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USDOT Integrated Corridor Management (ICM) Initiative

Integrated Corridor Management Analysis, Modeling, and Simulation Test Corridor Model Description

March 2008
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16. Abstract
This technical memorandum provides a description and definition of the test corridor; and provides explanatory meta-data including an inventory of the facilities in the test corridor, and the key challenges in providing efficient traffic operations in the test corridor.

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ANALYSIS, MODELING, SIMULATION, AMS, TEST CORRIDOR, FRAMEWORK, TOOLS, PERFORMANCE MEASURES, I-880 CORRIDOR, MACROSCOPIC, MESOSCOPIC, MICROSCOPIC, TRAVEL DEMAND FORECASTING MODEL	

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

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

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1.0 Background

The objective of the Integrated Corridor Management (ICM) initiative is to demonstrate how intelligent transportation systems (ITS) technologies can efficiently and proactively manage the movement of people and goods in major transportation corridors. The objectives of the ICM – Tools, Strategies, and Deployment Support project are to refine Analysis, Modeling, and Simulation (AMS) tools and strategies, assess Pioneer Site data capabilities, conduct AMS for four Stage 2 ICM Pioneer Sites, and conduct AMS tools post-demonstration evaluations.

In coordination with the U.S. Department of Transportation (USDOT), the study team led by Cambridge Systematics (CS) developed corridor selection criteria, and a list of corridors with available AMS data. CS applied the criteria to these corridors and presented the USDOT with a top 12 list of candidates. This document summarizes the results of the corridor selection process and makes the recommendation of selecting the I-880 corridor in Alameda County, California as the test corridor for AMS.

This technical memorandum provides a description and definition of the test corridor; and provides explanatory meta-data including an inventory of the facilities in the test corridor, and the key challenges in providing efficient traffic operations in the test corridor. The necessary data to support the AMS of the test corridor for the development and testing of AMS methodologies and tools also are provided in this technical memorandum and attached data DVD.

2.0 Corridor Selection

The study team defined criteria to compare the pre-selected 12 candidate sites, as shown in Table 2.1. The geographies of each candidate site are shown in Appendix A. Most of the candidate sites have a travel demand model and a microscopic simulation model; however, only one-half of them have a mesoscopic simulation model. Calibration data were available for freeways for the candidate sites, but only a few locations had arterial and local street calibration data.

After the 12 candidate sites were compared, the top 8 candidate sites were selected for further analysis. Table 2.2 shows the score analysis of the top 8 candidate sites.

The top three candidates were selected, including I-880 SF, I-10 LA, and I-10 TX for further analysis shown in Table 2.3. Among the final candidates, the I-880 in the San Francisco Bay Area appears to be the most appropriate corridor to be tested. This corridor has available travel demand, mesoscopic and microscopic simulation models, and validation/calibration data from previous studies; is truly multimodal; and, has a multitude of transportation facilities.

Table 2.1 Comparison of 12 Candidate AMS Test Corridors

Corridor	I-880	I-10	I-210	I-680	Tysons Corner	I-5	I-71/I-90 Cleveland Innerbelt	COTA LRT	I-70/I-71 Southern Innerbelt	I-270 Northwest	I-10 El Paso	I-40/I-85
Location	Alameda County, CA	Los Angeles, CA	Los Angeles County, CA	Alameda County, CA	VA	Los Angeles, CA	Cleveland, OH	Columbus, OH	Columbus, OH	Columbus, OH	City of El Paso, TX	Research Triangle Region, NC
Agency, Consultant	ACCMA, CCIT, SMG, CS	Caltrans D7, Dowling Associates	Caltrans, PATH	Caltrans, CS	Fairfax County, VDRPT, CS	Caltrans, PTV America	ODOT, Burgess & Niple	COTA, Burgess & Niple	ODOT, Burgess & Niple	MORPC, Burgess & Niple	TxDOT, UTEP	Triangle Regional Model Service Bureau
Travel demand model	EMME/2	SCAG Model, TRANPLAN	SCAG Model, TRANPLAN	EMME/2	Cube	TRANPLAN, VISUM	TRANPLAN	TRANPLAN (export to VISUM for subarea model)	TRANPLAN	TRANPLAN (export to VISUM for subarea model)	TransCAD	TransCAD
Mesoscopic simulation model	Dynasmart – partial	No	Cell transmission	No	–	–	Integration	–	Integration	–	DYNASMART-P	DYNASMART-P
Microscopic simulation model	Paramics, 4-hr AM and PM peak trip tables	Paramics, 5-hour, AM peak OD table	VISSIM	Paramics	VISSIM (freeway network is incomplete)	VISSIM	CORSIM/VISSIM/ Synchro	VISSIM	CORSIM/Synchro	VISSIM	CORSIM	No
Availability of validation/calibration data	PEMS for freeways, limited for arterials and local streets	Extensive data for freeway, limited for surface streets	Yes for freeways, no for arterials and local streets	Some	Yes for arterials, none for freeways	Yes, freeway and arterial streets	Yes for freeways and arterial streets	Yes for freeway and arterial streets, manual data	Yes for freeway and arterial streets	Yes for freeway and arterial streets	Yes for freeways, some for arterials and local streets	Yes for freeways, no for arterials and local streets
Transportation modes: SOV, HOV, transit, trucks, etc.	SOV, HOV, bus transit, rapid transit, trucks	SOV, HOV, bus, metrorail, trucks, HOV lane	SOV, HOV, bus transit, rapid transit, trucks	HOV lane, HOT lane planned, no transit	SOV, HOV, bus transit, trucks, heavy rail	SOV, HOV, trucks, no transit	SOV, trucks, no transit	SOV, transit	SOV, trucks, no transit	SOV, trucks, no transit	SOV, HOV, bus transit, trucks	Bus transit, rapid transit planned in Regional Rail Transit Project
Modeled ICM strategies: ramp metering, transit signal preemption, etc.	Ramp metering, CMS	Ramp metering	Ramp metering	Ramp metering	Ramp metering, CMS	Ramp metering	None		None	None	N/A	
Facilities in modeled corridor: freeways, HOV lanes, arterials, transit guideways	Freeways, HOV lanes, arterials, transit guideways	Freeway, HOV lanes, arterials, rail	Freeways, HOV lanes, no arterials	Freeway, HOV lane	Arterials, no freeways	Freeways, HOV lanes, arterials	Freeways, arterials	Freeways, arterials, transit guideways	Freeways, arterials	Freeways, arterials	Freeways, arterials	Freeways
Geographic scope of modeled corridor	27 x 5 miles	21 miles	14 miles (SR 134 to I-605)	~ 20 sq. miles	5 x 2 miles	10 x 9 miles	~ 30 sq. miles	~ 30 sq. miles, fairly small network, not conducive to dynamic mode shift	~ 20 sq. miles	~ 50 sq. miles	40 miles (state line to milepost 40)	30 miles

Table 2.2 Tradeoff Analysis of Top 8 Candidate AMS Test Corridors

Criteria	I-880 SF	I-10 LA	I-210 LA	Tysons Corner VA	I-5 LA	COTA LRT, OH	I-10 TX	I-40/I-85 NC
Travel demand model	+++	++	++	++	++	++	++	++
Mesoscopic simulation model	+	No	+	No	No	No	++	++
Microscopic simulation model	++	+++	++	++	++	++	++	No
Availability of validation and calibration data	++	++	+	+	++	++	++	+
Transp. modes: transit, SOV, HOV	+++	+++	++	++	++	++	+	++
Facilities: freeways, HOV, arterials, transit	+++	+++	+	+	++	++	++	+
Transferability, applicability	++	++	++	+	+	+	+	+
Ease of modifications	++	++	+	+	+	+	+	+

Table 2.3 Tradeoff Analysis of Top 3 Candidate AMS Test Corridors

Criteria	I-880 SF	I-10 LA	I-10 TX
Travel demand model	EMME/2, smaller model for AC County	SCAG, TRANPLAN, too large, for whole LA region	TransCAD, smaller
Mesoscopic simulation model	Dynasmart-P, partial	No	Dynasmart-P
Microscopic simulation model	Paramics, 4-hr AM and PM peak	Paramics, 5-hour, AM peak	Corsim
Availability of validation and calibration data	PeMS for freeway, some for surface streets – more being collected	PeMS for freeway, limited for surface streets	Yes for freeways, some for surface streets
Transp. modes: transit, SOV, HOV	SOV, HOV, bus transit, rapid transit, trucks	SOV, HOV, bus transit, metrorail, trucks	SOV, HOV, bus transit, trucks, no rapid transit
Facilities: freeways, HOV, arterials, transit	Freeways, HOV lane, arterials, transit guideways	Freeway, HOV lanes, arterials, rail	Freeways, arterials, no HOV lane
Transferability, applicability	Multimodal, good data	Multimodal, good data, no meso model	Less multimodal, not very typical corridor
Ease of modifications	All models available	Some models available	All models available

3.0 Test Corridor Description

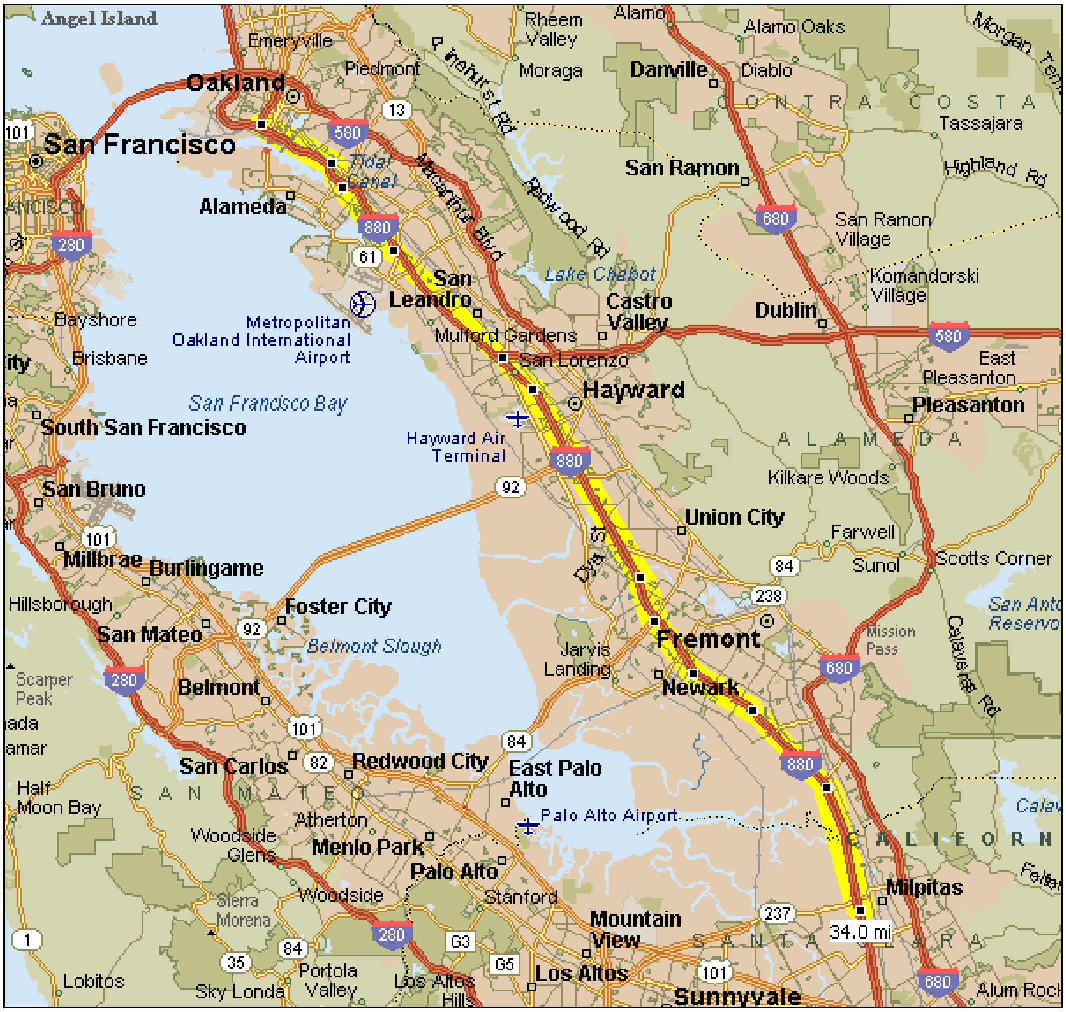
The Bay Area is the fifth most populated metropolitan area in the United States, and the I-880 corridor is centrally located within the region. It is a strategic route providing connectivity between densely populated residential areas and many major commercial and industrial centers. The corridor also plays a key role in freight and goods movement, directly serving the Port of Oakland, the fourth busiest port in the United States. The facilities in the test corridor include the I-880 freeway, arterial highways, the Alameda County (AC) bus transit routes, the Bay Area Rapid Transit (BART) rail, and the intercity passenger rail lines. The I-880 corridor is truly a multimodal, multiuse facility.

As one of the main arteries of the freeway system in the Bay Area, I-880 includes 45 miles of freeway connecting Silicon Valley with the East Bay (see Figure 3.1). Major interchanges in the corridor include junctions at Route 112 (Davis Street in San Leandro); I-238 (from Hayward, east to I-580); SR 92 (from Hayward, west to the San Mateo-Hayward Bridge); SR 84 (from Fremont, west to the Dumbarton Bridge); and SR 262 (from Fremont, east to I-680). I-880 serves the Port of Oakland, Oakland International Airport and the Oakland Intermodal Gateway Terminal (the Joint Intermodal Terminal), and the Oakland Coliseum, as well as a major concentration of industrial and warehouse land uses. I-880 serves as both an access route for major interregional and international shippers and a primary intraregional goods-movement corridor.

The segment of the I-880 corridor between the Cities of Oakland and Fremont, with the I-580/I-80 interchange as the northern boundary and SR 237 as the southern boundary, for a distance of about 38 miles or more than 250 lane miles, is selected to be the test corridor.

The overall traffic volumes along I-880 corridor are heavy. The average annual daily traffic (AADT) of the I-880 freeway ranges between 120,000 to 275,000 per weekday. The corridor experiences extended peak hours, involving northbound AM peak-period flow and southbound PM peak-period flow. The high-vehicle occupancy (HOV) lanes are operating effectively and have public and political support. Peak-hour carpools experience significant time savings on the HOV lanes in the I-880 corridor. The carpool lanes in the northbound morning peak (1.2-mile segment) to the Bay Bridge offer an 18-minute time advantage. During the morning peak, carpools on the southbound I-880 HOV lane save 36 minutes in travel time during their commute on a 19-mile segment of HOV lane.

Figure 3.1 Test Corridor Roadway System



Source: Cambridge Systematics, Inc., 2007.

I-880 is an intermodal freeway that serves the following major traffic generating sources:

- **Oakland Sea Port –** I-880 serves a key interregional role as the primary route serving the Port of Oakland. I-880 serves as both an access route for major interregional and international shippers and a primary intraregional goods-movement corridor. The connection with the Port of Oakland generates significant truck volumes, representing approximately 10 percent of the total freeway volume. The corridor carries the highest volume of truck traffic in the region and among the highest of any highway in the State. In 2004, the number of containers processed by the Port of Oakland was slightly more than 2 million Twenty-foot Equivalent Unit (TEU) containers. Ten container terminals and two intermodal rail facilities serve the Oakland waterfront. The Union Pacific (UP) and Burlington Northern Santa Fe (BNSF) railroad facilities are located adjacent to the heart of the marine terminal area to provide a reliable and efficient movement of cargo between the marine terminals or trainload facilities and the intermodal rail facilities.

- **Oakland International Airport –** The corridor also serves Oakland International Airport, one of three major airports in the Bay Area. The Oakland International Airport is located west of I-880 just north of the Oakland/San Leandro city boundary. It serves approximately 14 million passengers annually, and processes more than 600,000 metric tons of freight annually. The volume of air passengers and air cargo processed at this airport has been growing steadily each year. The Airport is currently undergoing a significant expansion.
- **Oakland Coliseum –** Located in the middle of the corridor and adjacent to the I-880 freeway and a BART station is the Oakland-Alameda County Coliseum and Sports Arena, home of the Oakland Raiders football team, the Oakland A's baseball team, and the Golden State Warriors basketball team. The Oakland Coliseum hosts the Raiders and A's football and baseball teams, as well as other events, and accommodates a capacity of 63,000 people. The Sports Arena hosts the Warriors' NBA games and other major events/attractions and has a capacity of 19,200 people. The arriving and departing event goers have a direct impact on the capacity and flow of traffic along the ICM corridor.

In addition, there is a major concentration of industrial and warehouse land uses along the I-880 corridor. There are a number of major north-south arterials along the entire project corridor on both sides of the I-880 corridor, with connecting arterials to the freeway segment. On the east side of the I-880 corridor, the major north-south arterial forms a continuous segment from the southern limits of the project corridor starting from Mission Boulevard (SR 238), E. 14th Street, and International Boulevard, which forms a continuous corridor from the southern limit of the project corridor to the northern limit. The arterial corridor ends in downtown Oakland. On the west side of the I-880 corridor, the major north-south arterial forms a continuous segment from the southern limit of the project corridor starting at the Ardenwood Boulevard, Union City Boulevard, and Hesperian Boulevard, where it crosses the I-880 corridor in San Leandro and joins the E. 14th Street. On the east side of the I-880 corridor, Doolittle Drive (SR 61) serves the Port of Oakland and Oakland Airport and is connected to the I-880 corridor via Davis Street (SR 112), 98th Avenue, and Hegenberger Road.

The following are major arterials connecting the arterial segment and the freeway segment:

- 29th Avenue (Oakland),
- 42nd Avenue (SR 77) (Oakland),
- Hegenberger Road (Oakland),
- 98th Avenue (Oakland),

- Davis Street (SR 112) (San Leandro),
- West A Street (Hayward),
- West Winton Avenue (Hayward),
- Tennyson Road (Hayward),
- Industrial Parkway (Hayward),
- Alvarado-Niles Road (Union City),
- Alvarado Boulevard (Union City), and
- Paseo Padre (Fremont).

Within downtown Oakland, the major arterials include 14th Street, Broadway, and Grand Avenue, where they join the I-880 corridor at the northern limits of the project corridor. Major portions of these arterial networks are currently included in the East Bay SMART Corridors program, which consists of the International Boulevard, East 14th Street, San Leandro Boulevard/Street, Hesperian Boulevard, and Union City Boulevard. The corridor is approximately 18 miles long and parallels Highway 880 from downtown Oakland to Union City.

There is a total of 40 miles of arterials along the corridor on both the east side and the west side of the I-880 corridor with approximately 12 major connecting arterials between the north-south corridors and the I-880 freeway. The arterials are typically 4 to 6 lanes wide with major turning lanes at all of the signalized intersections. There are approximately 250 signalized intersections along the entire north-side and east-west major connecting arterials with auxiliary turning lanes at all major intersections.

Traffic signals are maintained and controlled by their respective local agencies. Data from most of the systems are shared through the common data exchange platform to other participating agencies. Most of the intersections along the project corridor are interconnected with either hardwired twisted pair or fiber optic communication lines. Most of the traffic signals are fully actuated with detection system on both the mainline and side streets. There are some semi-actuated signals in the City of Oakland. The signals are also coordinated using time-of-day coordination plans during morning, midday, and afternoon peak hours. As a part of the East Bay SMART Corridors program, all agencies (except for Fremont and Newark) are interconnected via high-speed T1 lines to share signal coordination information between the agencies.

Except for a few short segments, on-street parking exists on both sides of E. 14th Street, International Boulevard, and Mission Boulevard. A significant amount of parking on each corridor is metered with 30-minute to 2-hour time limits. There is no parking for most of the Hesperian Boulevard and Union City Boulevard segment.

Moderate pedestrian volumes (from 20 to 150 pedestrians) exist throughout the corridors. Higher densities of pedestrians (from 150 to 300 pedestrians) are found along International Boulevard between 2nd Avenue and 25th Avenue. Bicycle volumes generally average 30 per hour at all intersections during all peak periods.

The truck/bus traffic along the routes does not appear to be heavier than normal, or within 2 percent of the overall traffic volumes, except for the routes that serve the Port of Oakland. These routes include Davis Street, 98th, Hegenberger, and Doolittle Drive (SR 61).

Several AC Transit routes operate along the corridor within the study limits. Transit routes operate with varying frequencies between 12 minutes and 60 minutes. The majority of the bus stop locations have adequate room for buses to pull over and stop without blocking the through traffic. This is due to having wide curb lanes with restricted parking or bus turn-outs.

The Average Daily Traffic (ADT) volumes range from 25,000 to 60,000 vehicles per day, depending on the location along the arterial network. Currently, the Level of Service (LOS) along the project corridor is between C to D at most of the project intersections

As a part of the East Bay SMART Corridors program, 18 miles of the existing arterial network are equipped with Closed-Circuit Television (CCTV) and monitoring stations. These devices collect real-time information about the project corridor and share the information with all of the agencies in the program. In addition, the East Bay SMART Corridors program will allow agencies to share and distribute incident and construction information about the project corridors. Freeway incident information is also received from California Highway Patrol (CHP) and displayed for the I-880 corridor, as well as the 511 congestion information on the freeway.

3.1 Inventory of Transportation Facilities

The inventory of transportation facilities is summarized in Table 3.1. There are four components of transportation facilities in this test corridor, including 1) the I-880 freeway, 2) arterial highways, 3) Alameda county bus transit routes, and 4) BART rail. The inventory is categorized to infrastructure and maintenance, data collection, data archiving, network, facility, operations, and problems and issues.

Table 3.1 Inventory of Transportation Facilities

I-880 freeway	Arterial Highways	AC Bus Transit Routes	BART Rail
Infrastructure and Maintenance			
• Dense deployment of ITS infrastructure on freeway, including 83 vehicle detection stations, 25 CCTVs, 5 CMSs, 86 operational ramp meters, 5 HARs, and communication to and from the Traffic Management Center (TMC). • CCTVs, CMSs, and HARs are checked by TMC Operators weekly or monthly. Problems are reported to Caltrans electrical maintenance staff. Ramp meters are monitored daily by Caltrans Field Operations. • A TOS Equipment Management System (TEMS) is being developed that will improve management of the TOS inventory and help ensure the reliability and accuracy of the TOS and TMC information. The database will begin to be populated in July 2006.	• CCTV and Non-Intrusive Monitoring Stations are installed on the arterials. There are also transit signal priority units (on E. 14th/International) and emergency preemption units installed. • Weekly manual inspection of all CCTV and Monitoring Stations units for functionality. • A maintenance contractor also provides annual and semi-annual inspection and cleaning for all units. Maintenance contractor will be issued a task order for corrective action.	• 2 main infrastructure systems: Orbital "Satcom" radio and Automatic Vehicle Locator (AVL) system; and the Nextbus prediction system. • When malfunctions are detected in the Orbital system, on-site personnel diagnose and correct the issues. • The Nextbus prediction system is provided under contract with an outside vendor; any malfunction is either handled by on-site personnel, or referred to the vendor.	• BART operation is entirely automated by using the Automated Train Control System. • BART has also developed a communication based train control system that uses MASH communication system to position and operate trains. The system has great potential for significantly increasing passenger throughput and can collected operation data in finer resolution. • BART and CCPJA are seeking assistance from telecommunication industry to provide Wi-Fi service onboard.

<table>
<tr><th>I-880 freeway</th><th>Arterial Highways</th><th>AC Bus Transit Routes</th><th>BART Rail</th></tr>
<tr><td colspan="4">Data Collection</td></tr>
<tr><td>Volume, speed, occupancy, travel time, ramp metering rate, HOV volume, and incident clearance time data are collected on I-880.
Data are collected using vehicle loop detectors, video, magnetic, microwave, and toll tag readers.
Data are owned mostly by Caltrans and exchanged with other agencies through dedicated network.</td><td>Volume and speed data are collected on arterials using RTMS data collection units.
The data are owned by ACCMA and data exchanges with other networks are carried through a leased T1 line.</td><td>Boarding and alighting passenger data, running times, schedule adherence, vehicle location, and prediction reports are collected using Automatic Passenger Counter (APC); AVLs, and Nextbus prediction systems.
The data are owned by AC Transit; and historical data currently are sometimes viewed by other agencies, but there is no real-time communication.</td><td>Train movements monitored in real-time through track circuits and twisted wires at stations. Route information (through switch positions), signal status, and system health information also are collected. Fare collection information is also collected.</td></tr>
<tr><td colspan="4">Network</td></tr>
<tr><td>I-880 between I-580/I-80 interchange in the north and SR 237 in the south; length 38 miles.</td><td>International Blvd, E. 14th St, San Leandro Blvd, Hesperian Blvd, and Union City Blvd; length 18 miles</td><td>2 major local AC Transit lines along I-880 (82 and 82L), plus about 15 express lines.</td><td>> 20 miles of double track.</td></tr>
<tr><td colspan="4">Data Archiving</td></tr>
<tr><td>Real-time detector station data are exported to TravInfo and PATH's Performance Monitoring System (PeMS) using an XML interface.</td><td>Radar data (i.e., traffic counts and speeds) are archived by 30-second intervals. Transit signal priority usage data will be archived starting Sept. 2006.
The data are stored on the production server for 6 months. Every month the data that are 7 months old are moved onto a separate archive server on which they are held indefinitely.</td><td>AC Transit's bus fleet is 100% equipped with CAD/AVL equipment. Archiving methodologies are in place to fully support both real-time and post processing requirements.
Schedule Adherence "events" are recorded in the long-term database (LTDB). Reports requiring post-processing, such as monthly schedule adherence reports, are available for a 3-month period; and based on the back-up, data is available for up to a year.</td><td>Data related the system operation (route, switch positions, and signal status); train operation (movements, schedule adherence); and passenger data are extensively archived for both operation and safety reasons.
BART's internal web site has real-time information available, such as the location of all of the trains and fare collection information within the system.</td></tr>
</table>

I-880 freeway	Arterial Highways	AC Bus Transit Routes	BART Rail
Facility			
• TMC located in Caltrans District Office in Oakland. 250+ freeway lane miles, all under TMC surveillance and control. 39 miles HOV lanes. • Dense ITS deployment includes traffic detectors, CMS, CCTV, HAR, etc.	• Distributed TMC with satellite locations. Arterials are primarily 4-lane undivided highways. Over 150 signalized intersections, 18 arterial miles, all under TMC surveillance and control.	• TMC located in Division D-2, Emeryville, CA. • There are approximately 200 bus stops along the corridor, with 3 major parking facilities. • AC Transit is in the process of implementing BRT between Berkeley and San Leandro along the International/E. Street corridor.	• 12 BART stations along study corridor. 10 stations have parking lots/garages, with 11,432 spaces.
Operations			
• Overall traffic volumes along I-880 corridor are very heavy, with AADT between 120,000 to 275,000 per weekday. • I-880 is an intermodal freeway that serves major traffic generators, including the Port of Oakland, Oakland International Airport, and Oakland Coliseum. Trucks comprise up to 11% of the AADT in the corridor.	• Current ADT along the arterials is between 25,000 and 50,000 vehicles per day.	• Passenger boarding for Routes 82 and 82L is 16,727 per day on weekdays. • AC Transit has several major transfer points along the corridor. Each of these stations serves between 5 and 8 bus routes and provides intermodal transfers with the BART service. Over 7,000 passengers per day access BART or buses at these stations.	• At stations along I-880, approximate number of passenger boarding and alighting per weekday is 138,000.

I-880 freeway	Arterial Highways	AC Bus Transit Routes	BART Rail
Problems and Issues			
• Recurrent congestion causes more than 10,000 veh-hrs of delay per weekday, and significantly disrupts freight movement through the corridor. • Non-recurrent congestion is also a major problem. I-880 averages over 10 collisions per day and over 100 incidents per day. It is estimated that collisions account for 30 percent of overall corridor delay.	• The arterials along the project corridor currently operate at LOS D or worse during the peak hours. Due to incidents on the freeway, there are routine diversions to the local arterials that will increase the delay and reduce the LOSs along these arterials. Therefore, coordination of the operation of the network of arterials with the freeway is crucial to optimizing the overall capacity of the system.		

3.2 Key Challenges in the Efficient Operation of the Test Corridor

There are significant opportunities to further improve the operation and management of the corridor.

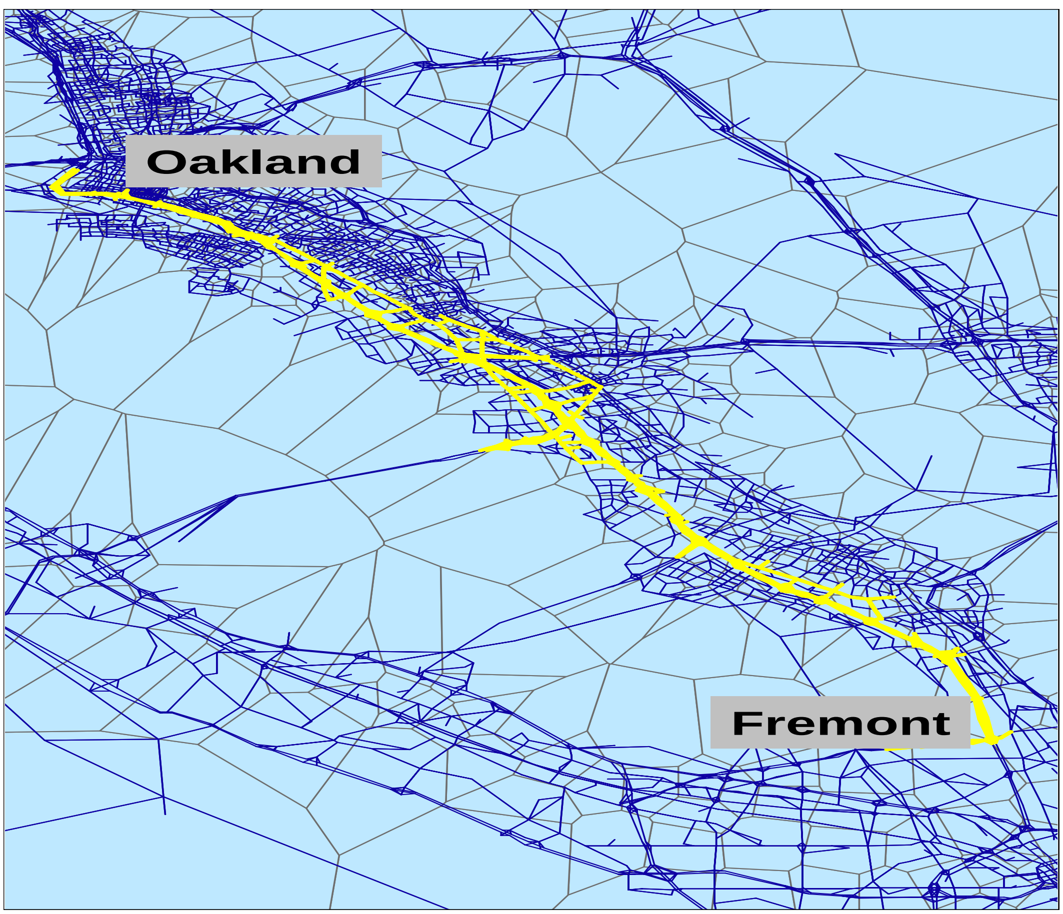
1. Major businesses along the corridor rely on just-in-time delivery of freight, and can be adversely affected by freeway congestion. Trucks that transport freight containers to and from the Port can experience delays both on the freeway and on the access roads, where long queues can develop as trucks wait to clear security.
2. Several major multiyear highway construction projects will begin on the I-880 corridor within the next year. These projects include the complete reconstruction of the I-880/SR 92 interchange ($111 million), the seismic retrofit of the Fifth Avenue overhead ($108 million), and the seismic retrofit of the High Street interchange ($85 million). This work will be scattered throughout the corridor; and complex construction staging will require occasional closures of the freeway, detouring traffic onto local streets. The ability to test ICM strategies within the context of ongoing construction closures and detours will be invaluable in determining the accuracy of the modeling effort and the effectiveness of various management strategies.
3. ICM can fill the gap and support effective use of existing transportation infrastructure through coordination and sharing resources of different systems for better incident management, first responder, and special event coordination. Possible strategies include adaptive operation of the freeway ramp meters, coordination of the metering with arterial signal timing, and dynamic re-routing of buses based on actual traffic conditions.
4. Emergency preparedness is an activity that has received substantial emphasis in the Bay Area. The strategic importance of the Port of Oakland necessitates that preparedness and response plans focus on that facility. Any transportation component of these emergency plans must consider how the I-880 corridor should be operated.

4.0 Test Corridor Data

The I-880 test corridor, shown in Figure 4.1, has been studied by many transportation agencies, including Caltrans, the ACCMA, and the California Center for Innovative Transportation (CCIT). This section provides a summary of available test corridor data organized in six subsections, including macroscopic travel demand model data, mesoscopic simulation model data, microscopic simulation model data, zone correspondence data, traffic data, and transit data. The electronic data files are also provided in the data DVD.

The test corridor was modeled in CUBE, Dynasmart-P, and Paramics macroscopic, mesoscopic, and microscopic models, respectively. The validation and calibration traffic data are adequate for freeways, but quite limited for arterials and local streets.

Figure 4.1 Test Corridor



4.1 Test Corridor AMS Framework

The approach adopted for the test corridor analysis applies the framework from the AMS Methodology document, as shown in Figure 4.2. The AMS methodology for Test Corridor applies macroscopic trip table manipulation for the determination of overall trip patterns, mesoscopic analysis of the impact of driver behavior in reaction to ICM strategies (both within and between modes), and microscopic analysis of the impact of traffic control strategies at roadway junctions (such as arterial intersections or freeway interchanges). The methodology also includes a simple pivot-point mode shift model and a transit travel time estimation module, the development of interfaces between different tools, and the development of a performance measurement/benefit-cost module.

4.2 AMS Tools

The Test Corridor modeling approach encompasses tools with different traffic analysis resolutions. All three classes of simulation modeling approaches – macroscopic, mesoscopic, and microscopic – will be applied for evaluating ICM strategies. The objective of the modeling approach is to provide the greatest degree of flexibility and robustness in supporting subsequent tasks for the Test Corridor and AMS support of Pioneer Sites. This section describes the various off-the-shelf and custom tools applied for the Test Corridor to conduct the modeling of the ICM strategies.

Travel Demand Forecasting Model

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

A calibrated CUBE travel demand model (TDM) of the Alameda County, shown in Figure 4.3, will be used to develop the trip tables for the Test Corridor. Two levels of subarea trip tables will be developed from the TDM – to cover the spatial extents of the mesoscopic and microscopic simulation models. The travel demand model also will be used as the analysis engine for a simple pivot-point mode-choice model, which will analyze the mode shifts due to ICM strategies. The output from mode choice analysis and trip table manipulation will be static corridor-based trip tables that take into account basic trip impacts associated with corridor conditions, current operations, or operational changes. A detailed description of the mode choice model is provided later in this section.

Figure 4.2 Test Corridor AMS Framework

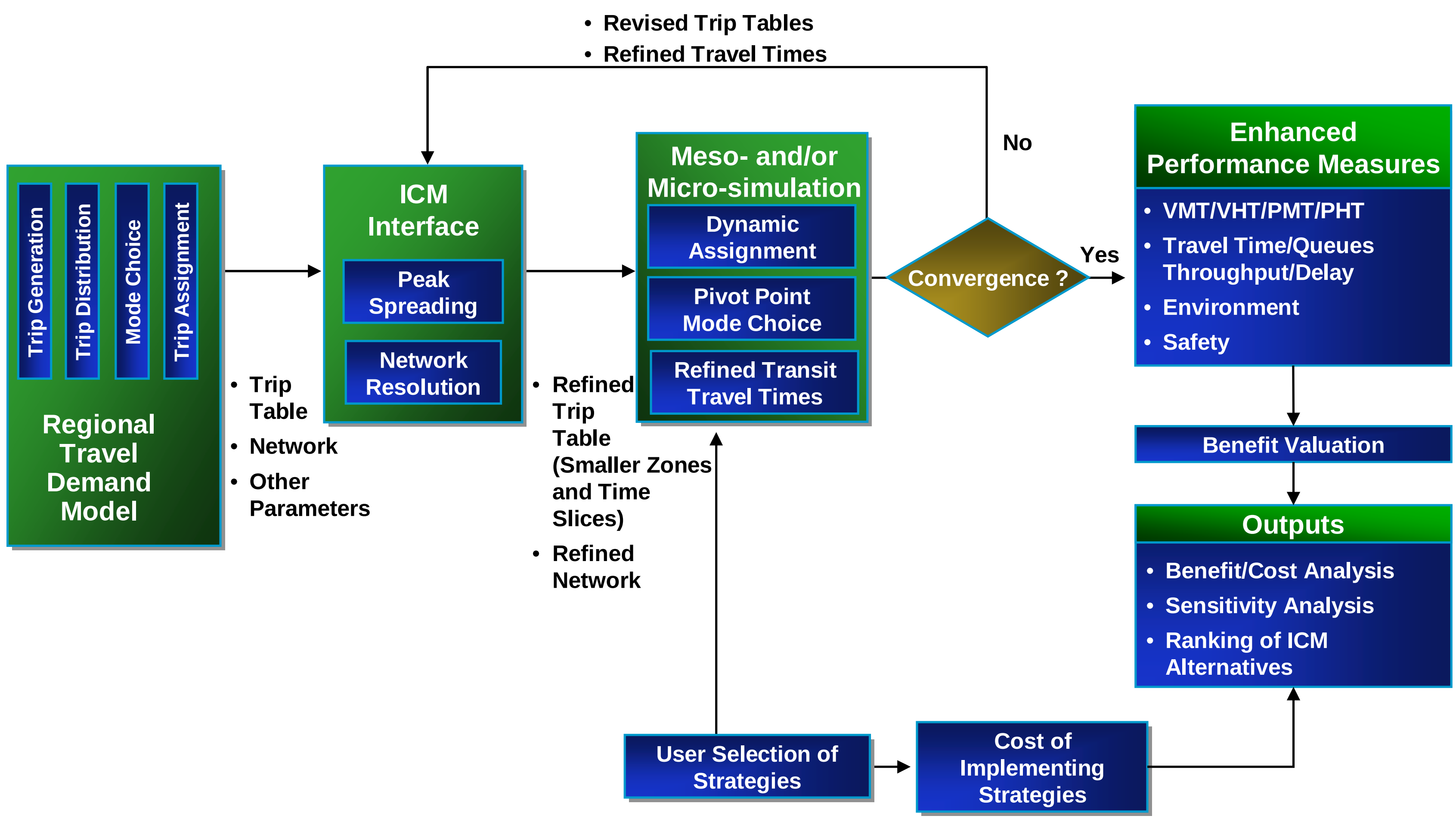
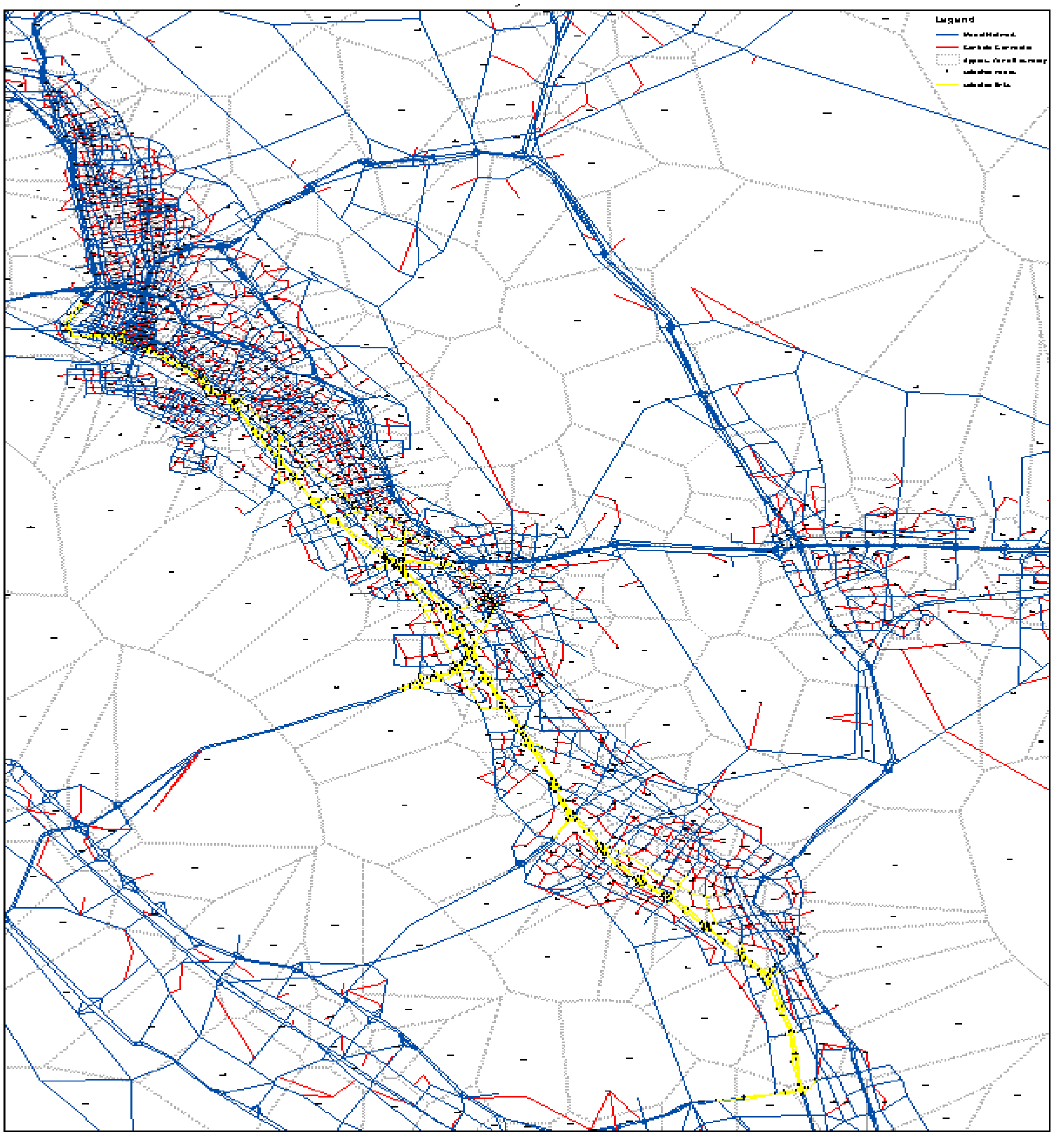


Figure 4.3 Alameda County Travel Demand Model



Mesoscopic Simulation Models

Mesoscopic models combine properties of both microscopic and macroscopic simulation models. The mesoscopic models' unit of traffic flow is the individual vehicle, and they assign vehicle types and driver behavior, as well as their relationships with the roadway characteristics. Their movement, however, follows the approach of macroscopic models and is governed by the average speed on the travel link. Mesoscopic model travel prediction takes place at an aggregate level, and does not consider dynamic speed/volume relationships as reflected in queue lengths and the temporal distribution of congestion. As such, mesoscopic models provide less fidelity than microsimulation tools, but are superior to travel demand models, in that, mesoscopic models can evaluate dynamic traveler diversions in large-scale networks.

A DynaSmart-P mesoscopic model of the subarea, which extends beyond the mainline I-880 corridor, will be used for the analysis of ICM strategies of the Test Corridor. The DynaSmart-P network will use a trip table from the travel demand model. After the subarea network is extracted from the macroscopic travel demand model, the subtracted network will then be converted into a dynamic network in the mesoscopic simulation model. Note that DynaSmart-P does not use centroids and centroid connectors; rather, it directly generates vehicles on generation links in a zone. Also, zonal aggregation will be needed to construct the dynamic network.

The standard bi-level origin-destination (O-D) estimation approach will be used. The upper problem is a variation of General Least Square (GLS) of the difference between simulated and observed volumes, and the lower problem is the DynaSmart-P dynamic traffic assignment. The module starts with the seed O-D demand matrices from the static network. The outputs from this module are dynamic O-D demand matrices. The matrices reflect paths and departure times as in the meso-model.

The model will be used to support the analysis of the dynamic impact of ICM strategies that try and induce shifts of trips from one network to another, such as pricing, and corridor-specific traveler information (pre- and during trip). An illustration of the mesoscopic network is shown in Figure 4.4. The network characteristics are presented in Table 4.1.

Figure 4.4 Mesoscopic Simulation Network for the Test Corridor

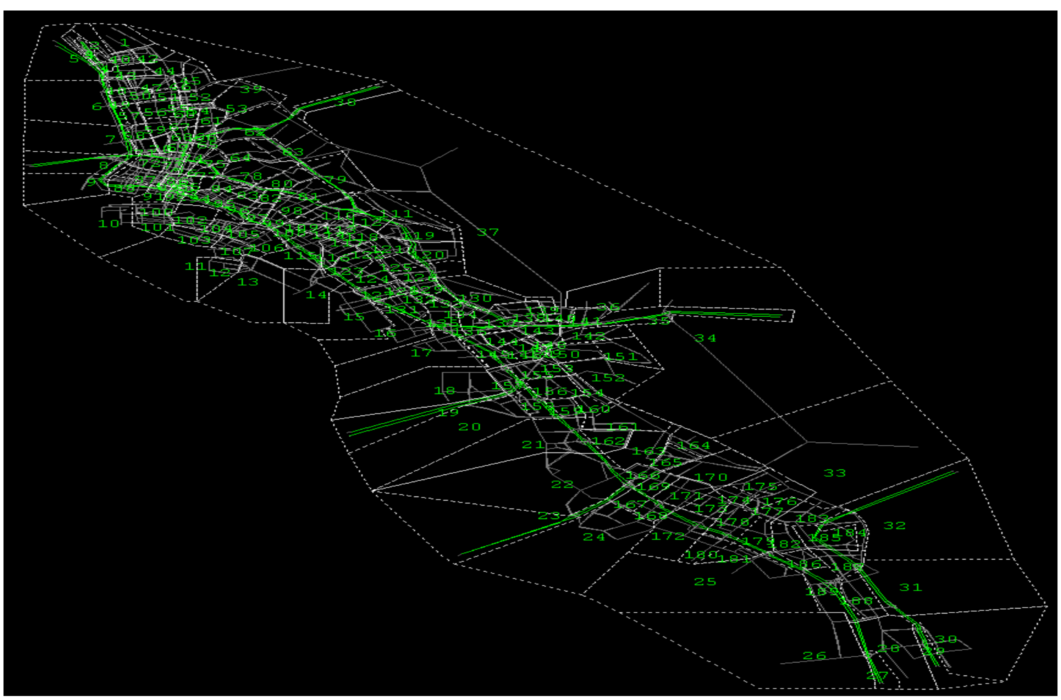


Table 4.1 Mesoscopic Network Characteristics

Network Data	
Number of nodes	2,658
Number of links	6,888
Number of zones	1,078

Microscopic Simulation Models

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

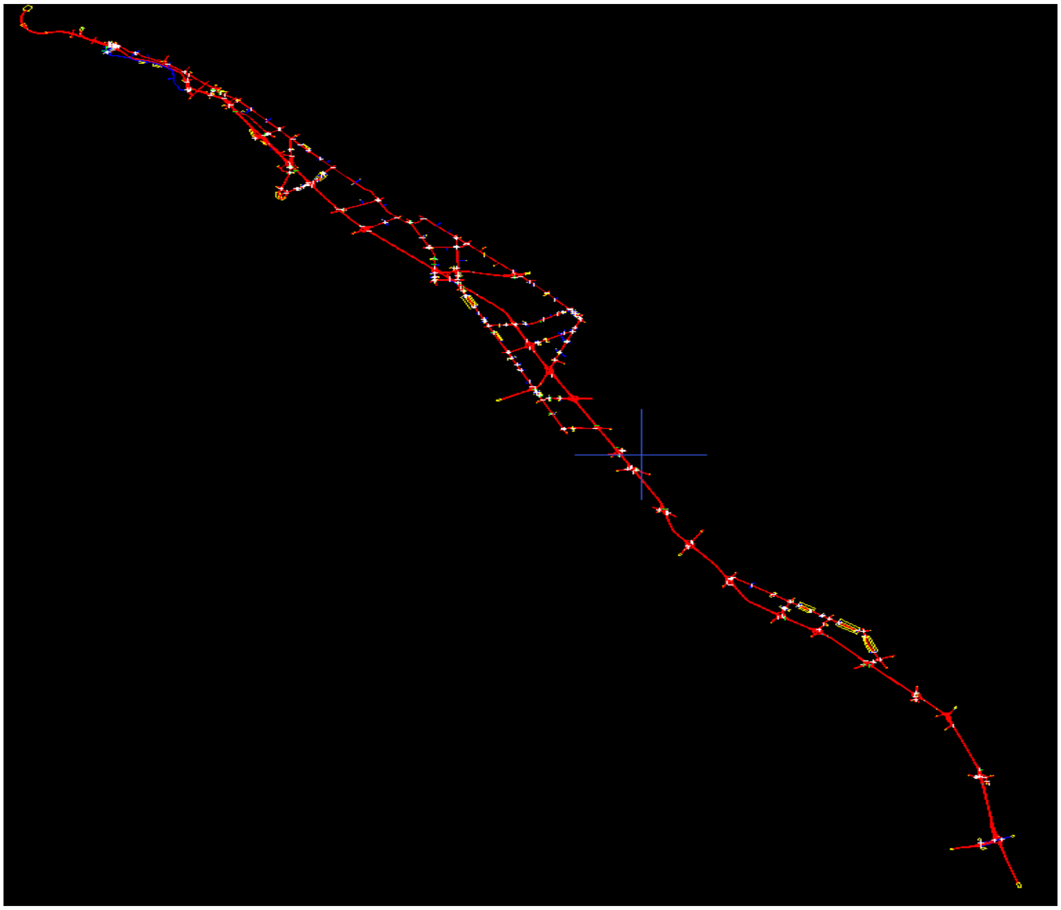
A Paramics microsimulation model for the Test Corridor is currently being developed for other studies. Depending on the delivery schedule for these other studies the Paramics model can be used to support the evaluation of the operational control aspects of the ICM strategies, such as ramp metering strategies. Microscopic simulation analysis will output detailed travel times that can be used to augment the mesoscopic simulation analysis. This augmentation entails the conversion of operational impacts identified at the microscopic level into adjustment factors at the mesoscopic level. These factors can support the modification of the mesoscopic analysis, such that the impacts of the operational control aspects of ICM strategies can be analyzed in conjunction with the trip management/shifting aspects of those strategies. An illustration of the Paramics model for the Test Corridor is shown in Figure 4.5.

4.3 Zone Correspondence

Traffic analysis zone correspondence between the macro, meso, and micro models will be created to achieve data transfer between these models. Zone correspondence between the CUBE travel demand model and the DynaSmart-P mesosimulation model will be achieved by converting the subarea model in CUBE to a shapefile, and importing the shapefile into DynaSmart-P.

To create zone correspondence between the meso model and the micro model, the "generating links" feature of DynaSmart-P will be used to create trip tables for the zones corresponding to the Paramics network.

Figure 4.5 Microscopic Simulation Network for the Test Corridor



4.4 Traffic Data

Data for model calibration include time-dependent freeway traffic counts, time-dependent section travel times (based on probe vehicles), intersection turning movement counts, and arterial traffic counts. Data processing will be necessary due to data missing and data inconsistencies. Detail explanations of data processing for ramp and mainline data are provided in this section.

The mainline counts were collected on March 1, 2, and 8, 2005 through PeMS. The averages of counts from these three days are used as the observed mainline traffic counts. Ramp count data comes from two different sources: the TMC and the census data from Caltrans.

Using the detectors installed in the field, the TMC can collect ramp and mainline data everyday with 30-second format. It is the best data source used for model calibration. However, the TMC data suffer from missing data due to detector and communication failures. Currently, PeMS can fill in missing records using historical data of the same detector or neighboring detectors.

4.5 TRANSIT DATA

Alameda County Bus Transit Routes

AC Transit operates two major local bus lines (82 and 82L) along I-880 and about 15 express bus lines. Line 82/82L operates 24 hours a day from the Hayward BART station (Bay Fair BART for 82L) to downtown Oakland via E. 14th Street and International Boulevard. Figure 4.6 shows the route map. The express lines using I-880 include Line S (South Hayward to San Francisco), Line SA (San Lorenzo to San Francisco), Line SB (Newark to San Francisco), Line OX (Harbor Bay/Alameda to San Francisco), Line O (Alameda to San Francisco), and Line W (West Alameda to San Francisco). Table 4.2 provides a summary of transit service along International Boulevard.

AC Transit is in the process of implementing Bus Rapid Transit (BRT) between Berkeley and San Leandro along the International/E. 14th Street corridor. Phase One will begin in fall 2006 with the initiation of Rapid Bus service (Line 1R) featuring signal coordination and priority, stop amenities, and real-time traveler information. Construction for Phase Two is scheduled to begin in 2008 and will feature dedicated transit ways at a large percentage of its runways and significant ITS and other technological improvements.

Figure 4.6 Test Corridor Bus Transit System

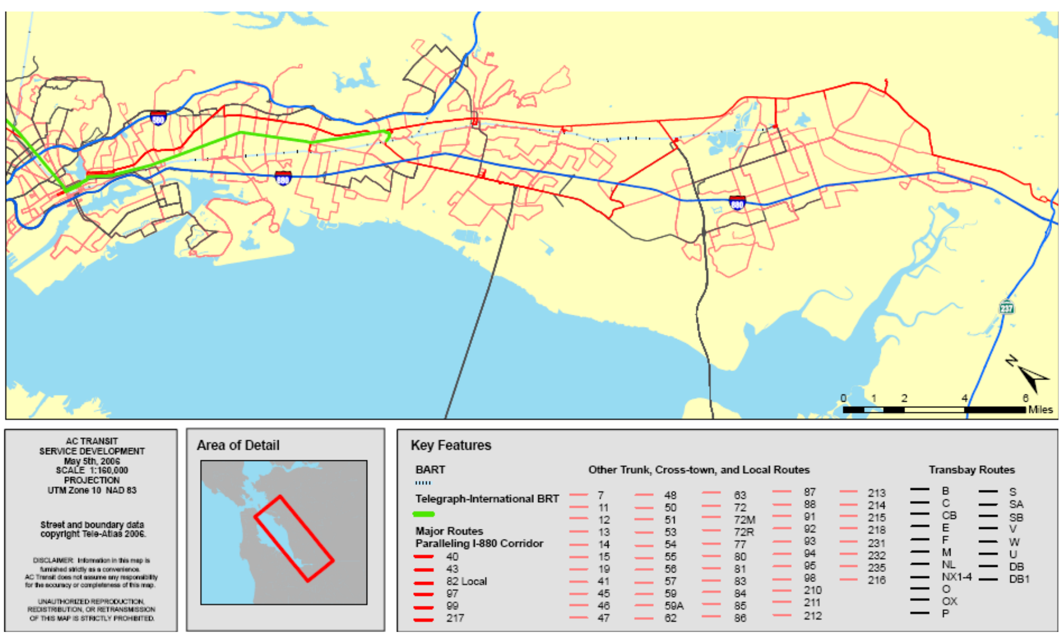


Table 4.2 Existing Transit Service on International Boulevard/E. 14th Street

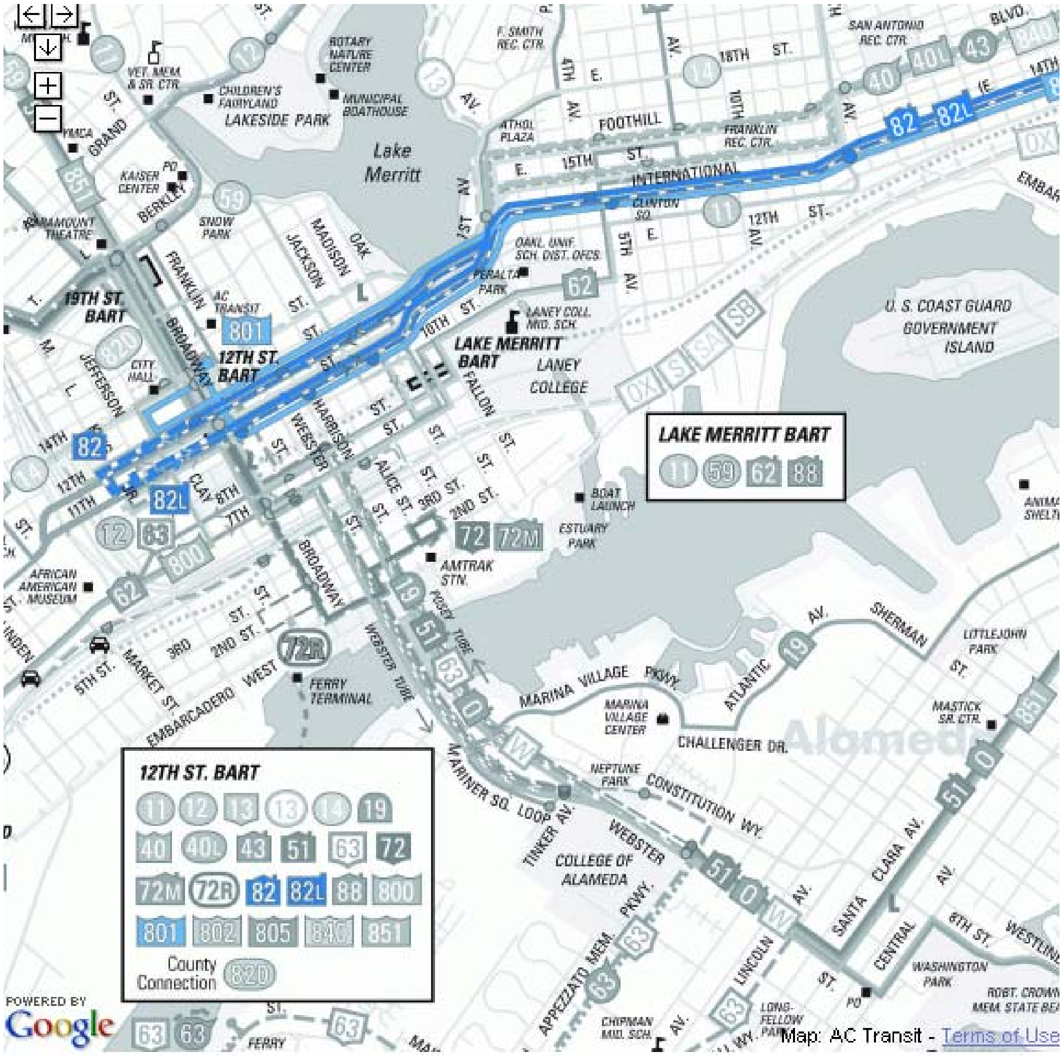
	Weekday Service				Weekend Service		
	Daily Operating	Service Frequency (in Minutes)			Daily Operating	Service Frequency (in Minutes)	
Route	Span	Peak	Base	Eve	Span	Base	Eve
82 International (downtown Oakland to SL BART)	24 hrs	12	15	No service	24 hours	15-60	No service
82 International (SL BART to Bayfair BART)	7:30 p.m.- 7:00 a.m.	No service	No service	15-60	7:00 p.m.- 10:00 a.m.	No service	15-60
82L International Limited (downtown Oakland to Hayward BART)	7:00 a.m.- 7:00 p.m.	12	15	No service	10:00 a.m.- 7:00 p.m.	15	No service

Passenger boardings and passenger miles for AC Transit Routes 82 and 82L are displayed in Table 4.3. AC Transit has several major transfer points along the corridor: Fruitvale BART, Coliseum BART, San Leandro BART, and Bayfair BART. Each of these BART stations serves between 5 and 8 bus routes and provides intermodal transfers with the BART service. Over 7,000 passengers per day access BART or buses at these stations. Figure 4.7 shows an example of bus routes accessing BART station at 12th Street, downtown Oakland.

Table 4.3 Existing Bus Operations

Route 82/82L	Daily Passenger Boardings	Average Daily Passenger Miles Per Trip
Weekday	16,727	244.3
Saturday	10,169	139.2
Sunday	9,723	173.7

Figure 4.7 Bus Routes Accessing BART Station at 12th Street



Bay Area Rapid Transit (BART) Rail

San Francisco Bay Area Rapid Transit District (BART) is a public rail rapid transit system that serves major parts of the San Francisco Bay Area. The total system comprises 104 miles of double track and 43 stations, as shown in Figure 4.8. The BART system along the test corridor includes 20 miles of double track and 12 BART stations. BART is connected to regional rail and bus services.

The combined daily ridership for the A-Line and L-Line, and downtown Oakland stations is close to 100,000, or 25 percent of the total BART's daily ridership. This ridership includes: ~48,000 on the A-Line (Lake Merritt Station to Fremont) or approximately 14.2 percent; ~10,000 on the L-Line (Castro Valley and Dublin/Pleasanton stations) or approximately 3 percent; and 29,000 entries or 8.6 percent) for the downtown Oakland stations (12th Street and 19th Street) or approximately 8.6 percent.

Figure 4.8 BART System Map

Appendix A. Test Corridor Candidate Sites

Figure A.1 I-880 in Alameda County, California

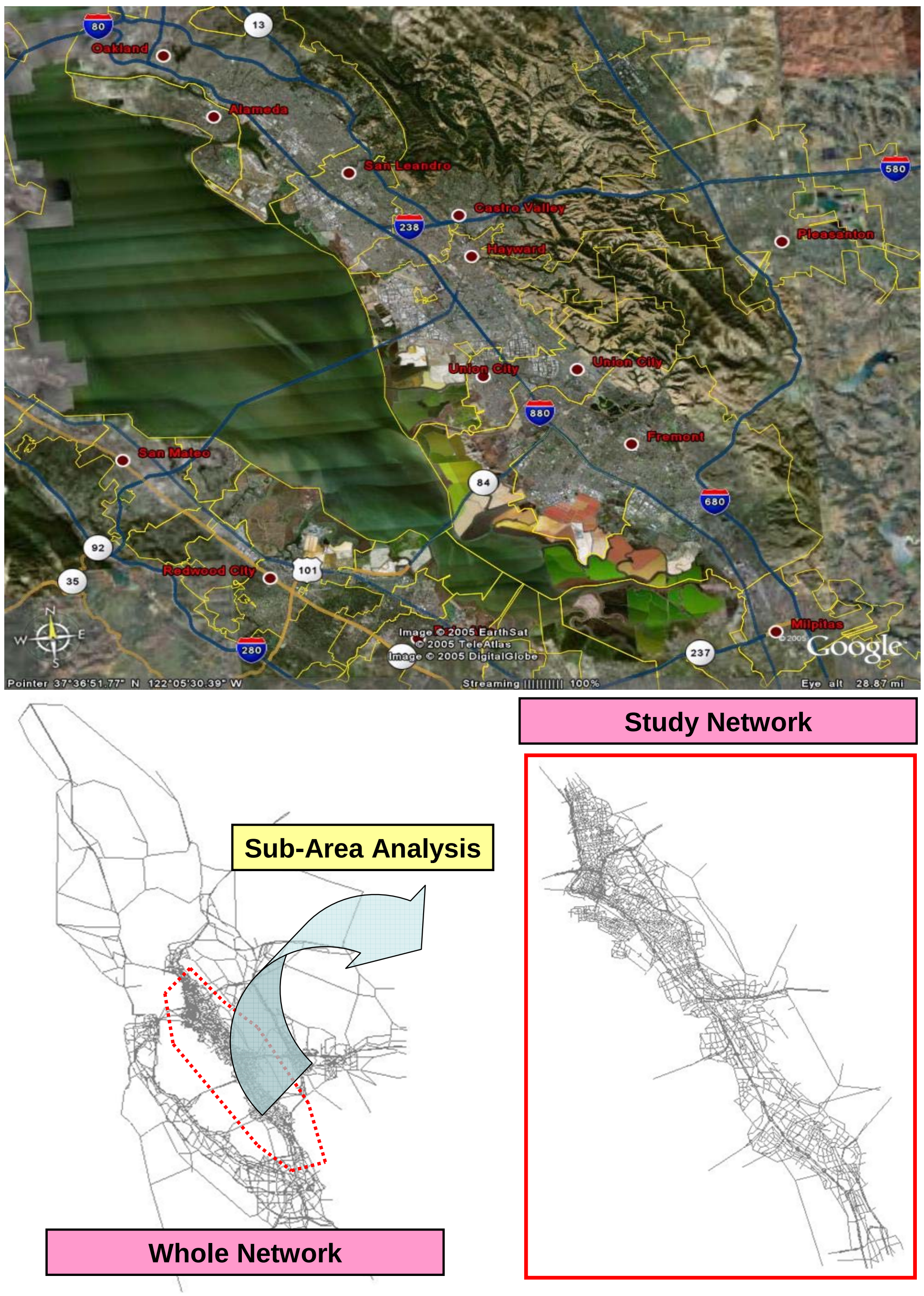


Figure A.2 I-10 in Los Angeles, California

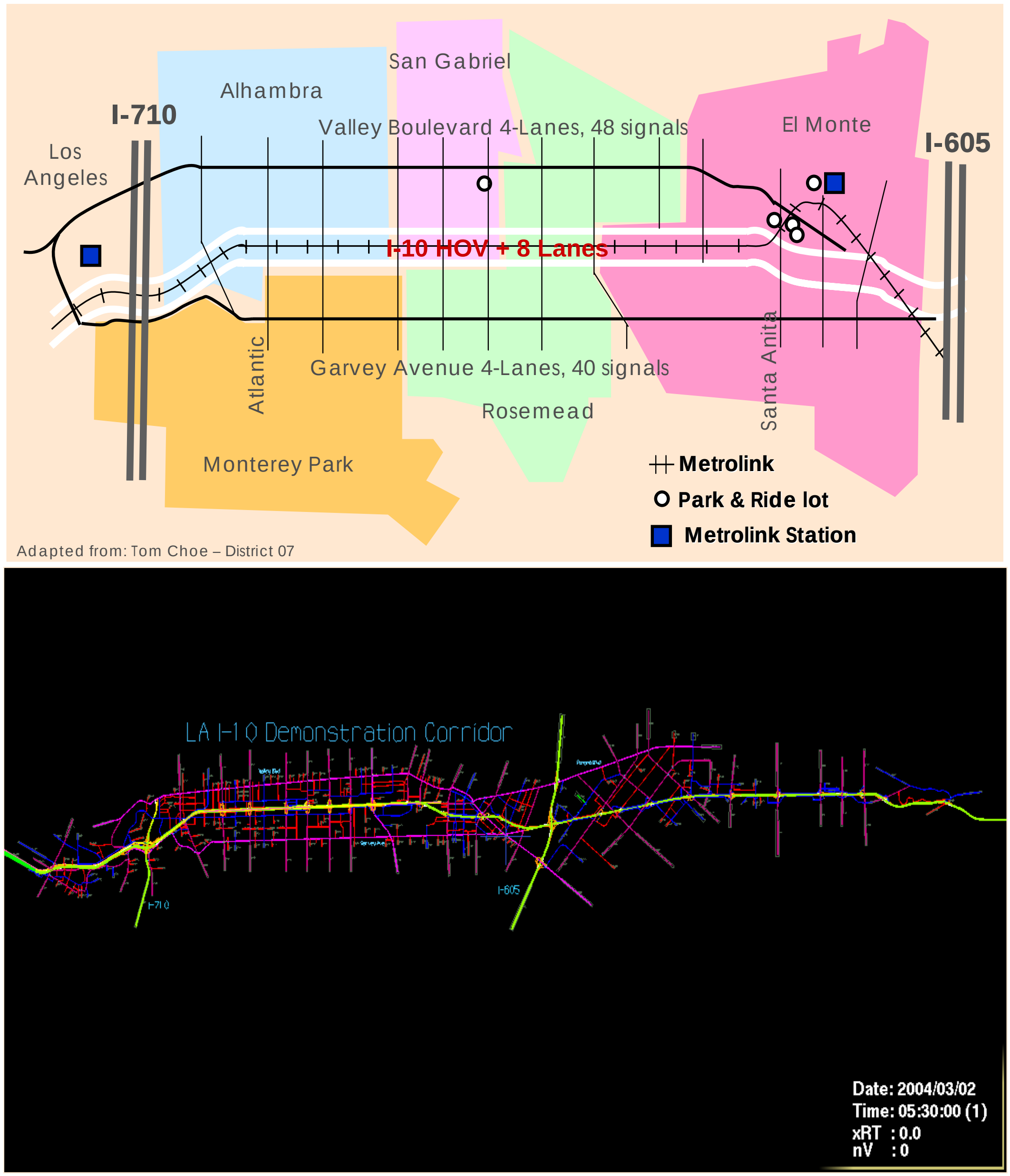
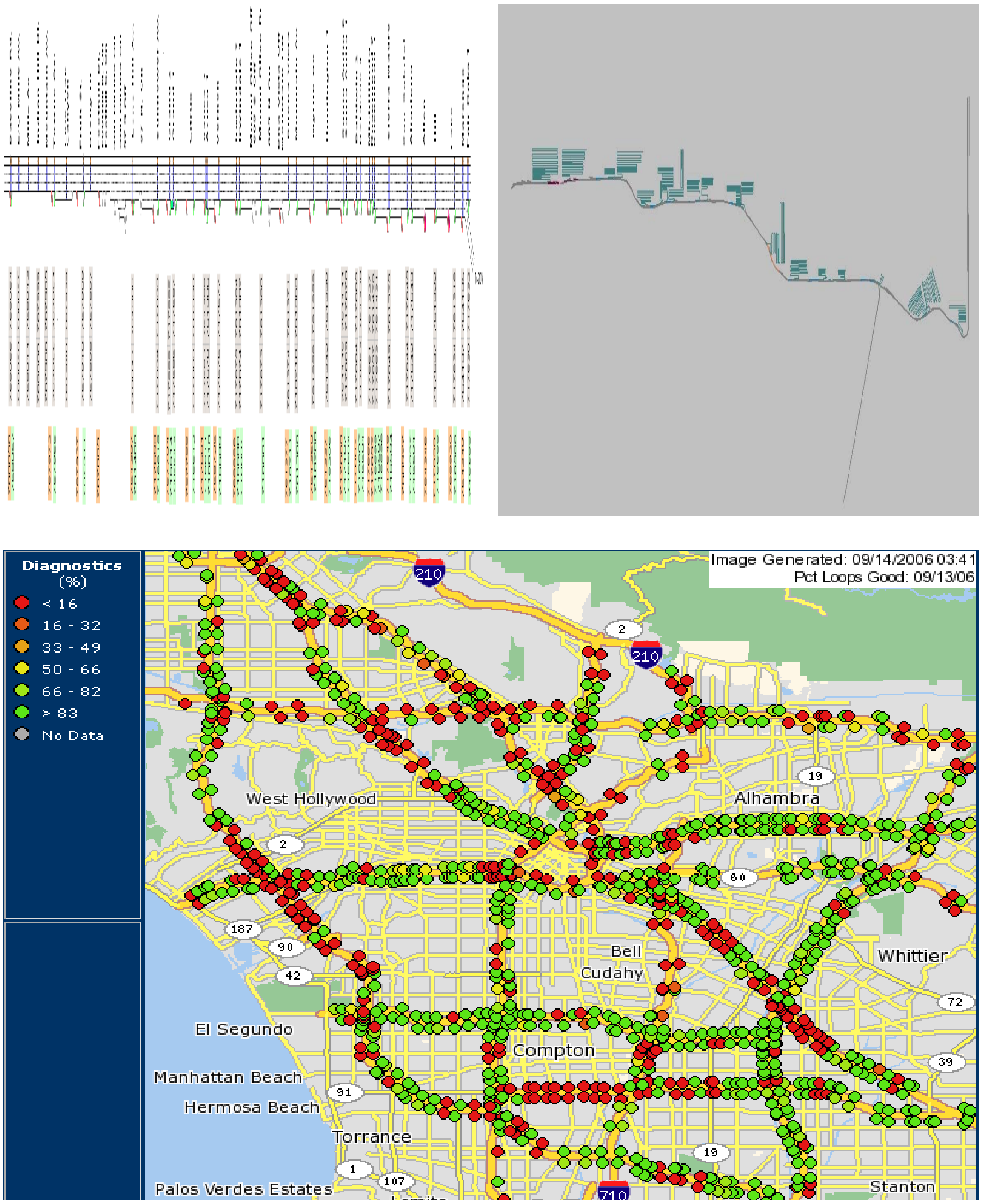


Figure A.3 I-210 in Los Angeles County, California



Source: California Performance Measurement System (PEMS), 2007.

Figure A.4 I-680 in Alameda County, California

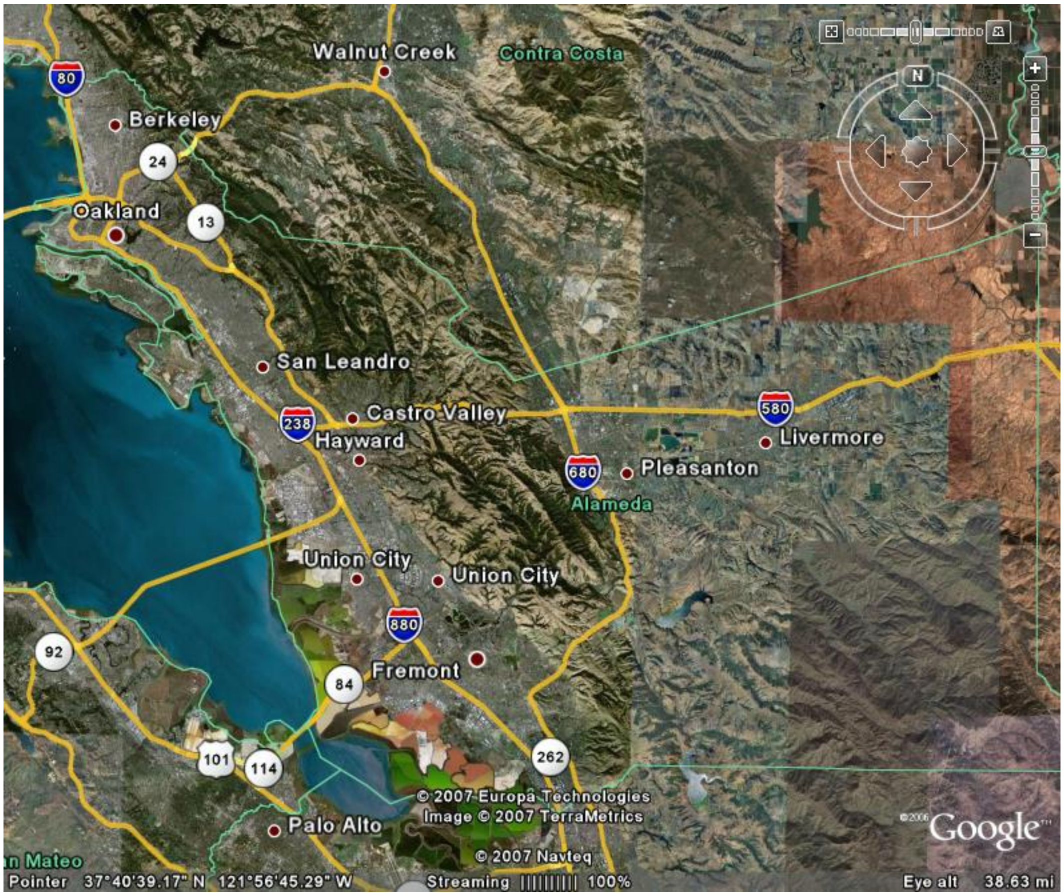
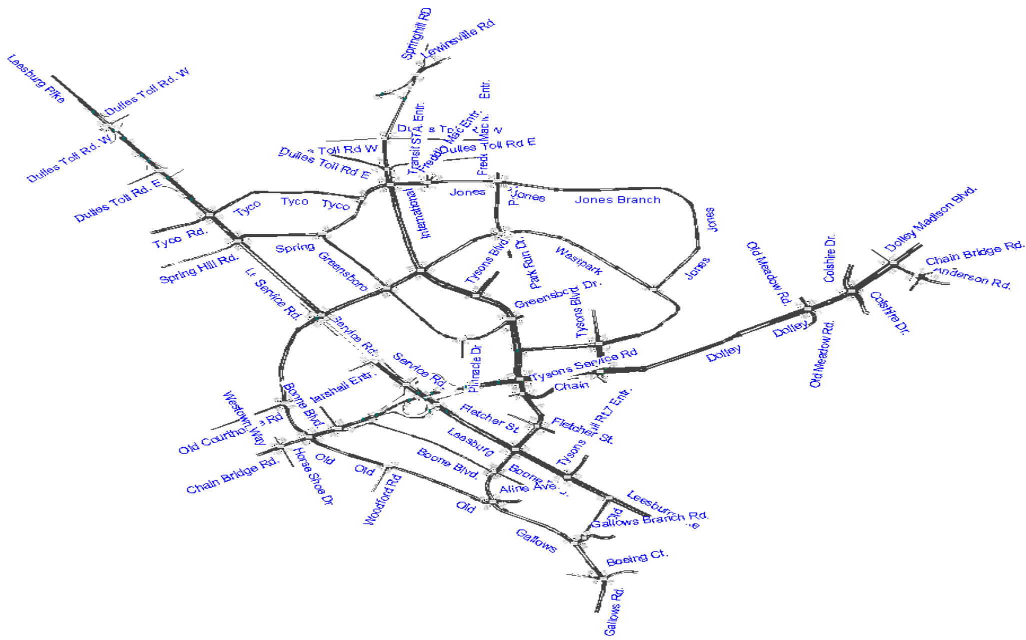


Figure A.5 Tysons Corner in Fairfax County, Virginia



Source: Cambridge Systematics, Inc. for Dulles Transit Partners, 2006.

Figure A.6 I-5 in Los Angeles, California

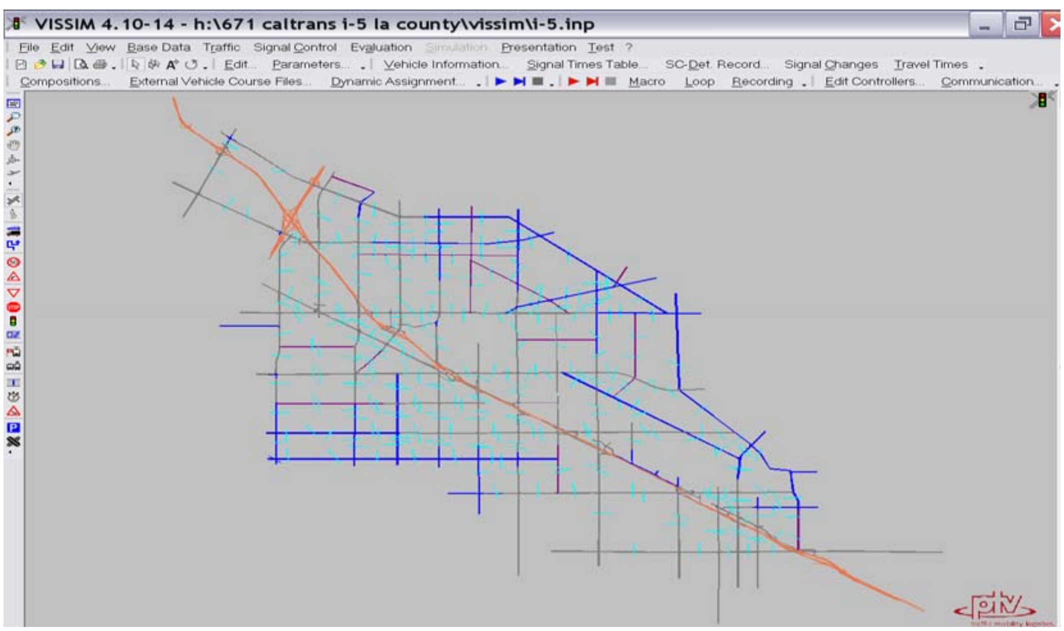
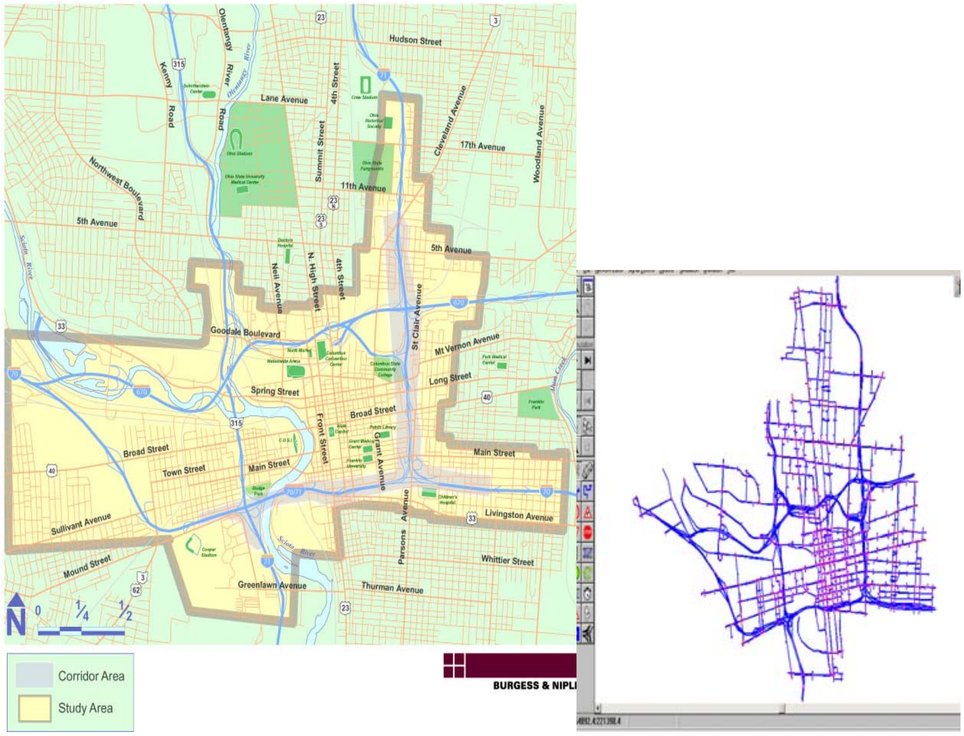


Figure A.7 I-71/I-90 Cleveland Innerbelt in Cleveland, Ohio

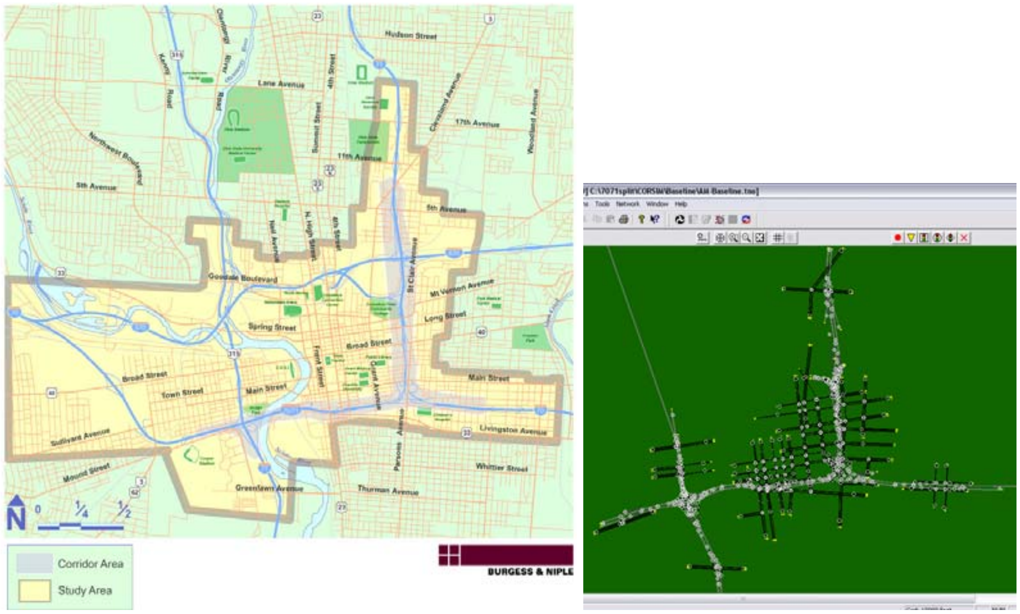
Source: Burgess & Niple, Inc.

Figure A.8 COTA LRT in Columbus, Ohio



Source: Burgess & Niple, Inc.

Figure A.9 I-70/I-71 Southern Innerbelt in Columbus, Ohio



Source: Burgess & Niple, Inc.

Figure A.10 I-270 Northwest in Columbus, Ohio

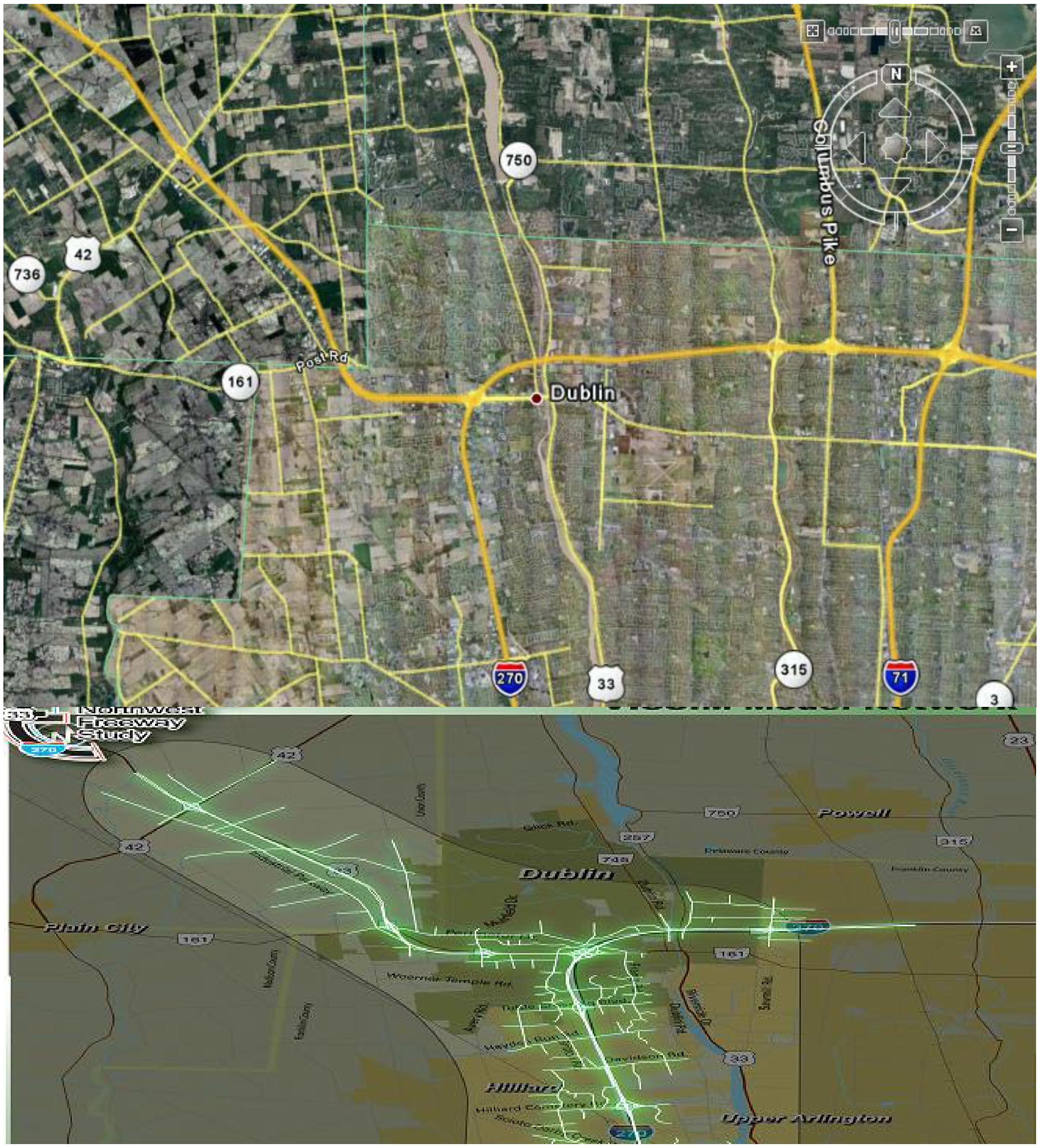


Figure A.11 I-10 El Paso in the City of El Paso, Texas

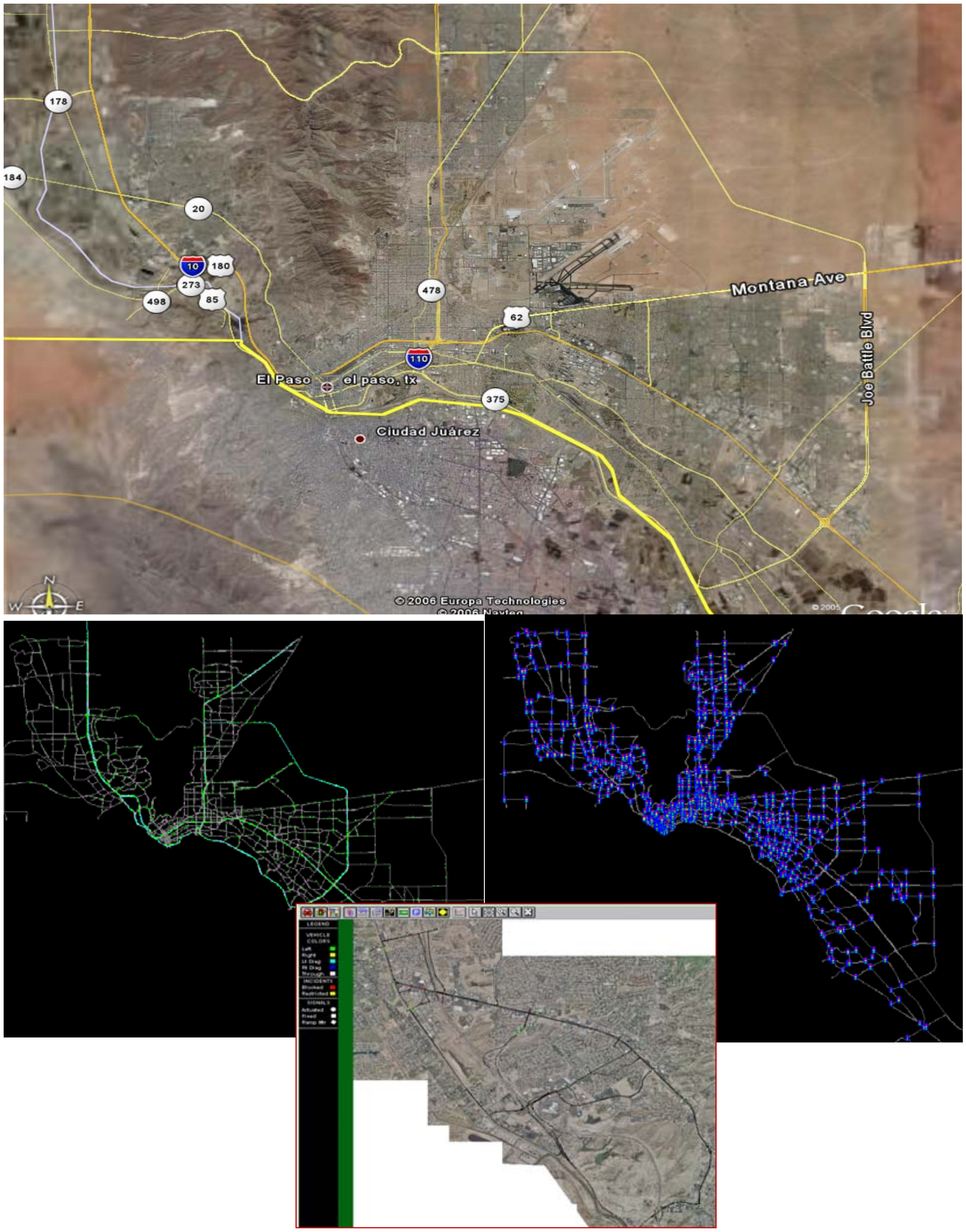
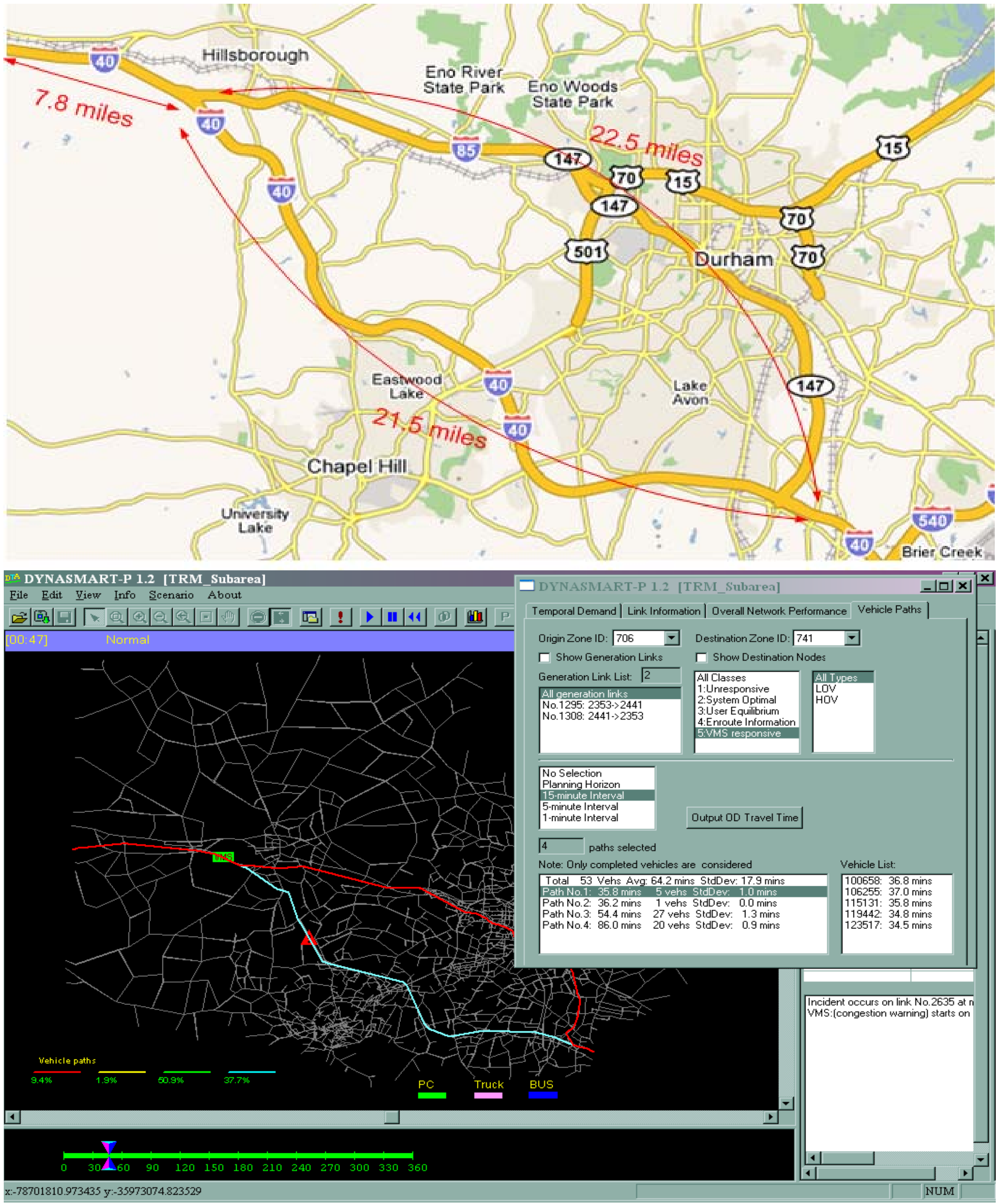


Figure A.12 I-40/I-85 in Research Triangle Region, North Carolina



Source: Google – Map Data ©2007 NAVTEQ™. Software: DynaSmartP.