
I-880/Washington Interchange	$1.1 M	Construction	2008	2009
Iron Horse Bike, Pedestrian, Transit Route	$4.5 M	Design	2013	2014
Route 84/I-580 Interchange	$20.0 M	Design/ROW	2009	2012
Lewelling/E. Lewelling Widening	$9.8 M	Design/ROW	2008	2010
Newark Local Streets	$1.2 M	Completed	2003	2004
Oakland Local Streets & Roads	$4.0 M	Completed	2004	2006
Route 84 Expressway	$70.0 M	Environmental/Design	2011	2013
San Pablo Corridor Transit Improvements	$1.8 M	Construction	2007	2008
Telegraph/International/E. 14th Bus Rapid Transit	$8.7 M	Environmental	2013	2016
Telegraph/International/E. 14th Rapid Bus	$9.5 M	Completed	2005	2006
Union City Intermodal Station	$9.2 M	Construction	2007	2010
Vasco Road Utility Relocation	$1.5 M	Completed	2007	2007
Westgate Extension Stage 1/2	$8.6 M	Completed/Study	2004/TBD	2007/TBD

Emerging Projects: Measure B 2000 recognizes that within a 20-year time frame, there may be emerging congestion areas that did not exist when the Expenditure Plan passed. In 2003, the board authorized $1.5 million of the total Measure B 2000 commitment of $7.6 million for utility relocation for the Vasco Road Safety Improvement Project in East County.
Source: http://www.acta2002.com/projects.html (Table is dated June 25, 2008).

Exhibit 5: Summary of ACTA Projects

ACTA Projects	Measure B Funding	Overall Project Cost	Project Status
Castro Valley Local Traffic Circulation Improvements	$5.0 million. This project was amended into the 1986 Expenditure Plan by the ACTA Board in December 2005.	$5.0 M	In Scoping phase
Central Alameda County Freeway System Operational Analysis	$5.0 million. This project was amended into the 1986 Expenditure Plan by the ACTA Board in December 2005.	TBD	In Scoping phase
I-580 Interchange Improvements in Castro Valley	$15 million. This project was amended into the 1986 Expenditure Plan by the ACTA Board in December 2005. It is also an ACTIA project.	$35.8 M	Construction beginning in Summer 2008
I-880/Mission Boulevard Interchange, Fremont	$29.3 M	$238.0 M	Under Construction
I-880/SR-92 Interchange	$10 M	$245.0 M	Under Construction
East-West Connector in North Fremont and Union City	TBD (to be determined)	TBD	In Environmental phase
Route 238/Mission-Foothill-Jackson Corridor Improvement Project	$80 million. This project was amended into the 1986 Expenditure Plan by the ACTA Board in December 2005, replacing the Hayward Bypass Project.	$111.0 M	In Design/Right-of-Way Phase

Source: http://www.acta2002.com/projects.html#acta (Table is dated June 25, 2008).

Exhibit 6: Transportation Improvements to be Included in 2015 Baseline Forecast

No.	Sponsor	Project	Description	Reference

This table to be filled in by ALA-580/238 CSMP Technical Team

2.7. Baseline Roadway/Transit Network Improvements 2035

The ACCMA model 2035 network currently includes the ACCMA Investment Program to be considered in Transportation 2035 which was approved by the Alameda County CMA Board of Directors on February 28, 2008. A complete listing of these improvements in the ACCMA model can be found in The Transportation 2035, Project Submittal dated March 5, 2008. The programmed projects that are specific to the I-580 freeway systems are shown in Exhibit 9.

Exhibit 7: ACCMA Investment Program 2035 Improvements

	Sponsors	Project	Comments
1	East County	I-580 Local Interchange Improvements in Dublin	Interchange improvements at Hacienda and Fallon.
2	East County	I-580 Local Interchange Improvements in Livermore	Reconstruction and modifications to I-580/First Street; I-580/Isabel Phase 2, I-580/Greenville Road and I--580/Vasco Road including auxiliary lanes.
3	East County	Project Development for I-580/I-680 Connector	This is the HOV flyover connection at the interchange as recommended in the Triangle Study list.
4	East County	I-580 Corridor Improvements	Includes auxiliary lanes at Isabel from I-580 EB and WB HOT Lanes
5	Alameda County CMA	I-580 / I-680 (NB I-680 to WB I-580) Connector, Phase 1	This project will build the flyover connection from NB I-680 to WB I-580 at the interchange.
6	Caltrans / Alameda CCMA	I-580 EBTruck Climbing Lane	Add one lane for trucks from the Greenville Rd. to N. Flynn Rd, Livermore; consistent with State's Goods Movement Action Plan.

This table provided for information purposes. These improvements, unless funded or programmed, would NOT be included in the baseline 2035 forecasts.

The highway and transit network improvements currently coded in the ACCMA model for 2035 will need to be reviewed and unfunded/unprogrammed projects removed from the network. The Corridor Technical Team will need to determine the transportation network improvements to be included in this model run (see Exhibit 8).

Exhibit 8: Additional Improvements to be Included in 2035 Baseline Forecast

No.	Sponsor	Project	Description	Reference

This table to be filled in by ALA-580/238 CSMP Technical Team

2.8. Performance Measures to be Produced by ACCMA Model

The ACCMA model will be used to produce mean travel time and delay estimates for the "Super Corridor" study area. The ACCMA model will still model the demand changes in the entire 9-county region; however, performance will be reported only for freeway and street links located within the "Super Corridor" identified in Exhibit 2 above. The Super Corridor performance measures that will be reported are:

1. Vehicle-Miles Traveled (VMT) (Daily, AM Peak 4-hour Period, and PM Peak 5-hour Period)
2. Vehicle-Hours Traveled (VHT) (same periods as for VMT)
3. Vehicle-Hours Delay (VHD) (comparing forecasted to free-flow travel times for same periods as for VMT)
4. Mean Vehicle-trip Speed (VMPH) (same periods as VMT)
5. Person-Miles Traveled (PMT) (same periods as VMT)
6. Person-Hours Traveled (PHT) (same periods as VHT)
7. Person-Hours Delay (PHD) (same periods as for VHD)
8. Mean Person-Trip Speed (PMPH) (Same periods as VMT)
9. Daily Transit Boardings (BART, Other) (Only daily)

Note that Transit vehicles and auto park & ride trips to access transit will NOT be included in the above performance measures produced by the ACCMA model. This is because the model does not currently have the capabilities of incorporating these vehicle trips into its overall estimate of vehicle trips.

The ACCMA model will NOT be used to identify or predict bottlenecks and queues.

The ACCMA model will be used to predict shifts in traffic demand between surface streets and the freeway. The model will be used to predict shifts in demand between SOV/HOV/bus.

Plot maps will be produced for the Super Corridor using red and green bandwidths to indicate which streets will experience increases or decreases in AM and PM peak period traffic under each alternative package of strategies.

2.9. OD Estimation Using Microsimulation Model or ACCMA Model

OD estimation is necessary to develop an OD table that reasonably matches the May 2008 freeway ramp (and mainline) traffic counts necessary for validating the freeway microsimulation model against the 2008 floating car travel time runs.

Differences Among Software Packages

There are always an infinite number of OD tables that when assigned to the highway network will reproduce the observed traffic counts on the network. This is because it is a mathematically unconstrained problem. There are always more OD cells than there are road links to be counted, so any number of OD tables can fit the observed counts.

It is necessary to constrain the OD estimation problem with a "seed" OD table. OD estimation software (whether operating within a microsimulation model or a travel demand model) then uses a mathematical search algorithm that attempts to find the OD table closest to the original seed OD table that when assigned to the network gives a reasonable match to the observed traffic counts.

The variation in the OD estimation approaches between different demand modeling packages (e.g. Cube and TransCad) and different microsimulation packages (e.g. Vissim and Paramics) then centers on the mechanics of how they assign the OD table to the network, how they go about finding that “close” OD table to the original seed table, how they measure “closeness”, and the degree to which they respect the information contained in the original seed OD table. Not all of these differences are actually documented, many times for proprietary reasons. Thus it is hard to say that one software package’s OD estimator is mathematically better than the other. In fact, even if they were documented, there is not consensus within the profession as to which mathematical approach is always superior.

A microsimulation model would presumably give a better assignment of traffic demands to the network since they model traffic operations and delays so precisely, but their ability to predict shifts in paths due to congestion is not very robust. They cannot employ equilibrium assignment, so various incremental methods are used (assign traffic to fastest route during the first 5 minutes, recompute travel times, assign next 5 minutes of demand to the new fasted route, etc.). Microsimulation models also do not include as much of the network as a demand model does, and therefore cannot deal with large scale route changes (such as between one corridor and another).

A demand model would generally be presumed to produce a poorer traffic assignment than a microsimulation model, because of a demand model’s more simplistic representation of traffic delays on the network. However, travel demand models can perform equilibrium assignment and they can take into account much larger geographic shifts of traffic between corridors.

Recommended OD Estimation Approach

Given that a demand model (the ACCMA model) will be used to forecast demand for the microsimulation model, taking into account shifts in demand between modes and corridors, we believe the same model should be used to fit the resulting OD table to the traffic counts.

Using the demand model to estimate the OD will give us an OD table that we can use for both surface streets and the freeway. If we were to use the microsimulation model to estimate the OD table we would be limited to just the portion of the network that was coded within the microsimulation model. Without an extensive amount of resources, there is no way that the entire corridor study limits (shown in Exhibit 2) can be coded and validated inside a microsimulation model. Thus a microsimulation estimated OD table would be a lot more limited in its geographic coverage than a demand model estimated OD table.

3. TRAFFIC OPERATIONS ANALYSIS METHODOLOGY

This section describes the recommended traffic operations analysis methodology. The methodology is designed to employ microsimulation models that will be sensitive to the majority of improvement strategies likely to be considered for the ALA-580/238 CSMP. The models were also selected to generate the performance measures necessary for the evaluation of the strategies.

A somewhat non-traditional two-model approach is recommended for the operations analysis. One microsimulation model will focus on the freeway. The other microsimulation model will focus on the surface streets. This two-model approach enables us to divide and conquer what would otherwise be a massive microsimulation effort and allows us to employ software that is best suited to each modeling environment (surface streets and freeways). The savings in modeling effort does come at the cost of extra effort ensuring that the two models are coordinated (working with the same demands, and congestion across model boundaries is correctly accounted for), but we believe the large savings in model set up and run times will more than make up for the extra coordination effort on the part of the consultant.

3.1. Time Periods and Forecast Years

The recommended traffic operations analysis time periods and the forecast years are the same as recommended previously for the travel forecasting method.

3.2. Microsimulation Model Limits

The recommended microsimulation model traffic operations analysis limits are as follows:

- The I-238 freeway from I-880 to I-580, including both freeway to freeway interchanges. A short portion of the I-880 freeway will necessarily be included in the I-238/I-880 interchange, but the modeled traffic volumes and congestion on this short stretch will not be considered accurate and will not be included in the traffic operations performance measure computations.
- The I-580 freeway between I-238 and I-205, including both freeway to freeway interchanges. A short portion of the I-680 freeway will necessarily be included in the I-580/I-680 interchange, but the modeled traffic volumes and congestion on this short stretch of freeway mainline of I-680 will not be considered accurate and will not be included in the traffic operations performance measure computations.
- All I-880/I-238/I-580/I-680/I-205 freeway to freeway ramps
- All freeway to/from surface street ramps on the I-580 and I-238 freeways within the study limits.
- The surface street intersection at the foot of each ramp
- The nearest signalized intersection to the foot of each ramp (if located within 2500 feet of the ramp intersection)

Exhibit 3 shows roughly the streets and freeway segments that will be included in the microsimulation traffic operations analysis. This is called the “Thin Corridor” study area.

3.3. Freeway Microsimulation Model Approach

It is recommended that the Paramics software be used to microsimulate freeway operations on the I-238 and I-580 freeways. This software is ideally suited for modeling large projects and generating performance measures.

The recommended freeway microsimulation model would include the freeway mainlines and the freeway ramps (freeway to freeway as well as surface street to/from freeway).

The freeway microsimulator would be provided with ramp-to-ramp and mainline vehicle OD tables (one set for the AM peak period, the second set for the PM peak period). Each set of OD tables would consist of individual tables for SOV, SR2, SR3+, and truck.

A set of peaking profiles by on-ramp and for the mainline in would be coded into Paramics so that the software can split each peak period OD table into demands by 15-minute periods within each peak period. The peaking profiles would be derived directly from the May 2008 ramp and mainline counts. These peaking profiles would be assumed to be applicable to future years as well as to 2008.

To save on model run times, it may be desirable to split the freeway microsimulation model into two or more submodels, where each submodel covers one-half (or less) of the total freeway. This will be determined by the microsimulation modeling team. Simulation run times are directly proportional to the number of vehicles within the network at any one time, so shorter networks can significantly speed up run times. With 4-hour and 5-hour simulation periods, it is highly desirable to accelerate simulation run times.

If the freeway microsimulation model is split into two or more submodels, the break will be made at locations on the freeway where congestion was never observed to occur in 2008, and is considered unlikely to occur in 2015 and 2035. Current thinking is to split the freeway model at Eden Canyon interchange with each submodel overlapping at this interchange.

The downstream vehicle output of one submodel would become the upstream demand input of the other submodel. If, in the future year runs, congestion is observed to cross the submodel boundaries, the boundaries may be changed to avoid splitting the congestion.

Further details of the recommended freeway microsimulation modeling approach will be presented in a subsequent memo. That memo will address the zone structure, link types, vehicle types, parameter values, error checking, validation approach, and validation targets for the microsimulation model.

3.4. Surface Street Microsimulation Modeling Approach

A different software package is recommended to model the surface streets than for the freeways for two reasons: splitting the microsimulation modeling load further accelerates model run times, and adopting a software package specifically designed for surface street simulation in the United States greatly accelerates coding and validation.

The recommended package for surface street microsimulation is Synchro/Simtraffic. The use of Synchro and it’s built in NEMA/170 controller defaults (phasing sequence, loop detector location, minimum and maximum greens, vehicle extensions, etc.) greatly accelerates the coding of traffic signals in SimTraffic and greatly accelerates validation testing.

Most of the freeway interchanges are so far apart that the ramp intersections and the short sections of surface streets leading to the signalized intersections adjacent to the ramp intersections can be coded as individual Synchro/Simtraffic models, one per interchange.

The Synchro/SimTraffic networks for each interchange would include up to 4 intersections (the two ramp intersections and the nearest signalized intersection each side of the freeway).

Synchro/SimTraffic would be used to estimate and report delays and queues at each. Off-ramp queues exceeding the length of the off-ramp will be identified and the reduced capacity input to the freeway simulator (Paramics), so that the freeway simulator will correctly report freeway congestion resulting from off-ramp queues backing onto the freeway.

All signal timing will assume vehicle actuated control. All signal timing will be quick-optimized for future conditions (timing plans will be near-optimal, without any fine tuning of signal plans). Phasing sequences (lead, lag left turns) will not be optimized. All left turns will be assumed to be leading phases. Existing signal timing will be approximated (unless the city provides the necessary data in Synchro format) to match observed field performance.

For the purposes of comparing future conditions to existing conditions, Synchro will be used to quick optimize signal timings for existing conditions. This will ensure that comparisons between the future alternatives and existing conditions will reflect the management strategies being tested, not suboptimal surface street timings.

Signal saturation flow rates will be estimated per HCM method in Synchro. There will be no field measurement of saturation flow rates.

Further details about the recommended surface street microsimulation modeling approach will be presented in a subsequent memo. That memo will address vehicle types, parameter values, signal timing, error checking, validation approach, and validation targets for the microsimulation model.

3.5. Surface Street and Freeway Microsimulation Models Interface

The mean Paramics estimated peak hour off-ramp flows will be used to adjust the forecasted turning movements for the surface street intersections. The reduced off-ramp flows would be propagated through the downstream intersections within the interchange and its environs.

The mean SimTraffic estimated peak hour on-ramp flows will be checked to see if they indicate a need to adjust the Paramics on-ramp demands to reflect limits on the ability of the surface street system to deliver the demands to the freeway. The reduced on-ramp flows would be propagated through the Paramics OD table to all downstream off-ramp and the mainline out.

Both the SimTraffic and Paramics models will then be re-run to obtain capacity constrained performance estimates. Only one capacity constraining iteration will be performed.

The capacity constraints will not be equilibrated and a 10% discrepancy between SimTraffic and Paramics mean peak hour volumes on the freeway ramps will be considered to be within the acceptable variance typical of simulation models.

The baseline forecasts will be evaluated using the above constrained volumes. However, the initial assessment of possible management strategies will be made using unconstrained volumes. This will ensure that strategies are designed to address demand. Once the basket of strategies has been settled on, then the basket will be analyzed using constrained volumes as described above.

3.6. Recommended Performance Measure Computations

Synchro/Simtraffic will be used to model existing and future surface street operations, identify bottlenecks, and identify queues for the surface streets and the on/off-ramps. The microsimulation model methodology memo describes how the Performance Measures for the Thin Corridor will be computed from the microsimulation model outputs.

4. RELIABILITY ANALYSIS METHODOLOGY

This section describes the recommended methodology for evaluating the travel time reliability of the ALA-580/238 Corridor

4.1. Measures of Reliability

As recommended in the CSMP Cookbook ("Corridor System Management Plans (CSMPs), Guidelines for Completing CSMP Milestones") the following measures of reliability will be computed:

- Travel Time Variance
- The Buffer Index

The travel time variance is computed as follows:

$$Var(T) = \frac{1}{N}\sum T^2 - \left[\frac{1}{N}\sum T\right]^2 \qquad \text{Equation 1}$$

Where:
Var(T) = variance of the travel time (minutes squared)
N = number of samples
T = travel time observation (minutes)

The Buffer Index is computed as follows:

$$BI = \frac{T_{95\%} - T_{Mean}}{T_{Mean}} \qquad \text{Equation 2}$$

Where:
BI = Buffer Index (unit-less)
T(95%) = 95 percentile highest travel time (minutes)
T(mean) = Mean travel time (minutes)

4.2. Reliability Data Collection

The following data on reliability will be collected:

Accident/Incident Data: The PeMS CHP Incident log will be queried for incident data for a 12 month period, July 1, 2007 to June 30, 2008.

Travel Time Reliability Data: 511.org travel time reports will be used to record the variance in travel times over the course of several weeks of the year for the following 6 directional timed segments:

- I-205/I-580 to/from I-680
- I-680 to/from I-580/I238
- I-580/I-238 to/from I-880/I-238

4.3. Forecasting Reliability – Recurrent Congestion

The likely changes in future travel time variance that are due to recurrent causes (cyclic demand peaks) will be computed for each of the 6 directional segments of the corridor (I-238 to/from I-880 & I-580, I-580 to/from I-238 & I-680, and I-580 to/from I-680 & I-205) according to the following methodology.

Step 1. Compute Existing Reliability Indices for Each Peak

The existing mean and variance of travel time within each peak period (AM and PM), each day (Mon-Fri) would be computed from the 511.org toll tag data for the several weeks for which observations are available for the spring and summer of 2008. The buffer index would also be computed. The computations would be for each of the 6 directional segments in the ALA-580/238 corridor.

Step 2. Segregate Peak Periods into Incident and Non-Incident

The PeMS incident log will be used to segregate the daily peak period observations of travel time variability between periods when an incident is present either on either direction of the analysis segment, or when no incident is present in either direction. Time periods with incidents would be further segregated into severe and non-severe incident periods.

Step 3. Compute Reliability for Recurrent Conditions

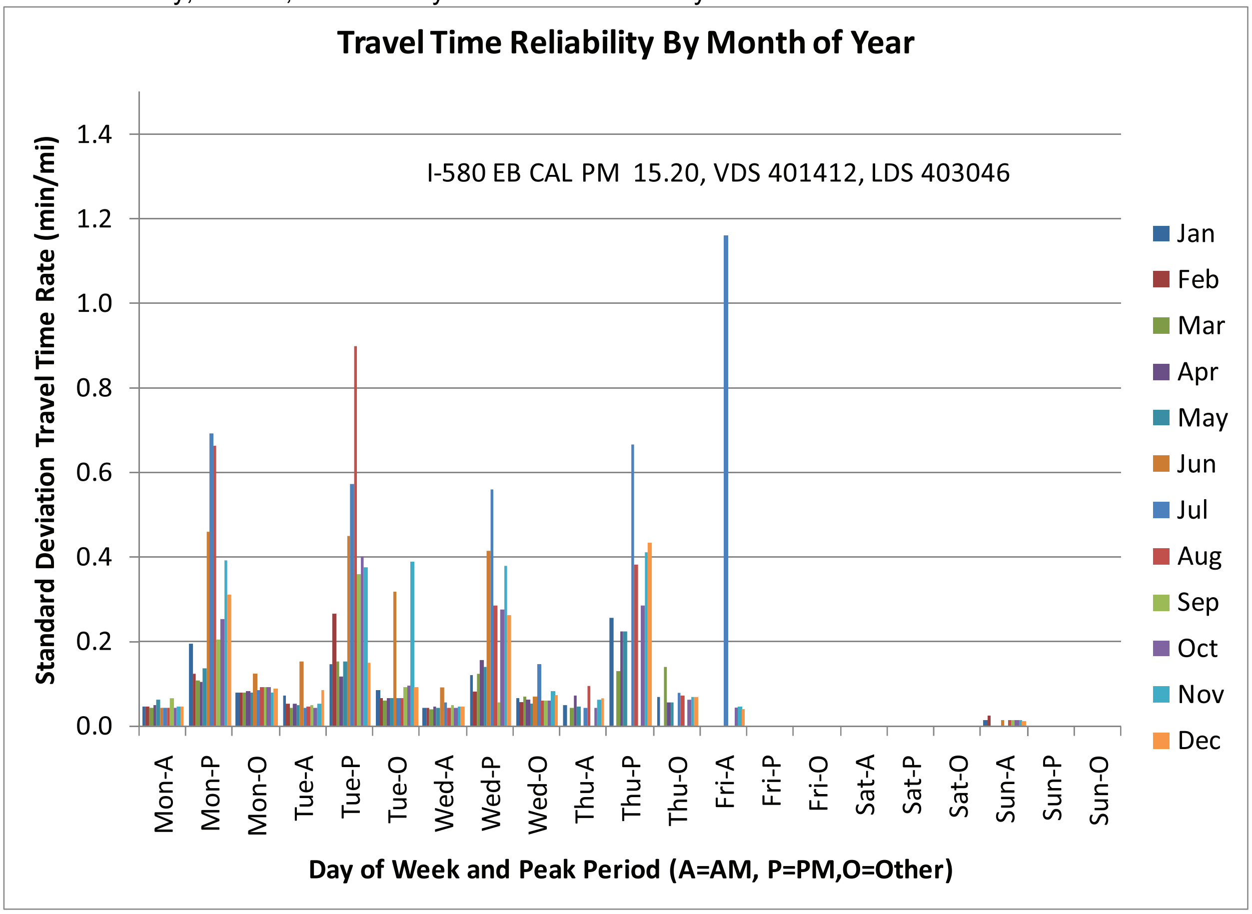
The existing Buffer Index, and the mean and variance of travel times would be computed for all time periods with no incidents. These become the reliability results for recurrent congestion conditions. Exhibit 10 illustrates how the cyclic characteristics of recurrent congestion travel time reliability for the corridor might be plotted.

Step 4. Forecast Reliability for Recurrent Conditions

A piece-wise linear model will be fitted to the observed volume and reliability data so that changes in demand levels can be used to predict changes in reliability. Exhibit 11 below shows one such relationship derived for I-580 eastbound.

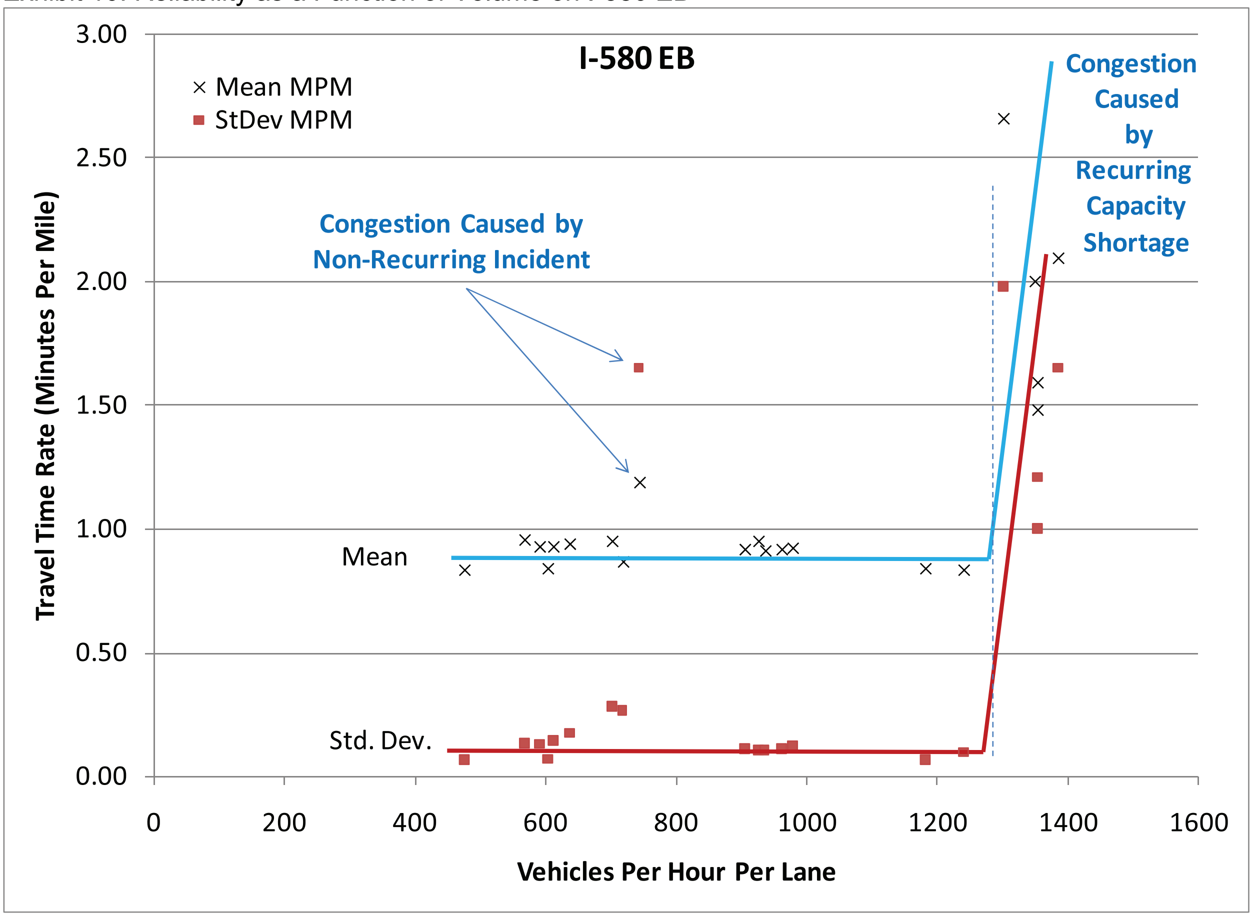
Forecasted changes in peak period volumes would then be used to estimate future recurrent congestion related reliability.

Exhibit 9: Daily, Diurnal, and Monthly Variation in Reliability on I-580 EB



Source PeMS, Vehicle Detector Station #401412, June 2007 through May 2008

Exhibit 10: Reliability as a Function of Volume on I-580 EB



PeMS VDS #401650, 402017, 401006, 400111, 401433, 401852, 400986, 400153, 401412, 402006, 402030, 402031, 402032, May 2-23, 2008. Source: R. Dowling, A. Skabardonis, R. Margiotta, M. Hallenbeck, “Reliability Breakpoints on Freeways”, TRB 09-0813.

4.4. Forecasting Reliability – Non-Recurrent Congestion

The likely changes in future travel time variance due to non-recurrent causes (incidents) will be computed for each of the 6 directional segments of the corridor (I-238 to/from I-880 & I-580, I-580 to/from I-238 & I-680, and I-580 to/from I-680 & I-205) according to the following methodology.

Step 1. Identify Current Frequencies and Probabilities of Incidents

The number of accidents, breakdowns, other, and traffic hazards are assembled from the PeMS incident logs for each of the 6 directional segments of the corridor for the period of one year. Estimated adjustment factors are applied to account for likely under reporting of incidents in the corridor in the log. The mean duration of each incident type is computed from the PeMS incident log data. The result is the table shown below.

Exhibit 11. Example Computation of Current Incident Probabilities

Incident Type	Logged Incidents	Estimated % Logged	Estimated Number Incidents	Duration (min)		Total Incident-Minutes	Annual Probability
				Mean	Std. Dev.		
Accident, injury	19	100%	19	42.8	40.3	813	0.87%
Accident, non-injury	84	99%	85	22.6	22.2	1915	2.05%
Accident, other	76	99%	77	19.7	17.0	1513	1.62%
Breakdown	88	60%	147	17.9	19.8	2620	2.80%
Other	15	60%	25	32.5	73.4	812	0.87%
Traffic hazard	274	60%	457	19.0	14.9	8662	9.25%
Subtotal Incidents	556	69%	809	20.2	22.2	16335	17.45%
Non-Incidents	N/A	N/A	N/A	N/A	N/A	77265	82.55%
Total Year	N/A	N/A	N/A	N/A	N/A	93600	100.00%

N/A = Not Applicable
Source: R. Dowling, A. Skabardonis, D. Reinke, "Predicting the Impacts of ITS on Freeway Queue Discharge Flow Variability", TRB Preprint 08-0788.

Step 2. Estimate Likely Change in Probabilities of Incidents

Based on information available on the effectiveness of various corridor management strategies (and engineering judgment when such information is lacking), the likely reduction in the frequency, duration, and severity of incidents in the corridor would be estimated and the new values used to compute the forecasted annual probability of each incident type in the corridor. A new table, in the style of Exhibit 10, would be computed for the future conditions.

Step 3. Estimate Likely Change in Reliability Indices

The existing mean travel times and variances for the AM and PM peak periods when incidents are present will be used to estimate the reliability by incident type (severe/non-severe). The estimated changes in the probabilities of incidents by incident type will then be applied to the existing data to estimate future reliability due to non-recurrent causes.

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MEMORANDUM

To:	ALA I-580 Technical Corridor Team
From:	Rick Dowling, Allen Huang
Project:	MTC/Caltrans I-580 Corridor System Management Plan Technical Support
Subject:	**Traffic Microsimulation Approach (FINAL)**
Date:	September 12, 2008 (revised September 27, 2008)
File:	c:\work\proj\061016b mtc i-580\task order 4 method\final microsim.doc

1. Introduction

This memorandum provides a detailed overview of the recommended traffic microsimulation methodology that will be used to provide technical support to the development of the ALA 580/238 corridor system management plan.

A meeting was held with the MTC and Caltrans04 corridor technical team on September 10, 2008 to review the August 25 draft of this memorandum. This Final version reflects the agreements reached at that meeting plus comments received up to September 23, 2008. Major additions have been highlighted in yellow. A new section at the end of this memo provides point-by-point responses to the comments as discussed at the meeting.

1.1. Purpose of Microsimulation

The basic purpose of a Corridor System Management Plan (CSMP) is "to preserve the mobility gains of urban corridor capacity improvements over time".[1] The purpose of using microsimulation in the corridor is to predict the likely benefits of various corridor management strategies on key corridor performance measures, specifically:

1. Vehicle-Miles Traveled (VMT)
2. Vehicle-Hours Traveled (VHT)
3. Vehicle-Hours Delay (VHD)
4. Mean Vehicle-Trip Speed (VMPH)
5. Person-Miles Traveled (PMT)
6. Person-Hours Traveled (PHT)

[1] California Transportation Commission, Corridor Mobility Improvement Account Program Guidelines, Adopted November 8, 2006

7. Person-Hours Delay (PHD)
8. Mean Person-Trip Speed (PMPH)

The microsimulation model(s) will also be used to identify link specific hot spots (bottlenecks), queues and queue lengths both on the mainline and on the ramps for future conditions under the various strategies. Plots showing link speeds or densities by color will be developed using Paramics Analyst.

1.2. Microsimulation Modeling Limits

The recommended microsimulation modeling limits are as follows:

- The I-238 freeway from I-880 to I-580, including both freeway to freeway interchanges. A short portion of the I-880 freeway will necessarily be included in the I-238/I-880 interchange, but the modeled traffic volumes and congestion on this short stretch will not be considered accurate and will not be included in the traffic operations performance measure computations.
- The I-580 freeway between I-238 and I-205, including both freeway to freeway interchanges. A short portion of the I-680 freeway will necessarily be included in the I-580/I-680 interchange, but the modeled traffic volumes and congestion on this short stretch of freeway mainline of I-680 will not be considered accurate and will not be included in the traffic operations performance measure computations.
- All I-880/I-238/I-580/I-680/I-205 freeway to freeway ramps
- All freeway to/from surface street ramps on the I-580 and I-238 freeways within the study limits.
- The surface street intersection at the foot of each ramp
- The nearest signalized intersection to the foot of each ramp (if located within 2500 feet of the ramp intersection)

1.3. Microsimulation Temporal Limits & Forecast Years

The time periods covered by microsimulation will be:

- Weekday AM peak 4-hour period (5:00 AM to 9:00 AM)
- Weekday PM peak 5-hour period (2:30 PM to 7:30 PM)

The forecast years for the microsimulation will be 2008 (existing) and 2015. A preliminary assessment of reasonableness of the microsimulation results for 2035 will be made. If the results appear to show unrealistically high congestion levels that are unlikely to help in the selection of strategies, then the 2035 microsimulation forecasts may be dropped.

1.4. Microsimulation Modeling Approach

A two-model approach is recommended. One microsimulation model will focus on the freeway. The other microsimulation model will focus on the surface streets.

The Paramics microsimulation modeling software will be used to model peak period operations on the freeway mainline. The coded network in Paramics will include the freeway mainline, the ramps, a short stretch of the surface street at the foot of the ramps, and the signal meters on the on-ramps. The signals at the foot of the ramps will be modeled in Paramics using the equivalent fixed time signal timings estimated by Synchro (see Exhibit 1).

The Synchro/Simtraffic modeling software will be used to model peak hour operations on the surface streets. The coded surface street network will include the ramps, the signals at the foot of the ramps, the surface street crossing the freeway at the ramps, and up to one signalized intersection each side of the freeway on the surface street beyond the ramps (see Exhibit 2). The signal meters on the on-ramps will be modeled in Synchro/Simtraffic using the equivalent meter discharge rates. Meters cannot be precisely modeled in Synchro/Simtraffic because of software limitations that do not allow HOV bypass and single vehicle discharge per green.

Exhibit 1: Example Paramics Freeway Network Coding

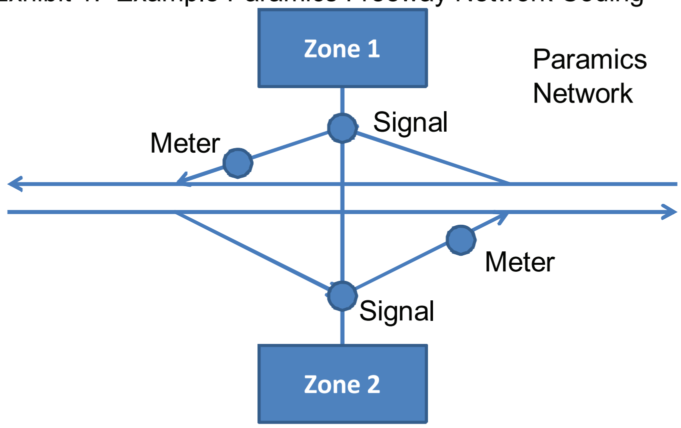
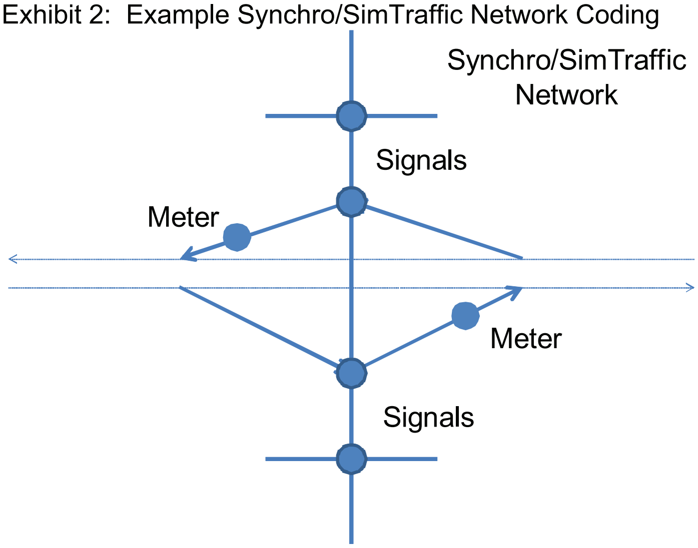


Exhibit 2: Example Synchro/SimTraffic Network Coding



This two-model approach enables us to divide and conquer what would otherwise be a massive microsimulation effort and allows us to employ software that is best suited to each modeling environment (surface streets and freeways). The savings in modeling effort does come at the cost of extra effort ensuring that the two models are coordinated (working with the same demands, and congestion across model boundaries is correctly accounted for), but we believe the large savings in model set up and run times will more than make up for the extra coordination effort on the part of the consultant.

SimTraffic cannot easily model multi-hour peak periods, so it will be limited to the AM and PM peak hours and the results expanded to the peak periods.

The microsimulation modeling approach will follow the steps and guidelines given in FHWA's Guidelines for Applying Traffic Microsimulation Modeling Software,[2]

1.5. Baseline Roadway/Transit Network Improvements 2015/2035

The ALA-580/238 Technical Corridor Team will determine the baseline network improvements to be assumed to be in place for baseline (no mitigation) 2015 and 2035. Exhibit 2 will list these improvements for 2015 once they are adopted by the Team.

Exhibit 3: Transportation Improvements to be Included in 2015 Baseline Forecast

No.	Sponsor	Project	Description	Reference

This table to be filled in by ALA-580/238 CSMP Technical Team

Exhibit 8 will list the transportation network improvements to be included in the baseline 2035 microsimulation.

Exhibit 4: Additional Improvements to be Included in 2035 Baseline Forecast

No.	Sponsor	Project	Description	Reference

This table to be filled in by ALA-580/238 CSMP Technical Team

[2] Traffic Analysis Toolbox Volume III: Guidelines for Applying Traffic Microsimulation Modeling Software, Federal Highway Administration, Publication No. FHWA-HRT-04-040 (2004).

2. Freeway Microsimulation Approach

It is recommended that the Paramics software be used to microsimulate freeway operations on the I-238 and I-580 freeways. This software is ideally suited for modeling large projects and generating performance measures.

The recommended freeway microsimulation model would include the freeway mainlines and the freeway ramps (freeway to freeway as well as surface street to/from freeway).

The rest of this section addresses the zone structure, link types, vehicle types, parameter values, error checking, validation approach, and validation targets for the microsimulation model as specified in the FHWA Guidelines.

2.1. Data Collection and Preparation

Input Data (Geometry, Control, Demand)

Lane geometry for the freeway, ramps, and ramp meters will be collected from field surveys and aerial photos shot May 2008.

Ramp metering rates for those meters active in May 2008 have been obtained from Caltrans.

AM and PM peak period demand will be obtained from machine counts made of the ramps and the mainline in May 2008. PeMS detectors will provide supplementary mainline count data. Where there is a conflict between the machine counts and PeMS that cannot be explained by vehicles being stored on the freeway in queues, the machine counts will be considered to be the more accurate data source.

Calibration Data (bottlenecks, travel time and queues)

Calibration data consists of identified bottleneck locations, measured queue lengths, and travel times.

The bottleneck locations will be identified from field observations and aerial photos shot every 30 minutes during the peak periods in May 2008.

Queue lengths will be estimated from aerial photos shot every 30 minutes during the peak periods in May 2008. Queues can also be identified from floating car runs.

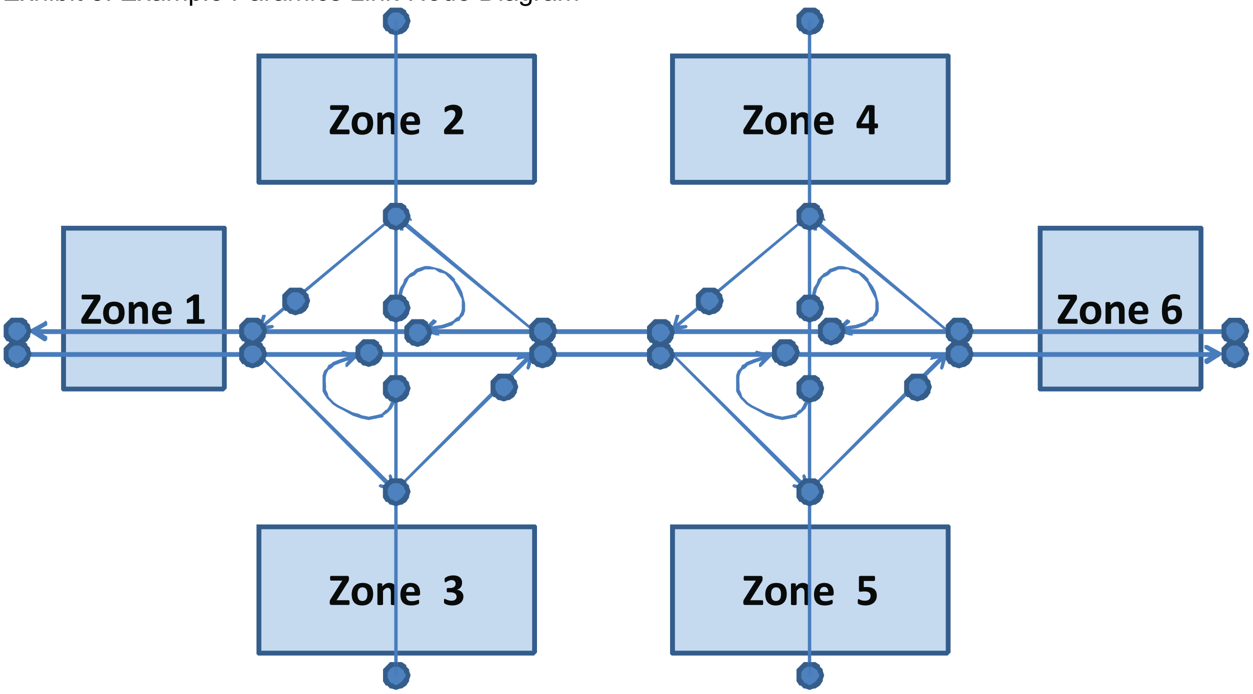
Travel time will be obtained from 511.org reported toll tag vehicle travel times and from supplementary floating car runs conducted in May 2008.

2.2. Base Model Development

Link-Node Diagram

A link node diagram will be prepared showing the link and node numbers for the coded Paramics network.

Exhibit 5: Example Paramics Link-Node Diagram



To save on model run times, it may be desirable to split the freeway microsimulation model into two or more submodels, where each submodel covers one-half (or less) of the total freeway. This will be determined by the microsimulation modeling team. Simulation run times are directly proportional to the number of vehicles within the network at any one time, so shorter networks can significantly speed up run times. With 4-hour and 5-hour simulation periods, it is highly desirable to accelerate simulation run times.

If the freeway microsimulation model is split into two or more submodels, the break will be made at locations on the freeway where congestion was never observed to occur in 2008, and is considered unlikely to occur in 2015 and 2035. Current thinking is to split the freeway model at Eden Canyon interchange with each submodel overlapping at this interchange.

The downstream vehicle output of one submodel would become the upstream demand input of the other submodel. If, in the future year runs, congestion is observed to cross the submodel boundaries, the boundaries may be changed to avoid splitting the congestion.

Link Geometry

The same 43 link types from the Caltrans I-880 model will be used to code the ALA-580/238 network. They are listed in Appendix A.

Traffic Control

The on-ramp signal meters will be coded in Paramics. The existing Caltrans metering rates will be coded by 15 minute period. The Caltrans API for ramp metering will be used and evaluated, if it is recompiled by Caltrans for the current release of Paramics and available in time for model calibration. The evaluation will assess whether the API is performing satisfactorily. If it passes the test, the API will be used in the analysis of future strategies.

The eastbound I-580 ramp meters from Foothill Road on-ramp to Greenville Road on-ramp will be coded as operational in May 2008 from 2:30 PM to 7:30 PM.
Where meters were present in May 2008 but not turned on, no ramp meters will be coded for the 2008 calibration runs.

For some of the future alternatives HOV lanes will be coded allowing SR2 and SR3+ vehicles during their hours of operation

Surface street signalized intersections will NOT be coded in Paramics.

Traffic Demand

The freeway microsimulator will be provided with ramp-to-ramp and mainline vehicle OD tables (one set for the AM peak period, the second set for the PM peak period). Each set of OD tables would consist of individual tables for SOV (single occupant vehicles), SR2 (shared ride 2-person vehicles), SR3+ (shared ride 3 or more person vehicles), and truck.

The OD tables will have been derived from the ACCMA model. The 2008 tables will have been fitted to the May 2008 traffic counts on the freeway mainline and ramps. The future year OD tables will be built off of the fitted 2008 tables.

A set of peaking profiles by on-ramp and for the mainline-in will be coded into Paramics so that the software can split each peak period OD table into demands by 15-minute periods within each peak period. The peaking profiles will be derived directly from the May 2008 ramp and mainline counts. The count locations used in determining the peaking profiles will need to be chosen carefully to ensure that they are, in fact, demand counts. If counts from constrained locations are used, they will need to be adjusted to demand. These peaking profiles will be assumed to be applicable to future years as well as to 2008.

Vehicle Types and Driver Behavior

The Caltrans I-880 model 17 vehicle types will be used. SOV, SR2, SR3+ vehicles will have their own OD tables. Trucks will have their own OD table, which will be split into truck subtypes according to the percentage of trucks observed by the weigh-in-motion (WIM) detectors east of Vasco Road in May 2008. The 17 vehicle types and their characteristics are listed in Appendix B.

The Paramics default driver behavior distribution and parameters will be used in the initial runs. The mean headway may be adjusted globally or on a link specific basis to calibrate the model.

Run Control Parameters

The Paramics default run control parameters will be used in the initial runs.

Quality Assurance/Quality Control

This microsimulation approach memo is the first step in the quality assurance process. Individual microsimulation modelers helped prepare the memo. The memo was then reviewed by a principal experience in microsimulation modeling.

Once network coding proceeds, every few days a copy of the model input files will be reviewed by a principal experienced in microsimulation modeling. Link color coding schema by attribute will be used to identify obvious errors.

When the input files reach the stage that testing is possible, then every few days a low volume OD table (1 vehicle per OD cell) will be loaded onto the network and the animation reviewed to identify network coding errors. Sudden changes in vehicle speeds will be investigated to determine if there is a network continuity problem.

2.3. Error Checking

On-going quality control and assurance will be handled as explained in the previous section.

Input Review

The network coding will be reviewed for values that are "out-of-bounds". Obvious errors will be identified and corrected.

Animation Review

When the initial model development is completed (OD tables, and fully coded network) then animation review will begin. Abrupt changes in vehicle behavior will be spotted and any coding errors corrected. Unusual or illegal vehicle behavior will be identified and coding errors causing this behavior corrected.

2.4. Calibration

The objective of calibrating the model is to obtain simulated performance similar to what was observed in May 2008. The model should have bottlenecks in the same locations, with queues of about the same extent as were observed in May 2008 for both the AM and PM peak periods. In addition, the model predicted mean speed for each hour of the simulation should approximate that measured in the field from 511.org and floating car data.

The model calibration will start with calibrating the capacity of the observed 2008 bottlenecks. The calibration will then proceed to matching the observed mean travel times by hour observed in the 511.org and floating car data.

Calibration of Capacity

The simulated capacity will be compared to the observed capacity at the critical bottlenecks.

The existing stretch of I-238 west of I-580 is a significant bottleneck in both directions, but because this stretch was under construction in both directions, the Paramics model will not be calibrated to the observed capacity in this stretch

In the eastbound direction, one bottleneck was observed in the PM peak on I-580, east of I-238. The single bottleneck was the stretch of eastbound I-580 between Santa Rita Road on-ramp and the Airway Boulevard off-ramp. Other minor bottlenecks west of this point were probably hidden by this major bottleneck, but they could not be observed in the field. During the AM peak period, there was no persistent eastbound congestion observed anywhere in the corridor.

There is also a transitory eastbound bottleneck at the start of the upgrade east of Greenville Road to Altamont Pass. This bottleneck was not observed in the field during the May 2008 data collection effort. The ability of the simulation model to represent the effects of the upgrade on truck speeds will be evaluated and the coding adjusted to capture this effect.

In the westbound direction, three minor transient bottlenecks were observed in the AM peak on I-580, east of I-238 (see Exhibit 6). They are:

- I-580 WB, between Hopyard Road On-Ramp and I-680 Off-Ramp, The bottleneck is actually on the collector-distributor road where the I-680 NB to I-580 WB loop ramp merges with the I-580 WB to I-680 SB loop ramp. It backs up onto the right hand lanes of I-580 WB, sometimes affecting all the lanes.
- I-580 WB, between Airway Blvd On-Ramp and Santa Rita/Tassajara Road Off-Ramp,
- I-580 WB, at Altamount Pass, between West Grant Line Road On-Ramp and North Flynn Road Off-Ramp.

No sustained congestion was observed in the westbound direction during the PM peak period.

Calibration of Route Choice

Route choice will be handled inside the ACCMA model along with mode choice shifts. Route choice will not be an option in the Paramics model since no parallel arterials will be coded within this simulation model. It would be infeasible for Paramics to handle the SR 84 and Stanley Blvd. alternative routes to the I-580 freeway.

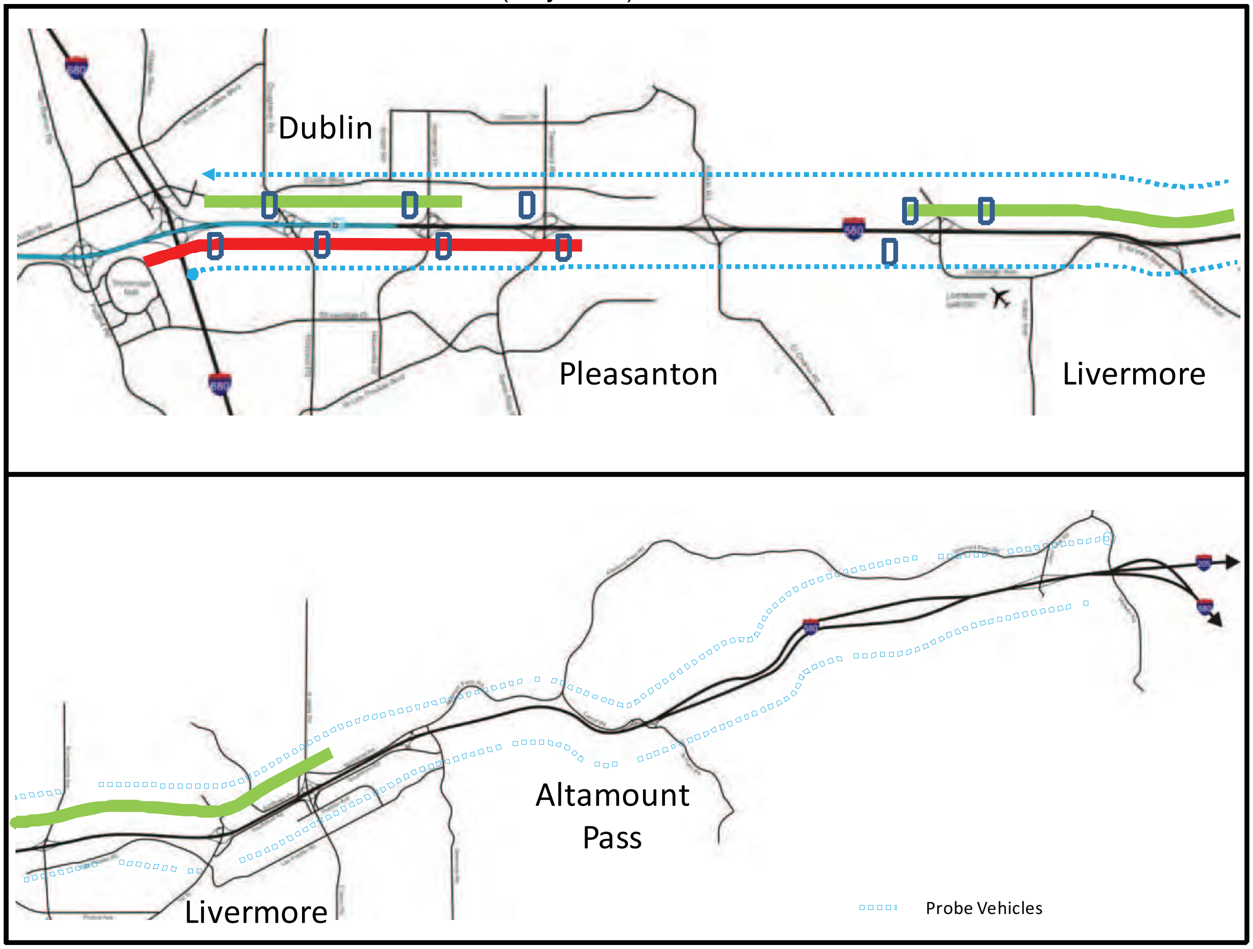
Validation of Caltrans Ramp Metering API

The Caltrans ramp metering API, written by UC Irvine, enables Paramics to dynamically modify the ramp metering rate as a function of the density of traffic on the adjacent freeway mainline. This API however does not currently function under the latest publicly distributed version of Paramics. Consequently Caltrans needs to initiate effort to have the API module recompiled by Quadstone for the new version of Paramics.

If Caltrans is able to get their ramp metering API recompiled before the end of October, the consultant will then give the API a try and see how well it mimics the observed dynamic ramp metering rates currently in place on eastbound I-580 during the PM peak period. If the API appears to reliably operate and reproduce reasonably well the observed dynamic metering rates, the consultant will use the API to test future ramp metering strategies.

If the API does not perform satisfactorily, the API will NOT be used in calibration and will NOT be used to test future alternatives (There is insufficient time to wait on further refinements of the API, should they be found necessary). The consultant will provide Caltrans with a copy of the Paramics files used in the evaluation, the ramp metering counts against which the API was evaluated, and a short memo identifying the major weaknesses in the API that were found in the consultant's evaluation.

Exhibit 6: Observed Bottlenecks on I-580 (May 2008)



Bottlenecks are at the head of the observed congestion

System Performance Calibration

System performance will be calibrated in the model in terms of queues and travel times. The simulated mean queue lengths each hour will be compared to field observations and the bottleneck capacities adjusted to better match the observed queues. Similarly the mean simulated travel time (for each hour of the simulation period) for the following segments of I-580 and I-238 will be compared to observed mean 511.org and floating car travel times.

- I-580 WB from I-205 to I-680
- I-580 WB from I-680 to I-238
- I-238 NB from I-580 to I-880
- I-238 SB from I-880 to I-580
- I-580 EB from I-238 to I-680
- I-580 EB from I-680 to I-205

Note that since I-238 was under construction in both directions in May 2008, wide differences between the modeled and observed travel times will be accepted to the extent that the observed travel times are considered to be non-representative of post-construction conditions.

The on-ramp meter queues observed during the PM peak period in the May 2008 aerial photos will be compared to those estimated by Paramics for existing conditions. The metering rates and demand rates will be adjusted, if necessary, to better match the observed queuing.

Calibration Targets

The calibration targets for the Paramics freeway microsimulation are taken from the FHWA Microsimulation Applications Guide. They are listed in Exhibit 6.

The simulation model will be run 3 to 5 repetitions using differing random number seeds and the results averaged. The averages will be compared to the calibration targets. Additional repetitions of the model may be made if the first 3 to 5 repetitions indicate a high degree of instability in the results (the variance is large compared to the mean). The number of runs will be determined by the variance in the VHT performance measure observed in the first 3 runs and the desired confidence interval for the VHT result. Additional runs will be made (up to 5 total), if found necessary to secure a satisfactory confidence interval for the estimate of VHT.

Exhibit 7: Paramics Model Calibration Targets

Criteria and Measures	Calibration Acceptance Targets
Hourly Flows, Model Versus Observed	
Individual Link Flows	
Within 15%, for 700 vph < Flow <2700 vph	>85% of cases
Within 100 vph, for Flow < 700 vph	>85% of cases
Within 400 vph, for Flow > 2700 vph	>85% of cases
Sum of all Link Flows	Within 5% of sum of all link counts
GEH Statistic < 5 for Individual Link Flows[3]	>85% of cases
GEH statistic for Sum of all Link Flows	GEH < 4 for sum of all link counts
Travel Times, Model Versus Observed	
Journey times network	
Within 15% (or one minute, if higher)	>85% of cases
Visual Audits	
Individual link speeds	
Visually acceptable speed-flow relationship	To analyst's satisfaction
Bottlenecks	
Visually acceptable queuing	To analyst's satisfaction**

Source: *Freeway System Operational Assessment*, Technical Report I-33, Paramics Calibration and Validation Guidelines, Draft, Wisconsin Department of Transportation, District 2, June 2002.

**The bottlenecks must be at the correct location for the right cause. The queue lengths may vary somewhat from field observations.

[3] The GEH statistic is computed as follows:

$$GEH = \sqrt{\frac{(E-V)^2}{(E+V)/2}}$$

where: E = model estimated volume; and V = field count.

3. Surface Street Microsimulation Approach

A different software package is recommended to model the surface streets than for the freeways for two reasons: splitting the microsimulation modeling load further accelerates model run times, and adopting a software package specifically designed for surface street simulation in the United States greatly accelerates coding and validation.

The recommended package for surface street microsimulation is Synchro/Simtraffic. The use of Synchro and it's built in NEMA/170 controller defaults (phasing sequence, loop detector location, minimum and maximum greens, vehicle extensions, etc.) greatly accelerates the coding of traffic signals in SimTraffic and greatly accelerates validation testing.

Synchro/SimTraffic would be used to estimate and report delays and queues at each intersection. Off-ramp queues exceeding the length of the off-ramp will be identified and the reduced capacity input to the freeway simulator (Paramics), so that the freeway simulator will correctly report freeway congestion resulting from off-ramp queues backing onto the freeway.

The rest of this section addresses the zone structure, link types, vehicle types, parameter values, error checking, validation approach, and validation targets for the microsimulation model as specified in the FHWA Guidelines.

3.1. Data Collection and Preparation

Input Data (Geometry, Control, Demand)

Signal geometry, timing, and turning movement counts for the City's of Pleasanton, Dublin, and Livermore will be obtained from each city's Synchro files.

For other jurisdictions, existing lane geometry will be obtained from field observations and aerial photos shot in May 2008. Future lane geometry will be assumed to be the same as existing lane geometry unless the corridor technical team makes the consultant aware of planned local improvements.

All signals (Outside of Pleasanton, Dublin and Livermore) will be assumed to be uncoordinated, fully actuated according to Synchro defaults unless the Corridor Technical Team provides the consultant with better information. Pedestrians will be assumed to be negligible.

Intersection count data will be obtained from most recent available historic count information and growth factored to May 2008 based on the May 2008 adjacent ramp counts.

Calibration Data (bottlenecks, travel time and queues)

Travel times will not be calibrated for the surface street network. Bottlenecks and queues for the surface streets will be noted from the May 2008 aerial photos shot every half hour during the AM and PM peak periods.

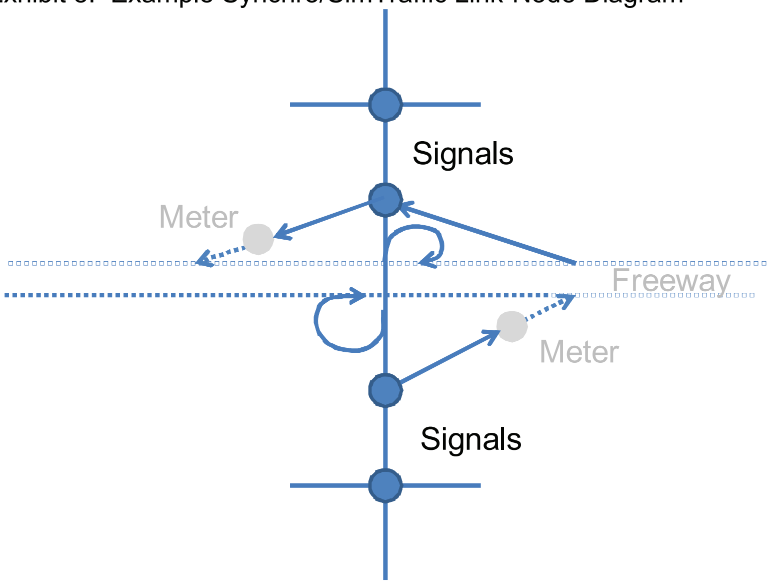
3.2. Base Model Development

Link-Node Diagram

Most of the freeway interchanges are so far apart that the ramp intersections and the short sections of surface streets leading to the signalized intersections adjacent to the ramp intersections can be coded as individual Synchro/Simtraffic models, one per interchange.

The Synchro/SimTraffic networks for each interchange would include up to 4 intersections (the two ramp intersections and the nearest signalized intersection each side of the freeway).

Exhibit 8: Example Synchro/SimTraffic Link-Node Diagram



Link Geometry

Lane geometry will be obtained from field surveys and aerial photos shot in May 2008.

Signal saturation flow rates will be estimated per HCM method in Synchro. There will be no field measurement of saturation flow rates.

Traffic Control

All signal timing will assume vehicle actuated control. All signal timing will be quick-optimized for future conditions (timing plans will be near-optimal, without any fine tuning of signal plans). Phasing sequences (lead, lag left turns) will not be optimized. All left turns will be assumed to be leading phases. Existing signal timing will be approximated (unless the city provides the necessary data in Synchro format) to match observed field performance.

Pedestrians will be assumed to be negligible at the signalized intersections, unless information from Caltrans indicates otherwise.

For the purposes of comparing future conditions to existing conditions, Synchro will be used to quick optimize signal timings for existing conditions. This will ensure that comparisons between the future alternatives and existing conditions will reflect the management strategies being tested, not suboptimal surface street timings.

Traffic Demand

Traffic demand for existing conditions will be input as AM and PM peak hour turning movements at each signalized intersection. Counts will be used where available and adjusted to match May 2008 values, as evidenced by the freeway ramp counts conducted in May 2008.

Future demand will be estimated by applying ACCMA model predicted growth increments to the estimated 2008 intersection approach peak hour volumes. The forecasted approach volumes will be distributed across the turning movements using the NCHRP 255 Furnessing approach.

Driver Behavior

The Synchro/SimTraffic default parameter values and distributions will be used for driver behavior and vehicle types for the initial runs. These values will be adjusted, if necessary, during the calibration.

Run Control Parameters

The default SimTraffic run control parameters will be used with the exception that the data recording period will be set to one hour. Three to five repetitions with differing random number seeds will be performed for each run. The number of runs will be determined by the variance in the VHT performance measure observed in the first 3 runs and the desired confidence interval for the VHT result. Additional runs will be made (up to 5 total), if found necessary to secure a satisfactory confidence interval for the estimate of VHT.

Quality Assurance/Quality Control

This microsimulation approach memo is the first step in the quality assurance process. Individual microsimulation modelers helped prepare the memo. The memo was then reviewed by a principal experience in microsimulation modeling.

Once network coding proceeds, every few days a copy of the model input files will be reviewed by a principal experienced in microsimulation modeling.

3.3. Error Checking

On-going quality control and assurance will be handled as explained in the previous section.

Input Review

The network coding will be reviewed for values that are “out-of-bounds”. Obvious errors will be identified and corrected.

Animation Review

When the initial model development is completed (OD tables, and fully coded network) then animation review will begin. Abrupt changes in vehicle behavior will be spotted and any coding errors corrected. Unusual or illegal vehicle behavior will be identified and coding errors causing this behavior corrected.

3.4. Calibration

Objectives

The objectives of calibration are to assure that the Synchro/SimTraffic model reasonably approximates the capacity and congestion on the surface streets.

Approach

The Synchro reported 95% queues and the Simtraffic animation will be reviewed to determine if queues during the AM and PM peak hours approximate those observed in the May 2008 aerial photos shot every 30 minutes during both peak periods.

Calibration Targets

No formal calibration targets are proposed for SimTraffic. The SimTraffic queue estimates will be visually compared to the observed queues in the aerial photos and if greatly different, the geometric and volume coding errors will be checked and corrected.

3.5. Expansion of Peak Hour to Peak Period

The AM peak hour and PM peak hour performance measures reported by Synchro/Simtraffic for the surface streets in the immediate vicinity of the freeway interchanges will be expanded to peak period results using the following procedure:

1. Separate hourly Synchro/Simtraffic simulation models will be coded for each hour of each AM and PM peak period (a total of 9 hourly models). The peak hour turning movements will be factored down to the non-peak hours according to observed volume peaks in the on and off-ramp counts for each non-peak hour within each peak period.
2. The hourly Synchro/SimTraffic output for VMT, VHT, and delay will be summed for each peak period to obtain full peak period microsimulation performance measures for the surface streets within the immediate vicinity of the freeway interchanges. (Peak period performance measures for surface streets farther away from the freeway interchanges will be estimated directly by the ACCMA demand model.)

Should the delivery schedule for the microsimulation analysis have to be accelerated so that all technical products can be delivered by March 31, 2009, then multiple hourly Synchro/Simtraffic models will not be coded for each peak period. Surface street microsimulation outputs will be computed for only the peak hour within each peak period The ACCMA demand model will be used to estimate the peak period performance for the entire surface street system, including surface streets within the freeway interchanges.

4. Alternatives Analysis

4.1. Baseline Demand Forecast

The baseline demand forecast will be generated as described in the Travel Demand Forecasting and Traffic Analysis memorandum.

The demand forecasts will be capacity constrained by the simulation models using the following procedure:

- The Paramics forecasted peak hour off-ramp flows will be used to adjust the forecasted turning movements for the surface street intersections. The reduced (or increased) off-ramp flows would be propagated through the downstream intersections within the interchange and its environs.
- The SimTraffic estimated peak hour on-ramp flows will be used to adjust the Paramics on-ramp demands. The reduced on-ramp flows would be propagated through the Paramics OD table to all downstream off-ramp and the mainline out.
- A spreadsheet tool will be written to assist in this constrained volume propagation process. One iteration of this volume constraining process will be applied, and then the engineer will use judgment to approximately equilibrate the constraints.

The baseline forecasts will be evaluated using the above constrained volumes. However, the initial assessment of possible management strategies will be made using unconstrained volumes. This will ensure that strategies are designed to address demand. Once the basket of strategies has been settled on, then the basket will be analyzed using constrained volumes as described above.

4.2. Generation of Alternatives

The alternatives to be tested will be generated as described in the scope of work.

Consultant will meet with MTC project manager to go over and refine process to be used to develop and refine mitigation strategies and projects.

Consultant will prepare an initial menu (or laundry list) of potential congestion mitigation strategies and projects for review by the MTC Project Manager and the CSMP Corridor Team. The initial list will include all currently planned but not programmed by the cities (San Leandro, Hayward, Dublin, Pleasanton, Livermore), BART, ACE train, Alameda County, ACCMA, MTC, and Caltrans projects. The primary focus of the measures will be on the freeway, but may also include improvements on other modes or on parallel arterials.

A sketch planning approach will be used to initially rate the relative strengths and weaknesses and feasibility of the measures against CSMP objectives. These measures may range from system management measures to maximize efficient use of the existing capacity within the corridor to more traditional capital improvements to increase corridor capacity.

Consultant will then work with the MTC Project Manager and other involved agencies, to narrow the initial list to a group of viable congestion relief measures for the corridor, based on existing and future conditions.

Consultant will segregate the proposed measures into short-term and long-term implementation timelines.

Consultant will finalize the list of strategies and projects based on comments received from the MTC Project Manager and other involved agencies

4.3. Selection of Measures of Effectiveness

The measures of effectiveness are described in the Travel Demand Forecasting and Traffic Analysis Memorandum.

4.4. Model Application

The Paramics and SimTraffic models will each be applied with 3 to 5 repetitions using different random number seeds. Additional repetitions will be performed if the variance of the results is large compared to the mean. The off-ramp demands for the SimTraffic model will be constrained by Paramics.

4.5. Evaluation of Alternatives

Synchro/Simtraffic will be used to model existing and future surface street operations, compute delay at intersections, identify bottlenecks, and identify queues for the surface streets.

Paramics will be used to identify future bottlenecks, estimate future queues, compute travel time and compute delay on the freeway mainline and on-ramps. (Ramp delays and queues at the off-ramps will be computed in Synchro/Simtraffic).

Vehicle-miles travelled (VMT) and vehicle hours traveled (VHT), and vehicle hours of delay (VHT delay) will be computed from the model outputs for the freeway only as follows:

1. Thin Corridor VMT = Paramics VMT
2. Thin Corridor VHT = Paramics VHT
3. Thin Corridor Vehicle-Hours Delay (VHD) = Paramics VHD
4. Thin Corridor Mean Vehicle-trip Speed (VMPH) = VMT/VHT
5. Thin Corridor Person-Miles Traveled (PMT) = AVO * VMT
6. Thin Corridor Person-Hours Traveled (PHT) = AVO * VHT
7. Thin Corridor Person-Hours Delay (PHD) = AVO * VHD
8. Thin Corridor Mean Person-Trip Speed (PMPH) = PMT/PHT

The VMT and VHT results will be converted to person results using estimated average vehicle occupancy (AVO) for the corridor. The average vehicle occupancy by peak period will be estimated from count data (where available) and from ACCMA model output (where data not available).

Future year vehicle occupancy will be estimated by comparing the ACCMA model forecasted changes in average vehicle occupancy for each forecast year and peak period.

Hot spots (bottlenecks), queues and queue lengths will be identified from Paramics and Simtraffic reports for future conditions. Existing conditions queues will be obtained from available field observations (aerial photos). The consultant will also estimate delay for each bottleneck.

The measures of effectiveness will be reported in a format similar to that provided by Caltrans HQ for its TMS masterplan.

Three to five repetitions with differing random number seeds will be used to compute the performance measures. The number of runs will be determined by the variance in the VHT performance measure observed in the first 3 runs and the desired confidence interval for the VHT result. Additional runs will be made (up to 5 total), if found necessary to secure a satisfactory confidence interval for the estimate of VHT.

The consultant will evaluate the pros and cons of reporting the mean performance from multiple runs, or selecting the median VHT run and reporting the performance measures from that particular run. The recommended method will then be used to compute and report all performance measures for all alternatives.

The performance measures VMT and VHT will be accumulated by 15 minute period (or less as appropriate for the software) and summed to total peak period and reported by total peak period.

6. APPENDIX A – Paramics Link Categories (From Caltrans I-880 Model)

categories 1 to 43

category 1 lanes 1 speed 65 mph width 12.0 ft colour 0x000000ff type highway major
median width 0.0 ft inside overtaking
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 0.800
signpost 820.2 ft,3.3 ft

category 2 lanes 2 speed 65 mph width 24.0 ft colour 0x000000ff type highway major
median width 0.0 ft inside overtaking
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 0.800
signpost 820.2 ft,3.3 ft

category 3 lanes 3 speed 65 mph width 36.0 ft colour 0x000000ff type highway major
median width 0.0 ft inside overtaking
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 0.800
signpost 820.2 ft,3.3 ft

category 4 lanes 4 speed 65 mph width 48.0 ft colour 0x000000ff type highway major
median width 0.0 ft inside overtaking
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 0.800
signpost 820.2 ft,3.3 ft

category 5 lanes 5 speed 65 mph width 60.0 ft colour 0x000000ff type highway major
median width 0.0 ft inside overtaking
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 0.800
signpost 820.2 ft,3.3 ft

category 6 lanes 6 speed 65 mph width 72.0 ft colour 0x000000ff type highway major
median width 0.0 ft inside overtaking
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 0.800
signpost 820.2 ft,3.3 ft

category 7 lanes 7 speed 65 mph width 84.0 ft colour 0x000000ff type highway major
median width 0.0 ft inside overtaking
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 0.800
signpost 820.2 ft,3.3 ft

category 8 lanes 1 speed 50 mph width 12.0 ft colour 0x00007fff type urban major
median width 0.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 1.000
signpost 820.2 ft,3.3 ft

category 9 lanes 2 speed 50 mph width 24.0 ft colour 0x00007fff type urban major
median width 0.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 1.000

signpost 820.2 ft,3.3 ft

category 10 lanes 3 speed 50 mph width 36.0 ft colour 0x00007fff type urban major
median width 0.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 1.000
signpost 820.2 ft,3.3 ft

category 11 lanes 4 speed 50 mph width 48.0 ft colour 0x00007fff type urban major
median width 0.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 1.000
signpost 820.2 ft,3.3 ft

category 12 lanes 5 speed 50 mph width 60.0 ft colour 0x00007fff type urban major
median width 0.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 1.000
signpost 820.2 ft,3.3 ft

category 13 lanes 1 speed 40 mph width 12.0 ft colour 0x00006400 type urban minor
median width 0.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 2.000
signpost 820.2 ft,3.3 ft

category 14 lanes 2 speed 40 mph width 24.0 ft colour 0x00006400 type urban minor
median width 0.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 2.000
signpost 820.2 ft,3.3 ft

category 15 lanes 3 speed 40 mph width 36.0 ft colour 0x00006400 type urban minor
median width 0.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 2.000
signpost 820.2 ft,3.3 ft

category 16 lanes 4 speed 40 mph width 48.0 ft colour 0x00006400 type urban minor
median width 0.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 2.000
signpost 820.2 ft,3.3 ft

category 17 lanes 5 speed 40 mph width 60.0 ft colour 0x00006400 type urban minor
median width 0.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 2.000
signpost 820.2 ft,3.3 ft

category 18 lanes 6 speed 40 mph width 60.0 ft colour 0x00006400 type urban minor
median width 0.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 2.000
signpost 820.2 ft,3.3 ft

category 19 lanes 1 speed 35 mph width 12.0 ft colour 0x0000ff00 type urban minor
median width 0.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 2.000
signpost 820.2 ft,3.3 ft

category 20 lanes 2 speed 35 mph width 24.0 ft colour 0x0000ff00 type urban minor
median width 0.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 2.000
signpost 820.2 ft,3.3 ft

category 21 lanes 3 speed 35 mph width 36.0 ft colour 0x0000ff00 type urban minor
median width 0.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 2.000
signpost 820.2 ft,3.3 ft

category 22 lanes 4 speed 35 mph width 48.0 ft colour 0x0000ff00 type urban minor
median width 0.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 2.000
signpost 820.2 ft,3.3 ft

category 23 lanes 5 speed 35 mph width 60.0 ft colour 0x0000ff00 type urban minor
median width 0.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 2.000
signpost 820.2 ft,3.3 ft

category 24 lanes 6 speed 35 mph width 72.0 ft colour 0x0000ff00 type urban minor
median width 0.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 2.000
signpost 820.2 ft,3.3 ft

category 25 lanes 1 speed 30 mph width 12.0 ft colour 0x00ff7648 type urban minor
median width 0.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 2.000
signpost 820.2 ft,3.3 ft

category 26 lanes 2 speed 30 mph width 24.0 ft colour 0x00ff7648 type urban minor
median width 0.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 2.000
signpost 820.2 ft,3.3 ft

category 27 lanes 3 speed 30 mph width 36.0 ft colour 0x00ff7648 type urban minor
median width 0.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 2.000
signpost 820.2 ft,3.3 ft

category 28 lanes 4 speed 30 mph width 48.0 ft colour 0x00ff7648 type urban minor
median width 0.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 2.000
signpost 820.2 ft,3.3 ft

category 29 lanes 5 speed 30 mph width 60.0 ft colour 0x00ff7648 type urban minor
median width 0.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 2.000
signpost 820.2 ft,3.3 ft

category 30 lanes 6 speed 30 mph width 60.0 ft colour 0x00ff7648 type urban minor
median width 0.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 2.000
signpost 820.2 ft,3.3 ft

category 31 lanes 1 speed 25 mph width 12.0 ft colour 0x00ffce87 type urban minor
median width 0.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 2.000
signpost 820.2 ft,3.3 ft

category 32 lanes 2 speed 25 mph width 24.0 ft colour 0x00ffce87 type urban minor
median width 0.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 2.000
signpost 820.2 ft,3.3 ft

category 33 lanes 3 speed 25 mph width 36.0 ft colour 0x00ffce87 type urban minor
median width 0.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 2.000
signpost 820.2 ft,3.3 ft

category 34 lanes 4 speed 25 mph width 48.0 ft colour 0x00ffce87 type urban minor
median width 0.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 2.000
signpost 820.2 ft,3.3 ft

category 35 lanes 1 speed 55 mph width 18.0 ft colour 0x00007fff type urban major
median width 6.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 0.800
signpost 820.2 ft,3.3 ft

category 36 lanes 2 speed 55 mph width 30.0 ft colour 0x00007fff type urban major
median width 6.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 0.800
signpost 820.2 ft,3.3 ft

category 37 lanes 3 speed 55 mph width 42.0 ft colour 0x00007fff type urban major
median width 6.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 0.800
signpost 820.2 ft,3.3 ft

category 38 lanes 2 speed 40 mph width 30.0 ft colour 0x00006400 type urban minor
median width 6.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 2.000
signpost 820.2 ft,3.3 ft

category 39 lanes 2 speed 40 mph width 34.0 ft colour 0x00006400 type urban minor
median width 10.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 2.000
signpost 820.2 ft,3.3 ft

category 40 lanes 3 speed 40 mph width 46.0 ft colour 0x00006400 type urban minor

median width 10.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 2.000
signpost 820.2 ft,3.3 ft

category 41 lanes 3 speed 40 mph width 42.0 ft colour 0x00006400 type urban   minor
median width 6.0 ft
headway factor 1.000 curve speed factor 0.0 toll 0.000 cost factor 2.000
signpost 820.2 ft,3.3 ft

category 42 lanes 1 speed 50 mph width 12.0 ft colour 0x00ff00ff type urban   major
median width 0.0 ft
headway factor 1.000 curve speed factor 0.0 toll 1.000 cost factor 1.000
signpost 820.2 ft,3.3 ft

category 43 lanes 2 speed 50 mph width 24.0 ft colour 0x00ff00ff type urban   major
median width 0.0 ft
headway factor 1.000 curve speed factor 0.0 toll 1.000 cost factor 1.000
signpost 820.2 ft,3.3 ft

1. APPENDIX B – Paramics Vehicle Types (From Caltrans I-880 Model)

vehicle types

type 1 car length 15.42 ft width 6.23 ft height 4.59 ft
acc 11.81 fpss dec -12.80 fpss crawl speed 5.00 mph horsepower 50.00 colour 0x00ffffff
name "Mustang"
matrix 1 proportion 19.500 perturbation 2.0 familiarity 5.00

type 2 car length 17.72 ft width 6.56 ft height 4.59 ft
acc 7.87 fpss dec -12.47 fpss crawl speed 5.00 mph horsepower 50.00 colour 0x00ffffff
name "Crown Victoria"
matrix 1 proportion 19.500 perturbation 2.0 familiarity 5.00

type 3 car length 14.44 ft width 5.58 ft height 4.59 ft
acc 7.55 fpss dec -13.45 fpss crawl speed 5.00 mph horsepower 50.00 colour 0x00ffffff
name "Focus Sedan"
matrix 1 proportion 19.400 perturbation 2.0 familiarity 5.00

type 4 car length 17.39 ft width 6.56 ft height 5.91 ft
acc 7.55 fpss dec -12.14 fpss crawl speed 5.00 mph horsepower 50.00 colour 0x00ffffff
name "F-150 Pick up"
matrix 1 proportion 6.300 perturbation 2.0 familiarity 5.00

type 5 car length 16.73 ft width 6.23 ft height 5.58 ft
acc 7.55 fpss dec -10.17 fpss crawl speed 5.00 mph horsepower 50.00 colour 0x00ffffff
name "Windstar Mini-Van"
matrix 1 proportion 6.000 perturbation 2.0 familiarity 5.00

type 6 car length 15.75 ft width 5.91 ft height 5.91 ft
acc 7.87 fpss dec -11.15 fpss crawl speed 5.00 mph horsepower 50.00 colour 0x00ffffff
name "Ford Explorer"
matrix 1 proportion 6.000 perturbation 2.0 familiarity 5.00

type 7 car length 15.42 ft width 6.23 ft height 4.59 ft
acc 11.81 fpss dec -12.80 fpss crawl speed 5.00 mph horsepower 50.00 colour 0x000000ff
name "Mustang HOV"
matrix 1 proportion 5.000 perturbation 2.0 familiarity 5.00

type 8 car length 17.72 ft width 6.56 ft height 4.59 ft
acc 7.87 fpss dec -12.47 fpss crawl speed 5.00 mph horsepower 50.00 colour 0x000000ff
name "Crown Victoria HOV"
matrix 1 proportion 5.000 perturbation 2.0 familiarity 5.00

type 9 car length 14.44 ft width 5.58 ft height 4.59 ft
acc 7.55 fpss dec -13.45 fpss crawl speed 5.00 mph horsepower 50.00 colour 0x000000ff
name "Focus Sedan HOV"
matrix 1 proportion 4.600 perturbation 2.0 familiarity 5.00

type 10 car length 17.39 ft width 6.56 ft height 5.91 ft
acc 7.55 fpss dec -12.14 fpss crawl speed 5.00 mph horsepower 50.00 colour 0x000000ff
name "F-150 Pick up HOV"
matrix 1 proportion 1.500 perturbation 2.0 familiarity 5.00

type 11 car length 16.73 ft width 6.23 ft height 5.58 ft
acc 7.55 fpss dec -10.17 fpss crawl speed 5.00 mph horsepower 50.00 colour 0x000000ff
name "Windstar Mini-Van HOV"
matrix 1 proportion 1.500 perturbation 2.0 familiarity 5.00

type 12 car length 15.75 ft width 5.91 ft height 5.91 ft
acc 7.87 fpss dec -11.15 fpss crawl speed 5.00 mph horsepower 50.00 colour 0x000000ff
name "Ford Explorer HOV"
matrix 1 proportion 1.600 perturbation 2.0 familiarity 5.00

type 13 car length 14.44 ft width 5.58 ft height 4.59 ft weight 0.79 ton
acc 7.55 fpss dec -13.45 fpss crawl speed 5.00 mph horsepower 50.00 colour 0x00ffffff
name "Buses"
matrix 1 proportion 0.100 perturbation 0.0 familiarity 5.00

type 14 OGV1 length 40.03 ft width 8.53 ft height 13.45 ft weight 3.88 ton
top speed 55.00 mph acc 5.58 fpss dec -12.14 fpss crawl speed 5.00 mph horsepower 50.00 colour 0x00ff0000
name "Truck - Class 5-8, empty"
matrix 1 proportion 2.000 perturbation 0.0 familiarity 0.00

type 15 OGV1 length 40.03 ft width 8.53 ft height 13.45 ft weight 7.09 ton
top speed 55.00 mph acc 5.58 fpss dec -12.14 fpss crawl speed 5.00 mph horsepower 50.00 colour 0x00ff0000
name "Truck - Class 5-8, loaded"
matrix 1 proportion 2.000 perturbation 0.0 familiarity 0.00

type 16 OGV2 length 64.96 ft width 8.53 ft height 13.45 ft weight 12.50 ton
top speed 55.00 mph dec -11.48 fpss crawl speed 5.00 mph horsepower 50.00 acc profile 4 dec profile 8 colour 0x0000758b
name "Truck - Class 9-14, empty"
trailer count 1
(
trailer 1 length 52.99 ft
colour 0x001a2d8b
model type 0
)
matrix 2 proportion 50.000 perturbation 0.0 familiarity 0.00

type 17 OGV2 length 64.96 ft width 8.53 ft height 13.45 ft weight 23.00 ton
top speed 55.00 mph dec -11.48 fpss crawl speed 5.00 mph horsepower 50.00 acc profile 4 dec profile 8 colour 0x00008b00
name "Truck - Class 9-14, loaded"
trailer count 1
(

```
        trailer 1 length 52.99 ft
        colour 0x00142c8b
        model type 0
    )
    matrix 2 proportion 50.000 perturbation 0.0 familiarity 0.00
```