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Concept of Operations for the I-880 Corridor in Oakland, California

March 31, 2008
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Integrated Corridor Management (Oakland, California)

Final
Concept of Operation

Submitted to

U.S. Department of Transportation

Submitted by

Building on Coalition of Successful Partners

Expanded Stakeholder Coalition

Prepared by
PATH, University of California, Berkeley
CCIT, University of California, Berkeley
Cambridge Systematics Inc.
DKS Associates
Kimley-Horn and Associates, Inc.
System Metrics Group

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I-880 Integrated Corridor Management

Concept of Operation
Final Submittal

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Submitted by

Metropolitan Transportation Commission (MTC)
California Department of Transportation (Caltrans) – District 4
Alameda County Congestion Management Agency (ACCMA)
Alameda-Contra Costa Transit District (AC Transit)
Bay Area Rapid Transit (BART)

Prepared by

California PATH Program, University of California at Berkeley
California Center for Innovative Technologies, UC Berkeley
Cambridge Systematics Inc.
DKS Associates
Kimley-Horn and Associates, Inc.
System Metrics Group

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16. Abstract

This report describes the draft Concept of Operations that has been developed for the Integrated Corridor Mobility (ICM) program by the I-880 corridor team. The I-880 corridor team has defined this Concept of Operations (ConOps) based on two primary principles: (1) it must improve overall corridor performance by meeting the needs of the local stakeholder agencies, within their practical operational, institutional and financial constraints; and (2) it must focus on integration of pre-existing systems rather than on implementation of new equipment or infrastructure. The I-880 corridor is a truly multimodal corridor, including a robust freeway network, major arterials which carry high volumes of local traffic as well as absorb diversion from the freeway networks, a transit network which includes the Bay Area Rapid Transit (BART) rail system and multiple AC Transit bus transit lines, and heavy freight movements with trucks comprising between 4% and 11% of the average annual daily traffic in the corridor. Transportation management systems (TMS) have been widely deployed in the corridor for many years including: a) ramp metering on I-880; b) HOV lanes and HOV bypass lanes for ramp meters; c) incident and emergency management systems on all freeways; d) changeable message signs on freeways; e) electronic toll collection systems (FasTrak); f) coordinated traffic signal systems on major arterials; g) BART transit management system; h) bus transit with signal priority capabilities and AVL; and i) transportation management centers for freeways, arterials, BART, bus transit and the Port of Oakland. Transportation facilities in the corridor are highly instrumented with real-time data collection systems. An institutional integration/coordination setting is already in place: the Metropolitan Transportation Commission (MTC), California DOT (Caltrans), Alameda County Congestion Management Agency (ACCMA), BART, Alameda-Contra Costa Transit District (AC Transit), and cities in the corridor have a history of cooperation.

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I-880 ICM Concept of Operation

Contents

1. EXECUTIVE SUMMARY 1

1.2 SCENARIOS AND STRATEGIES 4
1.3 EXPECTED BENEFITS AND COSTS 7

2. REFERENCES... 8

3. EXISTING CORRIDOR SCOPE AND OPERATIONAL CHARACTERISTICS 10

3.1 CORRIDOR BOUNDARIES AND NETWORKS 10
3.1.1 I-880 Freeway 10
3.1.2 Arterial Highways 14
3.1.3 AC Transit Bus Routes... 15
3.1.4 Transit Rail (BART) 18
3.1.5 Water Transit Authority 19
3.2 CORRIDOR STAKEHOLDERS 20
3.2.1 Caltrans 20
3.2.2 MTC 21
3.2.3 ACCMA 24
3.2.4 Local Jurisdictions 25
3.2.5 AC Transit 25
3.2.6 BART 26
3.2.7 The San Francisco Bay Area Water Transit Authority (WTA) 26
3.2.8 Port of Oakland 27
3.2.9 Emergency Responding Agencies (CHP, Police, fire and paramedics) 27
3.3 EXISTING OPERATIONAL CONDITIONS, CHARACTERISTICS AND STRATEGIES OF 880 CORRIDOR AND INCLUDED NETWORKS 28
3.3.1 Performance Measures 28
3.3.2 Existing Operation Conditions and Characteristics 33
3.3.3 Cross-Network Coordination Strategies Already Implemented 39
3.3.4 Summary 43
3.4 EXISTING NETWORK-BASED TRANSPORTATION MANAGEMENT/ITS ASSETS 45
3.4.1 Freeway 45
3.4.2 Arterial Highways 57
3.4.3 AC Transit 62
3.4.4 BART 65
3.4.5 Regional ITS Systems and Services... 67
3.4.6 Information Sharing Capabilities 70
3.4.7 Summary 74
3.5 PROGRAMMED NEAR-TERM NETWORK IMPROVEMENTS 76
3.5.1 Highways 76
3.5.2 Arterials 77
3.5.3 AC Transit 77
3.5.4 BART 78

3.6 CURRENT NETWORK-BASED INSTITUTIONAL CHARACTERISTICS 79
3.6.1 Summary of Existing Institutional Agreements... 80
3.6.2 Description of Existing Institutional Agreements 82
3.6.3 Major Milestones in Institutional Integration 89
3.6.4 Opportunities for Improved Institutional Integration 91
3.7 OVERVIEW OF REGIONAL ITS ARCHITECTURE... 92
3.7.1 Summary of Bay Area ITS Architecture... 92
3.7.2 Intra-network or center-to-field standards deployed 93
3.7.3 Center-to-Center ITS Standards Deployed 96
3.9 INDIVIDUAL NETWORK AND CORRIDOR PROBLEMS, ISSUES AND NEEDS 100
3.8.1 Freeway System 100
3.8.2 Arterial System 102
3.8.3 AC Transit 102
3.8.4 BART 103
3.9 CORRIDOR MANAGEMENT STRATEGIES ALREADY IMPLEMENTED FOR THE I-880 CORRIDOR 104
3.10 GAPS 105
3.10.1 Insufficient information sharing among different transportation systems: 105
Gaps in traveler information for influencing 106
travelers' decisions and choices: 106
3.10.2 Gaps in collaboration among agencies for coordinated operations 106
3.10.3 Gaps in collaboration among agencies for event planning 107
3.11 THE NEEDS FOR ICM 108

4. ICM SYSTEM CONCEPT OF OPERATIONS... 113

4.1 I-880 ICM CONOPS DEVELOPMENT APPROACH 113
4.1.1 System Engineering Approach 113
4.1.2 Guiding Principles and Development Process 114
4.1.3 Approach for Selecting ICM Strategies..116
4.2 I-880 CORRIDOR VISION, GOALS AND OBJECTIVES 117
4.3 ICM APPLICATION SCENARIOS...118
4.3.1 Normal Operations Scenario..119
4.3.2 Incident Scenario (Highway and Arterial) 123
4.3.3 Incident Scenario (Transit) 126
4.3.4 Planned/Scheduled Event Scenario 127
4.3.5 Catastrophic Event Scenario 131
4.4 DEVELOPMENT OF CANDIDATE ICM STRATEGIES 133
4.4.1 Information Sharing 133
4.4.2 Candidate ICM Strategies 135
4.5 ANALYSIS OF CANDIDATE ICM STRATEGIES 140
4.5.1 Assessment of Candidate ICM Strategies against issues and ICM goals.......140
4.5.2 Analysis of Candidate ICM Strategies 143
4.5.3. Potential Benefits of 880 ICM Strategies 161

5. ICM IMPLEMENTATION ISSUES 174

5.1 FUNCTIONAL ANALYSIS 174
5.2 ICM NEW ASSET REQUIREMENTS AND NEEDS 178
5.3 ALIGNMENT WITH REGIONAL ITS ARCHITECTURE 180

5.4 IMPLEMENTATION ISSUES 183
5.4.1Technical Issues *183*
5.4.2 Institutional and Operational Issues *186*
5.5 I-880 ICM CONCEPT IMPLEMENTATION INSTITUTIONAL FRAMEWORK 190
I-880 CORRIDOR ICM OPERATIONAL DESCRIPTION 192
5.7 AVAILABILITY OF DETAILED REAL-TIME DATA FOR EVALUATION 195
5.8 TRANSFERABILITY OF LESSONS LEARNED FROM 880 ICM IMPLEMENTATION TO OTHER METROPOLITAN REGIONS 201

APPENDIXES 203

APPENDIX A: MEETING MINUTES 203
A1. Kick-off meeting minutes *203*
A2: Stakeholder meeting Jan 11, 2007 .... *210*
A3: TAC meeting Jan 18, 2007 .... *217*
APPENDIX B: STRATEGIES 223
APPENDIX C: CANDIDATE STRATEGIES 229

APPENDIX D: ITS FUTURE PROJECT DESCRIPTION 238

APPENDIX E: BAY AREA REGIONAL ARCHITECTURE CHANGE APPROVAL PROCESS 244
APPENDIX F. FUNCTIONAL ANALYSIS 248
APPENDIX G AC TRANSIT BUS SERVICE IN THE NEIGHBORHOOD OF 880 CORRIDOR 277

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1. Executive Summary

This report describes the draft Concept of Operations that has been developed for the Integrated Corridor Mobility (ICM) program by the I-880 corridor team. This draft document aims to solicit feedback from federal reviewers who are responsible for selecting submittals for the next phase of the ICM program.

The I-880 corridor team has defined this Concept of Operations (ConOps) based on two primary principles: (1) it must improve overall corridor performance by meeting the needs of the local stakeholder agencies, within their practical operational, institutional and financial constraints; and (2) it must focus on integration of pre-existing systems rather than on implementation of new equipment or infrastructure. Considering that the individual transportation networks within the corridor are already generally well equipped with ITS systems, this is not as serious a limitation.

WHY THE I-880 CORRIDOR WAS NOMINATED?

The I-880 corridor in Alameda County, CA is well suited for ICM because:

- It is a long and densely populated urban corridor connecting a major employment center (Silicon Valley in the south) with the Port of Oakland, Oakland International Airport, and major population centers including the Cities of Oakland, Alameda, San Leandro, Hayward, Fremont, and Union City.

- It is a truly multimodal corridor, including a robust freeway network, major arterials which carry high volumes of local traffic as well as absorb diversion from the freeway networks, a transit network which includes the Bay Area Rapid Transit (BART) rail system and multiple AC Transit bus transit lines, and heavy freight movements with trucks comprising between 4% and 11% of the average annual daily traffic in the corridor.

- Alameda County has the greatest amount of freeway congestion of the nine Bay Area counties, with 50,000 vehicle-hours of daily delay. I-880 alone has average daily delays of more than 10,000 vehicle-hours. The corridor also has a high incident/accident rate, with an average of over 10 collisions and over 100 incidents per day. It is estimated that collisions account for 30 percent of overall corridor delay. These statistics suggest a significant opportunity to demonstrate improvements gained from ICM,

- Transportation management systems (TMS) have been widely deployed in the corridor for many years including: a) ramp metering on I-880; b) HOV lanes and HOV bypass lanes for ramp meters; c) incident and emergency management systems on all freeways; d) changeable message signs on freeways; e) electronic toll collection systems (FasTrak); f) coordinated traffic signal systems on major arterials; g) BART transit management system; h) bus transit with signal priority capabilities and AVL; and i) transportation management centers for freeways, arterials, BART, bus transit and the Port of Oakland.

- Transportation facilities in the corridor are highly instrumented with real-time data collection systems. Real-time data collection capabilities include: a) the freeway Performance Monitoring System (PeMS); b) the Smart Corridor system focusing on arterials; and the rail and bus transit operations systems. Furthermore, through the California Model Corridor Study high-quality data have been collected and used in modeling and microsimulation of all networks in the I-880 corridor; these data and models are readily available for use in the analysis of ICM opportunities in the corridor. Specifically for 880 ICM Field of Operational Tests, the primary operation agencies along 880 have all agreed to add additional instrumentation and communication to facilitate high quality real-time traffic and transit data to support quantitative before-and-after evaluation.

- The transportation management systems are consistent with the regional ITS plan, the national ITS architecture, and the Caltrans strategic plan for TMS. These management systems are semi-integrated, with higher levels of integration at freeway and arterial systems, and lower integration levels at BART and bus transit systems.

- An institutional integration/coordination setting is already in place: the Metropolitan Transportation Commission (MTC), California DOT (Caltrans), Alameda County Congestion Management Agency (ACCMA), BART,

Alameda-Contra Costa Transit District (AC Transit), and cities in the corridor have a history of cooperation.

- As the I-880 corridor is both operational and institutionally complex compared to most corridors in the U.S., the experience gained and lessons learned from deployment of ICM along I-880 can help other regions in the U.S learn how to deploy ICM in less complex environments.

1.2 SCENARIOS AND STRATEGIES

The agencies listed above have participated actively in the Technical Advisory Committee for the I-880 ICM project, providing guidance about their needs, desires and capabilities for ICM deployment. This project has followed the five-step ConOps development process developed by 880 ICM team, considering how corridor integration would be applied in the five broad classes of operating scenarios specified by DOT: normal operations, highway/arterial incidents, transit incidents, planned/scheduled events and major (unplanned) events. Specific instances of these scenarios were defined to focus on the special needs of the I-880 corridor.

In order to use ICM as a tool to address the gaps and needs for the I-880 corridor, the ICM team prepared a comprehensive list of ICM strategies that would be applied to deal with these scenarios, starting from the master list supplied by DOT. Some new strategies were defined to meet specific needs in the I-880 corridor, while other strategies on the original list were combined or re-characterized as enablers rather than independent strategies. A few strategies that have already been implemented in the corridor were dropped from further consideration within this project because they would no longer be considered new in this corridor (such as integrated transit fare payment and electronic toll collection). The stakeholders and consultants screened the candidate ICM strategies based on the following criteria:

- operational feasibility
- technical feasibility
- institutional constraints
- benefits and costs
- compliance with the regional ITS architecture.

Even after this screening, a substantial collection of strategies remained under consideration because of the high level of stakeholder interest in maximizing the opportunities for corridor integration. These strategies were grouped into logical clusters to be evaluated in the next phase of the ICM as shown in the Table:

(A) Influencing Travelers' Decisions & Choices and Traveler Information Strategies	
	A corridor-based advanced traveler information system (ATIS) database that provides information to travelers for pre-trip and en-route decisions, across all networks.
	Promote route shifts between roadways via en-route traveler information devices (e.g. DMS, HAR, "511") advising motorists of congestion ahead, directing them to adjacent freeways or arterials.
	Promote modal shifts from roadways to transit via en-route traveler information devices (e.g. DMS, HAR, "511") advising motorists of congestion ahead, directing them to high capacity transit networks and providing real-time information on the number of parking spaces available in the park and ride facility.
	Promote shifts between transit facilities via en-route traveler information devices (e.g. station message signs and public announcements) advising riders of service outages and directing them to adjacent rail or bus services.
(B) Facilitating Collaboration among Agencies for Operational Improvement	
Integrated Freeway/Arterial Operations	
	Coordinated operation between freeway ramp meters and arterial traffic signals to accommodate traffic shifts in both directions.
	Enhance arterial signal timing with advance information about special events at Coliseum.
Coordinated Roadway/Transit Operations	
	Signal priority for transit (e.g. extended green times to buses that are operating behind schedule).
	Adjustment of AC Transit bus operations based on real-time information about highway traffic and special events.
Integrated Transit Operations)	
	Transit hub connection protection for incidents and emergencies
Collaboration between Freeway Operations and Port of Oakland)	
	Port of Oakland advises trucks travel time based on real-time traffic information.
Coordination with Emergency Services)	
	Signal pre-emption or "best route" for emergency vehicles.
Coordination for Incident Response)	
	Multi-agency or multi-network incident response teams and service patrols and training exercises.
(C) Facilitating Collaboration among Agencies for Event Planning	
	Coordinate scheduled maintenance and construction activities among networks.
	Guidelines for construction work hours during emergencies or special events.

In order to determine the technical feasibility of these strategies, functional decompositions were performed to identify the specific functions that would have to be implemented in order for each strategy to work. The fundamental categories of functions that were considered were:

- data collection
- data receiving
- data archiving
- data processing
- interface with users.

Once the specific functions were identified, required data flows between functions were defined in block diagram form, as shown in Appendix F. This graphical display provided an effective way of showing which functions were already implemented by existing systems and which functions would still have to be implemented as part of the ICM integration activities. Through this process, it was concluded that the data collection and user interface functions are largely covered by existing systems and devices owned by the operators of the individual networks, but the new ICM functions are concentrated in the middle three categories: data receiving, archiving and processing. These functions involve communications and software development but not the installation of significant new field devices. For ease of display, the functional decompositions are shown separately for the freeways, arterials, transit and others (emergency services and freight).

The functional decomposition also reveal the synergy that can be gained when data collected by one network can be used by operators and travelers in other networks and user interface displays installed by one network can provide information about other networks. In this way, the incremental costs for adding strategies decline as more strategies are implemented because they make use of the same underlying capabilities for data collection and display.

Following the functional analysis, the 880 ICM team conducted a preliminary investigation of assets needs for implementing the candidate ICM strategies and provided an estimate of the cost of the ICM implementation. The ConOps concludes with a review of the technical, institutional and operational issues that affect deployability of the ICM capabilities and therefore need to be considered from the start. The stakeholder representatives are acutely aware of what is easy and what is hard to implement within their organizations. They provided a wealth of information about the practical considerations that will make or break attempts to implement each ICM strategy and what operational model will allow ICM to be a viable tool beyond Field Operational Tests. The institutional and operational complexity of the I-880 corridor bring their own sets of challenges, but at the same time set an example for other less complex corridors around the country. By showing that ICM can be made effective here, we can provide encouragement to other corridors that they can succeed with less complex challenges to address in their integration work.

1.3 EXPECTED BENEFITS and COSTS

At this early stage, and building on the aforementioned analyses, the I-880 corridor team estimated performance improvement targets for the multi-modal system. For instance, freeway congestion is expected to be reduced by at least 10 percent. Moreover, overall freeway travel time reliability will be improved by the same amount. Arterial and transit benefit targets are also estimated. The next phase of the ICM will focus on testing these targets and further narrowing the list of strategies based on the evaluation results. Fortunately, the existing models (e.g., corridor micro-simulation) will enable this evaluation to be accomplished in a cost effective manner. Costs associated with implementing the proposed strategies are still being developed, and will be refined as more detail is developed through the analysis process.

2. REFERENCES

1. Bay Area Regional Intelligent Transportation Systems (ITS) Plan
   http://mtc.ca.gov/planning/ITS/Bay_Area_ITS_Plan.pdf

2. Bay Area Transportation State of the System 2005

3. Bay Area Regional ITS Architecture

4. ICM Program Plan http://www.its.dot.gov/icms/icms_workplan.htm

5. ICM Generic Concept of Operation
   http://www.itsdocs.fhwa.dot.gov/JPODOCS/REPTS_TE/14281.htm

6. ICM Implementation Guide
   http://www.itsdocs.fhwa.dot.gov/JPODOCS/REPTS_TE/14281.htm

7. Develop Criteria for Delineating a Corridor
   http://www.itsdocs.fhwa.dot.gov/JPODOCS/REPTS_TE/14274.htm

8. Develop Alternative Definitions for Corridor and Integrated Corridor Management (ICM)
   http://www.itsdocs.fhwa.dot.gov/JPODOCS/REPTS_TE/14273.htm

9. Relationship Between Corridor Management and Regional Management
   http://www.itsdocs.fhwa.dot.gov/JPODOCS/REPTS_TE/14275.htm

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3. Existing Corridor Scope and Operational Characteristics

3.1 Corridor Boundaries and Networks

The San Francisco Bay Area is the fifth most populated metropolitan area in the United States, and the I-880 corridor is centrally located within the region. The I-880 corridor starts from the connector of freeways I-880, I-80 and I-580 and ends at SR237. A number of parallel arterial highways, including Highway 185 (International Blvd./E14 blvd. Fremont Blvd) and San Leandro St., are part of the I-880 ICM corridor. I-880 ICM corridor provides 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. Thus, the efficient operation of I-880 is of critical economic importance to the region the state, and the entire nation. The I-880 corridor is truly a multi-modal, multi-use urban freeway corridor.

3.1.1 I-880 Freeway

As one of the main arteries of the freeway system in the Bay Area, I-880 consists of 45 miles of freeway connecting Silicon Valley with the East Bay. Major interchanges in the corridor include junctions at SR-112 (Davis Street in San Leandro), I-238 (connecting I-880 in San Leandro 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 (Mission Blvd. in 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), 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 inter-regional and international shippers and a primary intraregional goods-movement corridor.

The I-880 ICM team has selected the segment of the I-880 corridor between the cities of Oakland and Fremont in Alameda County, with the I-580/I-80 interchange as the northern boundary and SR-237 as the southern boundary (a distance of about 38 miles and 250+ lane miles). This is a logical segment for the Integrated Corridor Management project as it matches the existing institutional agreements in place for the corridor management plan. In addition, the necessary infrastructure is already in place to support the integrated corridor management functionality, without major additional investments.

FIGURE 3.1a CORRIDOR MAP

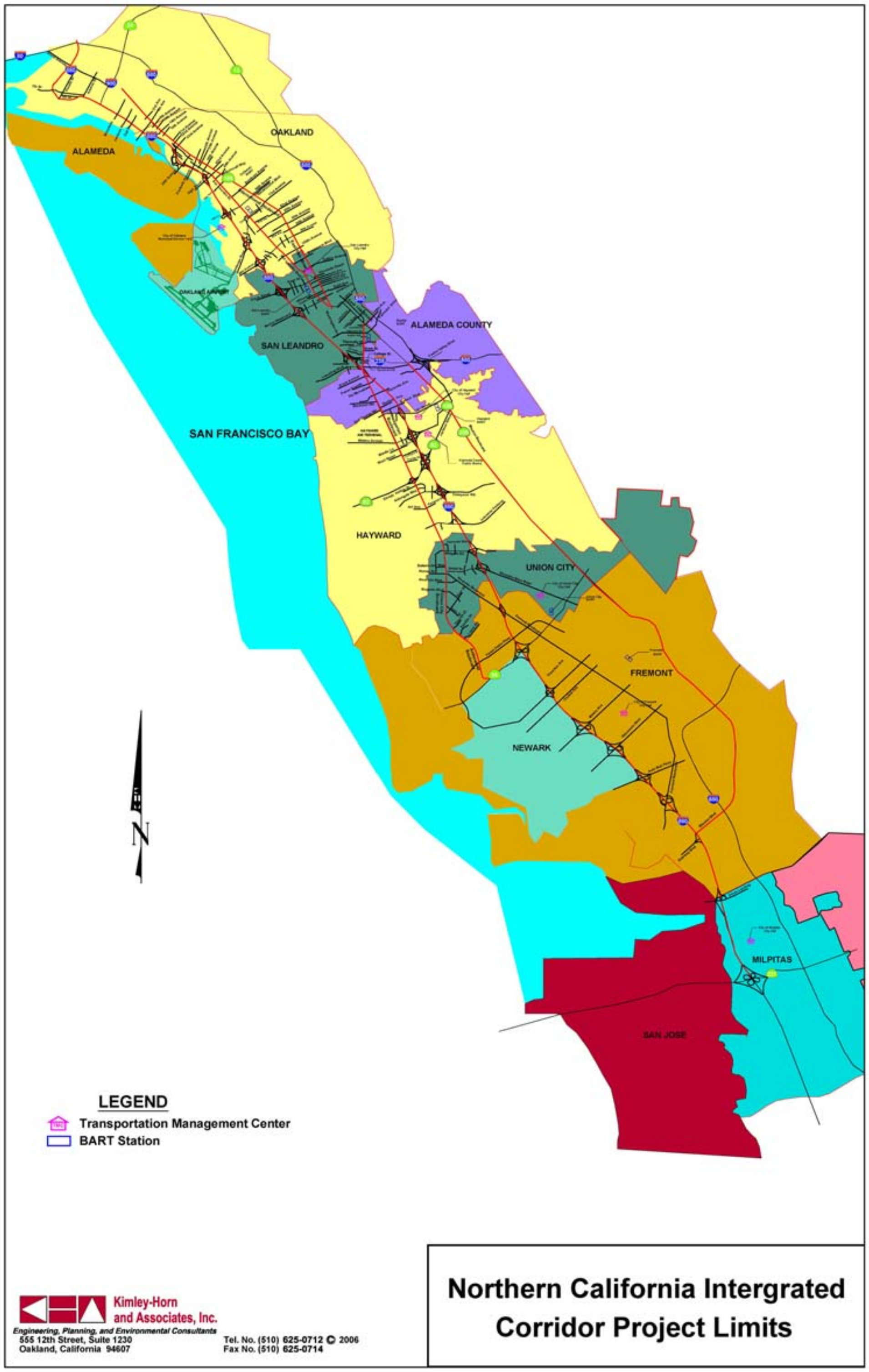
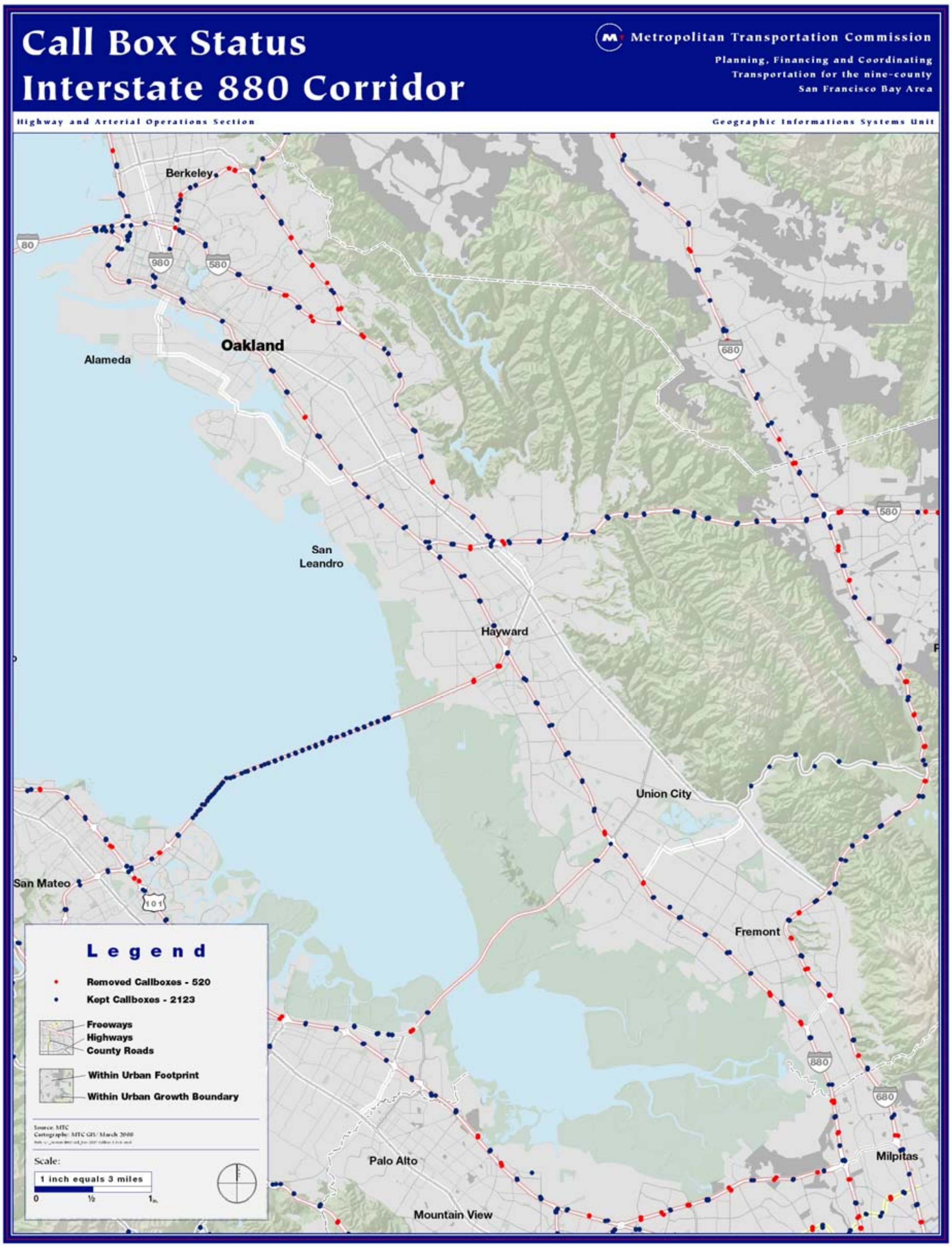


FIGURE 3.1b CORRIDOR CALL BOX MAP



3.1.2 Arterial Highways

There are a number of major north-south arterials along the entire project corridor on both sides parallel to I-880, with connecting arterials to the freeway segment. On the east side of the I-880 corridor, Mission Blvd (SR-238) and E.14th Street/International Blvd (SR-185) forms a continuous corridor from the southern limit of the project corridor to the northern limit.

On the west side of the I-880 corridor, the major north-south parallel arterials form a continuous segment from the southern limit of the project corridor, starting at the Ardenwood Blvd, Union City Boulevard and Hesperian Blvd, crossing I-880 in San Leandro and joining 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.

These major arterials link to a number of other key arterials that connect to the I-880 freeway. These connections include:

- 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 Blvd (Union City)
- Paseo Padre (Fremont)
- Fremont Blvd. (Fremont)

Within downtown Oakland, the major arterials include 14th Street, Broadway and Grand Avenue, where it joins 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. The East Bay SMART Corridors program includes East 14th/International Boulevard, East 14th Street, San Leandro Boulevard/Street, Hesperian Boulevard, and Union City Boulevard; this arterial corridor is approximately 18 miles long and parallels I-880 from downtown Oakland to Union City.

3.1.3 AC Transit Bus Routes

AC Transit operates a number of Regional Express Bus routes and dozens of local bus lines in the proximity of the I-880 corridor. This includes Route 82/82L, a key high-ridership trunk line along the I-880. This route 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 3.2 is the AC Transit route map for most of the East Bay, which includes Route 82/82L. Regional Express Bus 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). The following table is a summary of transit service along East 14th/International Blvd:

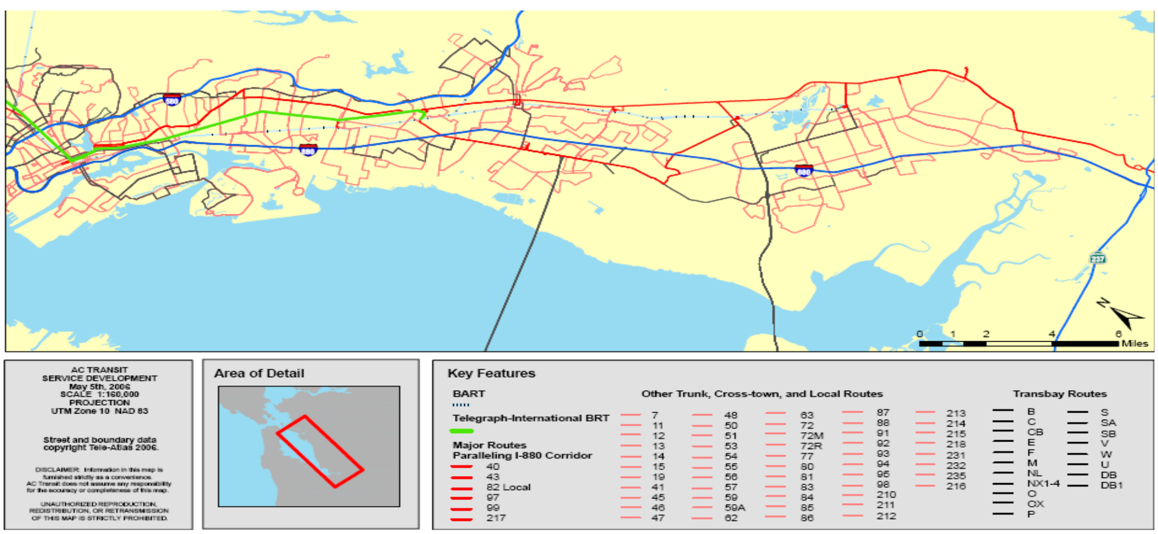
TABLE 3.1

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

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

AC Transit is in the process of implementing Bus Rapid Transit (BRT) between Berkeley and San Leandro along the E.14th Street/International Blvd. corridor. Completion of the first phase of arterial infrastructure to support BRT operations was completed in January 2007, featuring signal coordination and transit priority. Phase Two is scheduled to begin in 2008 and will feature dedicated transit ways at a large percentage of its run-ways and significant ITS and other technological improvements. Ridership for the BRT is anticipated to reach about 30,000 boardings per day in the next 20 years, which is almost double the current ridership for the corridor. Construction of the full BRT project is scheduled for completion in 2008.

FIGURE 3.2
AC Transit Route Map



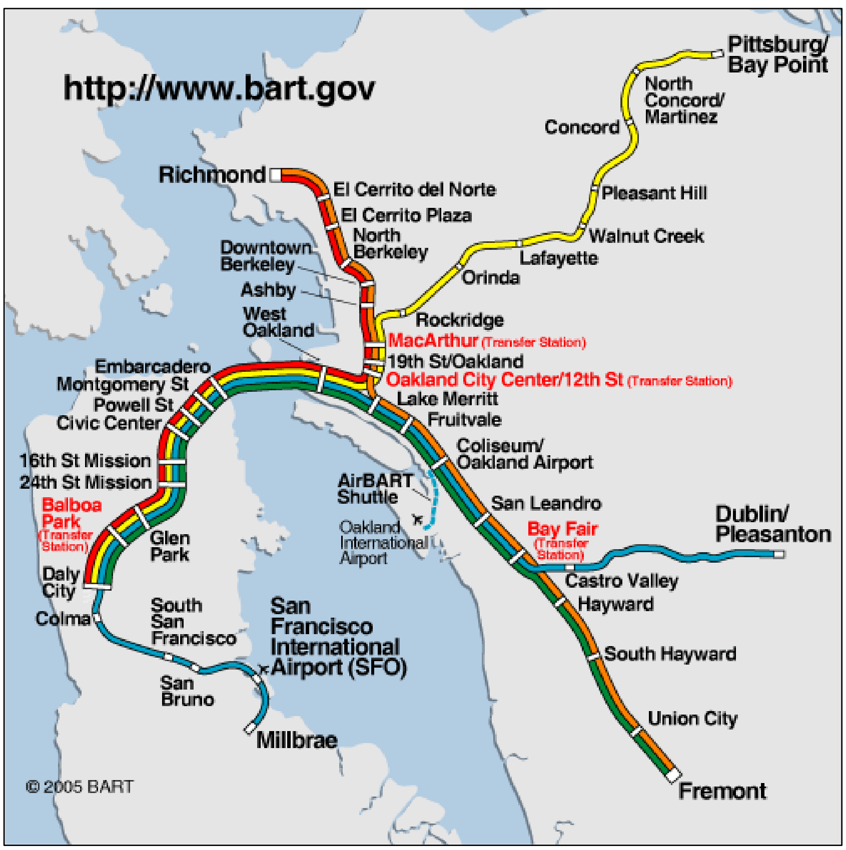
3.1.3.2– OTHER BUS TRANSIT SERVICES

The **Santa Clara Valley Transportation Authority (VTA)** operates primarily in Santa Clara County, but has bus service linking the Fremont BART station to its light rail network as well as ACE and Caltrain stations in Santa Clara and San Jose Diridon Station. **Union City Transit** provides bus transit service exclusively within Union City, including the key arterial Alvarado-Niles Blvd.

3.1.4 Transit Rail (BART)

3.1.4.1 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, including the I-880 corridor. The total system comprises 104 miles of track and 43 stations. Figure 3.3 shows the BART system, which along I- 880 corridor includes 20 miles of track and 12 BART stations. BART is connected to regional rail and bus services and to San Francisco International Airport and Oakland International Airport (via AirBART buses).

FIGURE 3.3
BART System Map



3.1.4.2 INTERCITY PASSENGER RAIL LINES

Two intercity passenger rail lines provide service along the I-880 freeway corridor, providing additional travel options for commuters and interregional travelers.

Amtrak Capitol Corridor is an intercity passenger train system that provides a convenient alternative to traveling along the congested I-80, I-680 and I-880 freeways by operating intercity rail service connecting the Sacramento and San Francisco Bay Areas. This includes 16 stations in 8 Northern California counties (Placer, Sacramento, Yolo, Solano, Contra Costa, Alameda, San Francisco, and Santa Clara) along a 170-mile rail corridor. An extensive, dedicated Amtrak motorcoach network provides connecting bus service beyond the Capitol Corridor route. The Amtrak Capitol Corridor is operated by a Capitol Corridor Joint Powers Authority (CCJPA), which is managed by the Bay Area Rapid Transit District (BART) with support from Amtrak and Caltrans. The CCJPA Board consists of representatives from the eight counties in The Capitol Corridor. Within the I-880 ICM corridor limits, the Amtrak Capitol Corridor runs parallel to the BART tracks with key stations at Jack London Square in Oakland, Coliseum/Oakland Airport, and Fremont Centerville Station. The Coliseum Station is a true "cross-platform" connection point with BART.

Altamont Commuter Express (ACE) rail line provides service from Stockton in San Joaquin County to San Jose in Santa Clara County. The route parallels the highly congested I-580 corridor, part of the I-680 corridor (Sunol Grade), then along I-880 (Fremont Centerville Station, Great America, Santa Clara, San Jose). Near the southern limits of the I-880 ICM corridor, the rail line connects from the Diridon Intermodal Station to Fremont Centerville Station, and has an intermediate stop at the Great America Intermodal Station (just south of SR-237). The possibility of Union City BART Station becoming an intermodal connection for the Altamont Commuter Express (ACE) and the proposed Dumbarton Rail line has also been discussed.

3.1.5 Water Transit Authority

The Water Transit Authority (WTA) operates a comprehensive San Francisco Bay Area public water transit system. Alameda-Oakland-San Francisco is the most popular route.

3.2 Corridor Stakeholders

Several institutions and agencies play key roles in the management of the I-880 corridor. These institutions include two State agencies, the California Department of Transportation, District 4 and the California Highway Patrol (CHP); one metropolitan planning organization, the Metropolitan Transportation Commission (MTC); one county agency, the Alameda County Congestion Management Agency (ACCMA); three transit agencies, Alameda-Contra Costa Transit District (AC Transit), Bay Area Rapid Transit (BART) Water Transit Authority, and the Port of Oakland. A description of each institution's role and responsibility in the management of the I-880 corridor is described further below.

3.2.1 Caltrans

The California Department of Transportation (Caltrans) is the owner-operator of all state highways, and is comprised of twelve regional districts and a Headquarters office in Sacramento, California. Caltrans District 4's boundaries are the nine Bay Area counties, and its headquarters are in downtown Oakland at the northern end of the I-880 corridor. District 4 is responsible for the planning, design, construction, maintenance and operations of more than 1,425 miles of Bay Area highways and freeway.

Along the I-880 corridor, Caltrans not only has jurisdiction over the freeway, but also over several of the major arterials that are also part of the State Highway System. These include East 14^{th}/International Boulevard (SR-185), Davis Street (SR-112), Mission Boulevard (SR-238 and SR-262), and Jackson Street (SR-92).

District 4's 2,360 employees are divided among eight separate divisions, each of which has specific responsibilities in carrying out the Department's mission, ranging from Program Management, Planning, Design, Construction, Maintenance and Operations. The division that will be primarily involved with ICM activities is the Division of Operations, which employs 320 staff serving under a Deputy District Director. The following six offices in the division will play an active role in the ICM demonstration:

- **Office of Traffic Operations Strategies** develops and implements a Traffic Operations Strategic (TOPS) Plan for Caltrans District 4. The plan provides guidance and establishes priorities for traffic operations on the development of the plan, coordination with adjoining Caltrans

Districts, and presenting and promoting the plan to local and regional transportation partners.

- **Office of Truck Services** coordinates truck and freight activities to ensure that they are appropriately considered in all transportation decisions.
- **Office of Highway Operations** reviews and performs all traffic operational analyses, including corridor studies, interchange and intersection analyses, and also identifies and develops operational improvement projects.
- **Office of Traffic Management** coordinates work on the freeways and expressways in the Bay Area to minimize the impact of construction and maintenance activities on the traveling public.
- **Office of Traffic Systems** plans and develops the Traffic Operations Systems (TOS) and Park & Ride Lot operations for the District. TOS includes traffic monitoring stations, ramp metering systems, CCTVs, CMSs and HARs. The Office also develops intelligent transportation strategies with its transportation partners, and operates and maintains over 200 ramp meters in the Bay Area. In addition, the Office operates the District 4 TMC.
- **Office of Traffic** is primarily involved in traffic safety issues. It designs and reviews the design of signing and striping components for Bay Area freeways, maintains sign logs and photo logs, maintains accident records, provides services for Legal and Claims, conducts speed zone studies and administers the District's Traffic Safety Program.

In addition, Caltrans has contracted with UC Berkeley, System Metrics Group, Inc. and Cambridge Systematics, Inc. to perform a corridor management study of I-880 that is currently in progress.

3.2.2 MTC

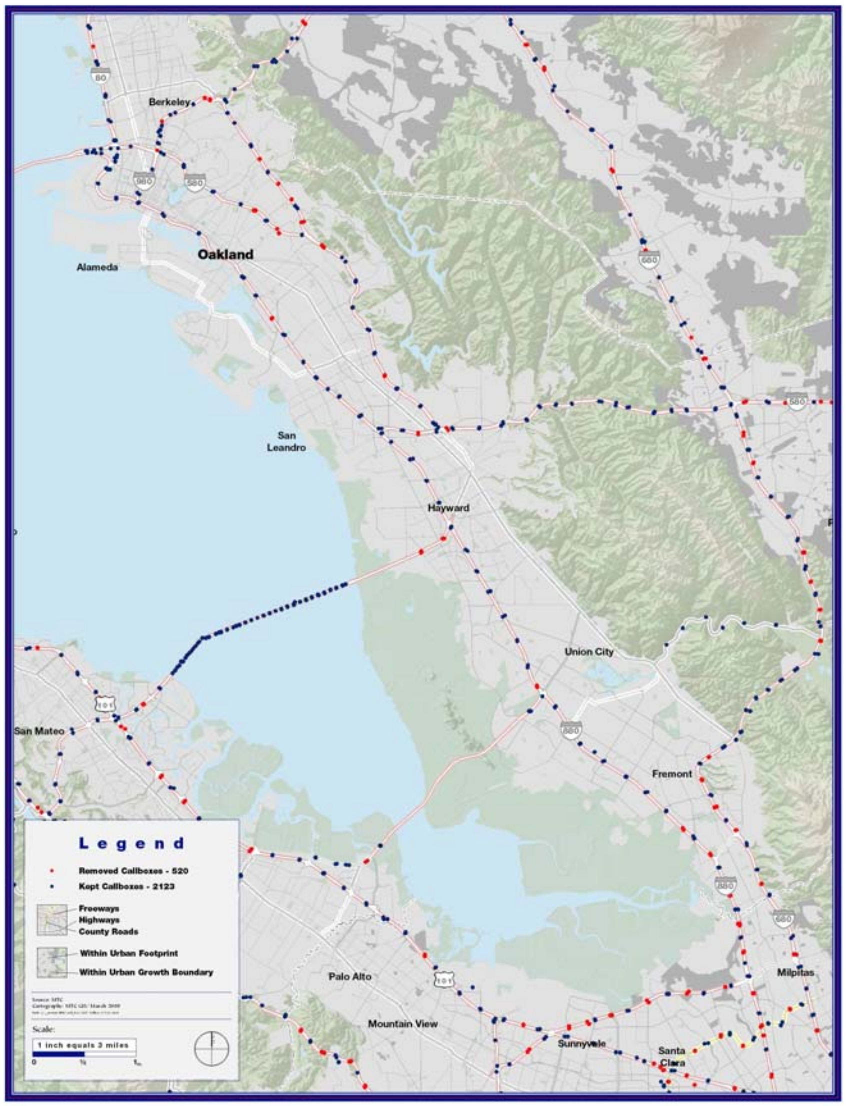
Created by the state Legislature in 1970 (California Government Code § 66500 et seq.), MTC is the transportation planning, coordinating and financing agency for the nine-county San Francisco Bay Area. MTC functions as both the regional transportation planning agency —a state designation– and, for federal purposes, as the region's metropolitan planning organization (MPO). As such, it is responsible for regularly updating the Regional Transportation Plan, a comprehensive blueprint for the development of mass transit, highway, airport, seaport, railroad, bicycle and pedestrian facilities.

MTC also acts as the region’s Service Authority for Freeways and Expressways (SAFE) — in partnership with the CHP and Caltrans— overseeing the maintenance and operation of call boxes along Bay Area freeways and administers the Freeway Service Patrol, a roving tow truck service designed to quickly clear incidents from the region's most congested roadways.

In recent years, MTC has taken a more active and direct role in expanding transportation system management capabilities in the Bay Area. MTC’s 511 Traveler Information System is the premier real-time traveler information system in the nation, and provides real-time traffic conditions via the phone and a companion web site at www.511.org. The system relies on an elaborate data-gathering network that MTC and Caltrans have jointly installed along Bay Area freeways as well as transit data from Bay Area transit agencies. Other MTC programs to improve the efficiency of the system include the Regional Signal Timing Program to re-time and coordinate signals on major arterials, the Traffic Engineering Technical Assistance Program to provide consultant support to smaller jurisdictions that do not have in-house traffic expertise, and more recently, the development of a transit connectivity plan and TransLink, a regional electronic electronic fate payment system to facilitate transfers between the different transit operators in the region.

The Commission’s work is guided by a 19-member policy board. Fourteen commissioners are appointed directly by local elected officials (each of the five most populous counties has two representatives, with the board of supervisors selecting one representative, and the mayors of the cities within that county appointing another; the four remaining counties appoint one commissioner to represent both the cities and the board of supervisors). In addition, two members represent regional agencies — the Association of Bay Area Governments and the Bay Conservation and Development Commission. Finally, three non-voting members represent federal and state transportation agencies and the federal housing department. The District Director of Caltrans District 4 is one of the non-voting members of the Commission. Carrying out the Commission’s directives is a staff of approximately 160.

As the Service Authority for Freeways and Expressways (SAFE), MTC — in partnership with the CHP and Caltrans—oversees the maintenance and operation of call boxes along Bay Area freeways and administers the Freeway Service Patrol (FSP), a roving tow truck service designed to quickly clear incidents from the region's most congested roadways. Within the I-880 ICM corridor, MTC SAFE operates approximately 90 call boxes and 12 tow trucks that provide coverage along five service routes. The SAFE program is funded by a $1 per year fee on motor vehicle registrations. In addition, MTC supports the 511 Traveler Information System that provides real-time traffic and transit conditions via the phone and a companion Web site located at www.511.org.



(Source: MTC SAFE 2007)

The Highway & Arterial Operations section of MTC has responsibility for the agency's role in ICM. This section oversees the SAFE program, and works directly with Caltrans District 4 on system management issues and the agencies' own corridor management efforts.

3.2.3 ACCMA

The Alameda County Congestion Management Agency (ACCMA) was created in 1991 after the passage of State Proposition 111, which raised the state gasoline tax by 8 cents and required counties to designate agencies to perform specific duties to better integrate transportation, land use and air quality in order to receive the additional funds. The ACCMA was established by a joint-powers agreement between Alameda County and all of its cities to assist local governments to meet the requirements of federal, state and local transportation laws by providing technical assistance. The ACCMA decides which transportation projects are the best investments for Alameda County. Through traffic studies, the ACCMA assesses traffic problems and explores solutions along specific corridors.

An example of such a project is the East Bay SMART Corridors Program. The East Bay SMART Corridors Program is an East Bay multi-modal advanced transportation management system, which provides real-time traffic conditions to the public. The intent of the East Bay SMART Corridors Program is to give easy access to local real-time conditions and empower users of the project website at www.smartcorridors.com to make better travel decisions. The East Bay SMART Program consists of two major arterial corridors in the East Bay portion of the San Francisco Bay Area - the San Pablo Avenue (I-80) corridor and the Hesperian/International/E. 14th Boulevard (I-880) corridor.

The ACCMA Board includes representatives from Alameda County, its cities, AC Transit and BART. Technical expertise is provided by the staff-level Alameda County Technical Advisory Committee with representatives from each of these organizations, plus Livermore-Amador Valley Transit Authority (LAVTA), Union City Transit, the Alameda County Transportation Authority (ACTA), the Metropolitan Transportation Commission (MTC), Caltrans, the Port of Oakland and the Bay Area Air Quality Management District (BAAQMD).

ACCMA has retained Kimley-Horn and Associates, Inc. (KHA) to provide technical support for several of their technology initiatives, including the East Bay SMART Corridors project. KHA also provides support for 880 ICM activities.

3.2.4 Local Jurisdictions

The I-880 ICM demonstration corridor is located within the Alameda County, which is comprised of 17 cities. The corridor extends through seven of these jurisdictions (the cities of Oakland, Alameda, San Leandro, Hayward, Union City, Fremont and Newark). Collectively, each local jurisdiction has an economic and political interest in the efficient management, maintenance and operations of the I-880 system networks. The transportation needs of the locals are represented by the Alameda County Congestion Management Agency (ACCMA). However, several of the cities have been particularly active on transportation matters through their Public Works departments.

3.2.5 AC Transit

AC Transit is a regional bus agency serving 364 square miles of Alameda County and Contra Costa County in the western San Francisco Bay Area. In addition, AC Transit runs "Transbay" routes across the San Francisco Bay to the City of San Francisco, and selected areas in San Mateo County and Santa Clara County. Paratransit services for the elderly and disabled are made available to individuals with conditions that preclude them from using public transit.

AC Transit is constituted as a special district under California law. It is governed by seven elected members (five from geographic wards and two at-large). It is not a part of the Alameda or Contra Costa County governments, although the initials "AC" are often mistaken to mean "Alameda County".

3.2.6 BART

BART is a special governmental agency created by the State of California to operate the Bay Area's rapid rail system. The District consists of Alameda County, Contra Costa County, San Mateo County and San Francisco City/County. It is governed by an elected Board of Directors, and each of the nine directors represents a specific geographic area within the BART district. In addition to its rail transit services, BART has its own police force. BART also manages the Capitol Corridor Joint Powers Authority (CCJPA).

BART provides rail transit service for most of the San Francisco Bay Area, including the cities of San Francisco, Oakland, Berkeley, Daly City, Richmond, Fremont, Hayward, Walnut Creek, and Concord. It also serves San Francisco International Airport and, via AirBART buses, Oakland International Airport. The BART system operates three rail lines along the I-880 corridor, the Richmond-Fremont, Millbrae-Dublin/Pleasanton and the Daly City-Fremont lines. Trains on each line typically run every 15 minutes on weekdays and 20 minutes during the evenings, weekends and holidays.

3.2.7 The San Francisco Bay Area Water Transit Authority (WTA)

The San Francisco Bay Area Water Transit Authority (WTA) is a regional agency authorized by the State of California to operate a comprehensive San Francisco Bay Area public water transit system. In 2003, the WTA's plan, " A Strategy to Improve Public Transit with an Environmentally Friendly Ferry System" was approved by statute (Senate Bill 915, Ch. 714, stats of 2003). WTA operates a total of 8 ferry routes across San Francisco Bay Area. The Oakland-Alameda-San Francisco is the most popular route.

3.2.8 Port of Oakland

The Port of Oakland is responsible for the operation of the Oakland International Airport, Maritime Seaport Facilities and over 400 acres of commercial real estate. It is through the management of these facilities that the Port of Oakland generates revenues to reinvest in the City of Oakland and Alameda County's infrastructure. The Oakland Airport serves more than 9.8 million passengers and handles more than 1.4 billion pounds of cargo annually. The Port of Oakland is the fourth busiest container port in the nation behind, Long Beach, Los Angeles and Newark. Ten Container terminals and two intermodal rail facilities serve the Oakland waterfront. The Port loads and discharges more than 99 percent of the containerized goods moving through Northern California. The I-880 freeway is the major thoroughfare that facilitates the movement of the region's imports and exports to and from the Port.

3.2.9 Emergency Responding Agencies (CHP, Police, fire and paramedics)

The California Highway Patrol (CHP) has law enforcement jurisdiction over all California State Routes, U.S. Highways and Interstate Highways, and also serves as a statewide police force. Its officers enforce the provisions of the California Vehicle Code, pursue fugitives spotted on the highways, and attend to all significant obstructions and incidents within their jurisdiction. CHP requests and coordinates the incident scene response efforts of the fire department, paramedics, tow truck operators and Caltrans personnel when requested. Incident management and emergency preparedness have been increasingly significant priorities for the CHP in recent years. The CHP's offices in the Bay Area are headquartered in Vallejo, California, with 11 separate area offices. The specific area offices that will be involved in the ICM demonstration are the Oakland and Hayward offices. Through reports from the field officers and additional phone calls from drivers, an incident database is filled. This database is then shared with other transportation agencies.

3.3 Existing Operational Conditions, Characteristics and Strategies of 880 Corridor and Included Networks

3.3.1 Performance Measures

Different performance measures are typically used in different networks to capture the characteristics and performance of the facilities. This section discusses the performance measures used in each network.

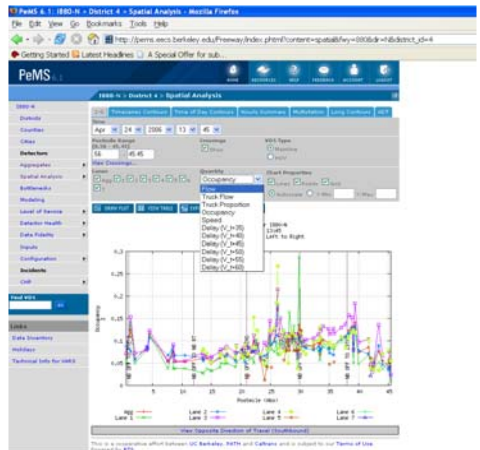
3.3.1.1 FREEWAY PERFORMANCE MEASURES

Freeway performance measures are primarily collected through an extensive freeway loop detector network. Real-time detector station data is sent to the Caltrans TMC, which in turn provides this data to UC Berkeley's Freeway Performance Monitoring System (PeMS) using an XML interface.

PeMS is a web-enabled system and analysis tool that collects and stores data for the California freeway system. The traffic data include traffic volume (number of vehicles traveling over the detectors during 30 seconds) and occupancy (the percentage of time that a vehicle "occupies" the detector). PeMS stores the freeway detection data then uses the data to compute a number of performance indicators and present data both numerically and graphically via the web. Currently, PeMS is hosted at UC Berkeley and can be accessed at http://pems.eecs.berkeley.edu/; it is in the process of being transitioned from UC Berkeley to Caltrans.

Currently, the performance measures provided by the system include speed, density, delay, and other aggregated values such as VMT and VHT. PeMS also provides incident related measures based on CHP CAD data, which include the number, type and duration of incidents, as well as the relationship between other performance measures and incidents. Figure 3.4 illustrates the interface to the PeMS analysis tool.

FIGURE 3.4
Screenshots of PeMS Web Interface



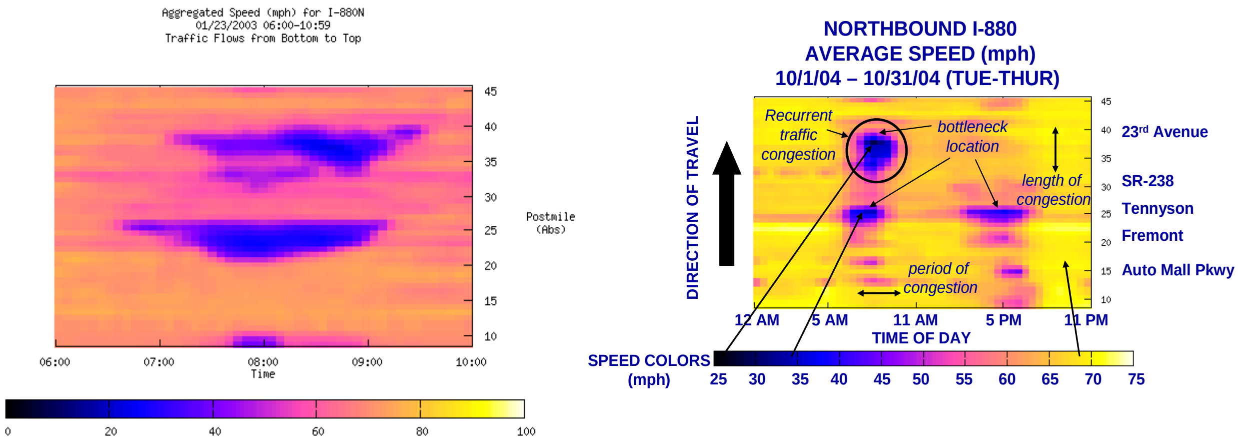
(Source: PeMS, https://pems.eecs.berkeley.edu/)

PeMS contains a suite of applications that processes the detector data into information of use to managers and other decision makers, traffic engineers, planners, value-added resellers (VARS), transportation consultants and researchers, and the public. Examples of information provided by PeMS include:

- freeway speeds by time of day
- freeway vehicle miles and hours traveled trends (for State, District and routes)
- congestion delay trends (for State, District and routes)
- Diagnostic information for field detectors

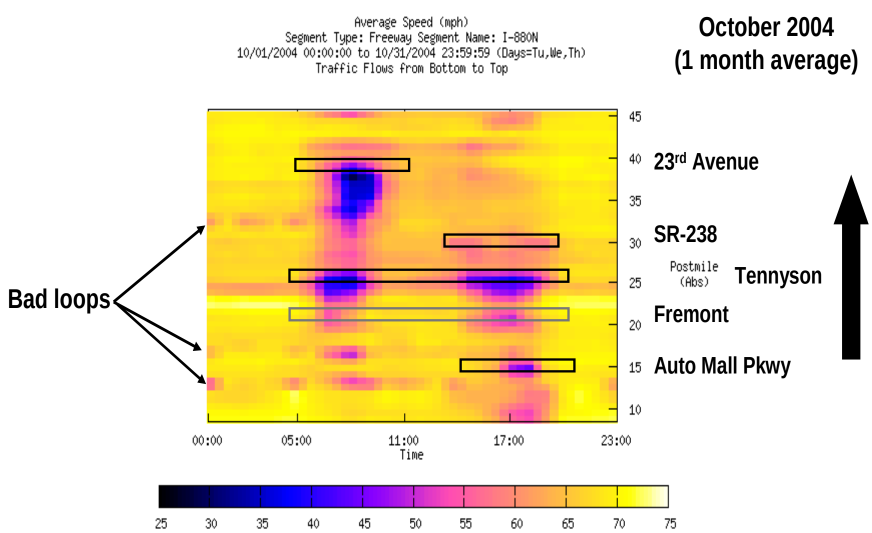
Figure 3.5 is an example that illustrates how speed patterns from PeMS were used to identify bottleneck locations and length and duration of congestion, and other speed patterns and trends and how bottleneck severity changes from day to day. Figure 3.6 shows how bottlenecks were identified over a one month average by PeMS, and also point out how the data can indicate locations with bad loop detectors.

FIGURE 3.5
(A) congestion level and (B) bottleneck severity



(Source: PeMS, https://pems.eecs.berkeley.edu/)

FIGURE 3.6
Bottleneck identification and loop condition monitoring



(Source: PeMS, https://pems.eecs.berkeley.edu/)

3.3.1.2 ARTERIAL PERFORMANCE MEASURES

The 2000 Highway Capacity Manual (HCM2000) uses the average travel speed as a measure to define Level of Service (LOS) along signalized arterials. The average speed is calculated from the running time along the arterial links and the delays at the traffic signals. Level of Service analysis is performed using the Synchro software. Delay analysis is conducted using standard floating car studies along the project corridor to measure the overall travel time and delays at each intersection. Emergency response time is also used as a measure for arterial performance. The performance analyses are currently done manually.

Ongoing research as part of the NCHRP 3-70 project[1] on arterial quality of service identified average speeds (travel time), and number of stops (quality of progression), as key factors affecting the perceived quality of service by auto users.

As part of the PeMS system, UC Berkeley PATH is assisting in the development of Arterial Performance Measures (A-PeMS), which is intended to provide tools for traffic performance monitoring on arterials and optimization of signal timing plans to avoid queue spillovers at the critical intersections. While not yet deployed, A-PeMS expects to provide these performance measures from surveillance data (counts and speeds) and signal status data.

3.3.1.3 TRANSIT PERFORMANCE MEASURES

Transit performance measures indicate both quantitative and qualitative factors used to evaluate a particular aspect of transit service. These measures include quality of service aspects, the overall measured or perceived performance of transit service from the passengers' point of view, as well as transit service measures,

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1 Dowling, R.G, "NCHRP 3-70: Multimodal Arterial Level of Service: Status Report," Presentation, Mid-Year Meeting of Transportation Research Board Committee on Highway Capacity and Quality of Service, Las Vegas, July 2005.

or measures of effectiveness. These measures are indicative of transit access and use.

Transit routing is determined by each operator based on a variety of criteria, including the location of “attractors” such as employment centers, street network characteristics and travel pattern. Consequently, transit routing is an important measure used to indicate access to transit, the area of coverage and proximity of transit service to residential areas and job centers. This measure is commonly shown as the percentage of major centers served within ¼-mile of a transit stop. Access to transit increases the propensity to use transit, thus reducing auto trips, improving air quality and informing decisions regarding land use.

Transit frequency is a measure that is used to determine the convenience of the transit service. It effects mobility, air quality and land use. The data needed for this measure is the number of lines operating at each frequency level. Transit frequency can also indicate the number of buses and operators needed to provide the service, along with the associated costs.

Coordination of transit service is a measure that is used to determine reliability and convenience for patrons when connecting between services. Regional mobility and air quality can be improved if transit connectivity is enhanced between modes or services. This qualitative measure includes the coordination of fares, schedule, service, public information, marketing, and administration.

Transit ridership is a measure that is used for micro and macro trend analysis. It affects economic factors within the transit agency as well as air quality and land use. The data needed for this measure is the number of riders stratified by route, corridor, service type of bus type. A related measure to ridership is the percentage of transit dependent within the total population.

Transit vehicle maintenance is a measure that has several applications. It can be used for trend analysis, to compare between

operators, and can be a factor in investment allocation. It ensures that facilities are in operation and effects air quality. The data needed for this measure for BART is mean time between service delays, and miles between mechanical road calls for AC Transit.

Transit performance is also examined at the route level. Travel time, trip length, wait time, and dwell time are other measures that are used to determine transit quality and effectiveness. Service schedules and on-time performance are also often used as measures. At the route level , comparison are made between scheduled and actual service provided, such as hours of service, number of trips, miles traveled, number of operators, and speed of the vehicle. Additional passenger information can be measured including counts of passengers carried, boardings, and alightings. From this data other measures such as average passenger load during each trip and number of passengers per mile can be calculated. AC Transit and BART use a variety of these performance measures relative to ridership and operating performance in the I-880 corridor. Additional performance measurements include the number of service hours, number of trips, load factor, miles traveled, number of operators and the speed of the bus coach.

3.3.2 Existing Operation Conditions and Characteristics

3.3.2.1 HIGHWAY

Overall traffic volumes along the 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, which are typically heaviest for the northbound AM peak period and southbound PM peak period.

HOV Network: Carpool lanes in the Bay Area operate effectively and generally enjoy 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.

I-880 is an intermodal urban freeway corridor which serves the following major traffic generating sources:

Port of Oakland: 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 inter-regional and international shippers and a primary intraregional goods-movement corridor. The connection with the Port of Oakland generates significant truck volumes, representing approximately 10% 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 two million Twenty-foot Equivalent Unit (TEU) containers. Ten container terminals and two intermodal rail facilities serve the Oakland waterfront. The Union Pacific and 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 transload facilities and the intermodal rail facilities. Additionally, there a major concentration of supporting industrial and warehouse land uses along this portion of the I-880 corridor.

Oakland International Airport: The I-880 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 steadily growing each year. The airport is currently undergoing a significant expansion.

Oakland Coliseum: The Oakland-Alameda County Coliseum & Sports Arena is located just north of the Oakland /San Leandro city boundary, adjacent to I-880 freeway and a BART station. It is home to the Oakland Raiders NFL football team, the Oakland A's MLB baseball team and the Golden State Warriors NBA basketball team. The Oakland Coliseum hosts Raiders and A's games, as well as other events accommodating up to 63,000 people. The Sports Arena hosts the Warriors games and other major events/attractions with a capacity of 19,200 people. People attending these events have a direct impact on the capacity and flow of traffic along the I-880 corridor. The Coliseum, in coordination with MTC's 511 Traveler Information System, ensures that event information is reported as a "hot spot" on the system to inform the public of potential traffic delays.

3.3.2.2 ARTERIAL HIGHWAYS

There are a total of 40 miles of arterials along the project 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 controlled and 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.

The following are the signal control systems in each agency:

- Oakland — BITrans QuicNet System
- Hayward — Econolite Aries System
- San Leandro — Econolite Icons System

- Fremont — Eagle Actra
- Union City — BITrans QuicNet System
- Alameda County — Naztec Streetwise System
- Caltrans — CTNET System

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 Blvd. A significant amount of the parking on each corridor is metered with 30-minute to 2-hours 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% 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 (State Route 61).

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

The Average Daily Traffic (ADT) volumes range between 25,000 to 60,000 vehicles per day, depending on the location along the arterial network. Currently the level of service along the project corridor is between C to D at most key intersections. Below are levels of services at selected intersections along the E. 14th/International Blvd corridor.

TABLE 3.2
Existing Level of Service and Delay

Intersection	AM Peak		Midday Peak		PM Peak	
	Delay	LOS	Delay	LOS	Delay	LOS
E 14th St. and Fairmont Dr.	23.0	C	30.1	C	39.5	D
E 14th St. and 150th Ave.	100.3	F	17.9	B	50.2	D
E 14th St. and Bancroft Ave.-Hesperian Blvd.	33.7	C	74.6	E	125.1	F
E 14th St. and Castro St.-Sybil Ave.	25.1	C	9.0	A	34.4	C
E 14th St. and Hwy. 112-Davis St.-Washington	22.8	C	27.0	C	30.1	C
E 14th St. and Dutton Ave.-Best St.	20.8	C	19.3	B	36.5	D
E 14th St. and 98th Ave.	23.4	C	24.1	C	43.4	D
E 14th St. and Hegenberger Rd.-73rd Ave.	22.1	C	30.1	C	48.1	D
International Blvd. and 42nd Ave.	38.8	D	24.5	C	39.5	D
International Blvd. and Fruitvale Ave.	20.7	C	23.5	C	21.2	C
International Blvd. and 29th Ave.	23.0	C	21.9	C	24.7	C

As a part of the East Bay SMART Corridors program, 18 miles of the existing arterial network are equipped with Closed Circuit TV (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 and displayed for the I-880 corridor, as well as the 511 congestion information on the freeway.

3.3.2.3 AC TRANSIT

Of the dozens of AC Transit routes that serve the I-880 corridor, Route 82/82L is the primary high-ridership route that parallels the majority of the I-880 corridor. Passenger boardings and passenger miles for AC Transit routes 82 and 82L are displayed in the Table 3.3 on the following page.

TABLE 3.3
AC Transit Route 82 and 82L Passenger Information

Daily Passenger Boardings

Route	Weekday	Saturday	Sunday
82/82L	16,727	10,169	9,723

Average Daily Passenger Miles per Trip

Route	Weekday	Saturday	Sunday
82/82L	244.3	139.2	173.7

AC Transit has several major transfer points along the I-880 corridor: Fruitvale BART, Coliseum BART, San Leandro BART and Bayfair BART. Each of these BART stations serves between 6-12 bus routes and provides intermodal transfers with BART. Over 7000 passengers per day access BART or buses at these stations.

3.3.2.4 BART

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

3.3.3 Cross-Network Coordination Strategies Already Implemented

Certain cross-network coordination strategies are already implemented in the I-880 corridor, primarily through manual coordination among different agencies. Such strategies for the corridor can be categorized as four groups: within freeways, between freeways and arterials, within transit, and between freeways and transit.

3.3.3.1 STRATEGIES ALREADY IMPLEMENTED WITHIN FREEWAYS

As shown in Figure 3.7, The 511 system in the Bay Area provides freeway travel times and delay information via a web interface (www.511.org) and phone services to the public. Using information from 511, motorists can make informed decisions pre-trip and en-route regarding which freeway to use to their specific destinations.

FIGURE 3.7
The 511 Website in the Bay Area (Source: www.511.org)

Nine (9) Changeable Message Signs (CMS) are currently deployed along the I880 freeway. Two (2) of the signs, located at 5th St and Oak St on NB I880 respectively, are now activated for providing travel time information to motorists at en-route. Similarly as the 511 system, motorists can make informed decisions on freeway choices based on travel times displayed on CMS.

For freeway operations managers, the Caltrans TMC is the hub for interagency transportation coordination. Co-located with CHP and

MTC (which operates 511 and the Freeway Service Patrol), coordinated management strategies can be implemented and monitored from the TMC.

3.3.3.2 STRATEGIES ALREADY IMPLEMENTED BETWEEN FREEWAYS AND ARTERIALS

Signal pre-emption devices are installed at some intersections in the I-880 corridor. Under emergencies, some first responder agencies can trigger signal pre-emption along major arterials. Otherwise, signal coordination between Caltrans signals near freeway on/off ramps and local signals along arterials is done manually, with the notable exception of the 880 Smart Corridor (where an interagency agreement and operations plan are in place regarding signal coordination).

3.3.3.3 STRATEGIES ALREADY IMPLEMENTED WITHIN TRANSIT

MTC is implementing Translink, a multi-modal payment system for riders to pay for transit in the Bay Area (www.mtc.ca.gov/services/translink). Translink provides smart fare payment card so that riders can use to access bus, train and ferry services in the Bay Area (including the I-880 corridor).

AC transit receives the BART schedule every time the schedule is changed. Transit planners at AC transit manually review and revise their schedules to best serve their riders and maintain coordination between BART and AC transit.

Other coordination strategies between BART and AC transit occur during incident and emergency scenarios only. With major disruptions in BART service, AC transit often provides “bus bridges” between BART stations. However, this coordination is done manually and based on professional judgment. Under certain emergency conditions and pre-planned special events, AC transit often provides connection protection between BART arrivals and bus departures.

3.3.3.4 STRATEGIES ALREADY IMPLEMENTED BETWEEN FREEWAYS AND TRANSIT

Research has shown that parking availability is an important factor impacting commuters' choice of using transit and transit mode choice. A pilot study at the Rockridge BART stations provided real-time parking availability information via a freeway CMS on State Route 24. This information helped motorists determine whether or not they should exit the freeway, park their cars, and use BART rather than continue in congested freeway conditions. The pilot program proved the utility and feasibility of the concept, which could be repeated elsewhere in the Bay Area (particularly the I-880 corridor). Figure 3.8 shows such CMS with parking availability information for the BART station.

FIGURE 3.8.
Parking Information for BART Station on Freeway CMS

(Source: Caltrans 2007)

Another example of interagency coordination between Caltrans, BART and AC transit is regarding special events. Caltrans, BART and AC transit receive notification of special events schedules from event sponsors or organizers. BART and AC transit will often provide extra services if the attendance is expected to impact freeway operations in order to relieve the potential congestion before or after the scheduled events.

When major freeway incidents occur, a typical AC transit response is to make or receive a call from the Caltrans TMC and/or check the ACCMA SMART Corridor website. AC Transit can then use the information to manually provide route guidance for express bus drivers and generally assist all Bus Operators (via a state of the art radio system) that are operating in the vicinity of the highway alert.

3.3.4 Summary

Table 3.4 summarizes the operation conditions and characteristics of the freeway, arterial and key transit networks.

TABLE 3.4
Network Operation conditions and characteristics

	Freeway	Arterials	AC Transit	BART
Network	I-880 between I-580/I-80 interchange in the north and SR-237 in the south; length 38 miles	International Blvd, East 14th St, San Leandro Blvd, Hesperian Blvd, and Union City Blvd; length 40 miles	Two major local AC Transit lines along I-880 (82, 82L) plus about 15 express lines	20 miles of double track
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 4-6 lane undivided highways. Over 250 signalized intersections, 40 arterial miles, 48 miles under TMC surveillance and control.	TMC located in Division D-2, Emeryville, CA. There are approximately 200 bus stops along the corridor, with three major parking facilities. AC Transit is in the process of implementing BRT between Berkeley and San Leandro along the International/E.14th 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 which 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 15,000 and 60,000 vehicles per day.	Passenger boarding for Route 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 7000 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.
Problems & 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 level of service 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 levels of service 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.		

3.4 Existing Network-based Transportation Management / ITS Assets

There have been significant investments in ITS infrastructure within the I-880 corridor, which establishes a solid foundation for the ICM demonstration.

3.4.1 Freeway

3.4.1.1 FREEWAY FACILITIES

Within the 38-mile section of I-880 identified for the Integrated Corridor Management demonstration, the freeway is primarily an eight-lane facility, with numerous auxiliary lanes between major interchanges.

An HOV lane has been in operation in the southern two-thirds of this corridor for 15 years. The oldest HOV segment started in the Hayward area, then the HOV network was extended to the San Leandro and Fremont areas during the late 1990's. The HOV lane is in effect during weekday commute periods, and the minimum occupancy is two persons per vehicle. Two shorter segments of HOV lanes in the northern part of the corridor lead to the Bay Bridge and eastbound I-80, with minimum occupancy of three persons per vehicle.

In November 2006 voters approved a state infrastructure bond package that includes $19.9 billion to make safety improvements and repairs to state highways, upgrade freeways to reduce congestion, repair local streets and roads, upgrade highways along major transportation corridors, improve seismic safety of local bridges, expand public transit, help complete the state's network of car pool lanes, reduce air pollution, and improve anti-terrorism security at shipping ports. Specifically, the bond includes $4.5 billion to relieve congestion by expanding capacity, enhancing operations, and improving travel times in high-congestion travel corridors. As a result, this bond measure could provide new funding opportunities for corridor management projects in the I-880 corridor.

3.4.1.2 FREEWAY ITS INFRASTRUCTURE

The transportation infrastructure on I-880 includes a dense deployment of ITS field elements, which enable traffic monitoring and management at the Caltrans District 4 TMC. The TMC is housed in the main Caltrans District 4 office in downtown Oakland. The facility is co-staffed by Caltrans Maintenance and Operations workers, CHP officers, and operators for the 511 traveler information system. This management system communicates with a variety of ITS field equipment along I-880. The I-880 corridor is extensively instrumented with ITS field elements such as:

Vehicle Detection and Traffic Monitoring on I-880 is performed primarily through inductive loops and microwave sensors. Caltrans currently has 83 inductive loop traffic monitoring stations and three microwave stations along the I-880 corridor. Traffic monitoring stations are typically placed at interchanges, and between interchanges at 1/2-mile increments. All vehicle movements are detected for each freeway mainline lane, on-ramp and off-ramps. Mainline detectors are generally dual loops in each lane. Toll tag readers have been deployed on several freeway corridors that measure average travel times of vehicles with the toll tag transponders. The data from these traffic monitoring are used locally by the ramp metering systems, and sent back to the TMC for real-time traffic data (speed, volume, and occupancy) for the speed maps and archiving. Caltrans also has partnerships with private firms such as Traffic.com and SpeedInfo. Traffic.com provides traveler information to the public, while SpeedInfo supplements microwave type detection where Caltrans has no detectors. Figure 3.9 illustrates detection stations in the I-880 corridor.

Ramp Metering along the I-880 corridor consists of local-traffic responsive meters that help manage the freeway corridor. Freeway on-ramps have been controlled by ramp meters along the entire length of the corridor from Jackson Street in Oakland to SR-237 for over 10 years. Of the 98 on-ramps on the proposed ICM corridor, 86 of them are currently metered. This includes ramps from local streets and arterials to some freeway-to-freeway interchanges. Additional ramp meters are being installed and will be operational within the next few years. The metering strategy is to meter all on-ramps in the corridor taking into account freeway operations at bottlenecks and local street operations. Field staff has the capability to upload and download ramp-metering parameters remotely, and are currently monitored with field crews. Figure 3.10 illustrates ramp meters in the I-880 corridor.

Closed Circuit Television (CCTV) cameras give the TMC staff real-time traffic surveillance and incident verification remotely. Currently Caltrans has 25 CCTVs along the I-880 corridor. CCTVs are typically deployed at the interchanges and between at one mile spacing to provide full video coverage of the corridor. Caltrans typically uses cameras with capabilities of panning, tilting, and zooming. The joint MTC-Caltrans BAVU project is upgrading the CCTV control interface for TMC operators and will provide the capability to distribute real-time video from these cameras to other transportation agencies. Figure 3.11 illustrates CCTV cameras in the I-880 corridor.

Changeable Message Signs (CMSs) give motorists information on incidents, closures, environmental warnings, amber alerts, and travel-times. There are five_Model 500 CMSs along the I-880 corridor. Typically CMSs are installed upstream of major decision points on the freeways, which are usually at major freeway interchanges. Messages are controlled remotely from the TMC. Figure 3.12 illustrates CMS deployments in the I-880 corridor.

Highway Advisory Radios (HARs) are typically installed every six miles along a freeway corridor, and are used to advice motorists of incidents via short-range public radio (three mile radius). Two Extinguishable Message Signs (EMSs) are installed in each freeway direction within the radio coverage. These signs are only active when a message is broadcasting. Typically Caltrans broadcast HAR using station 840 AM. There are five HAR stations installed along the I-880 corridor.

FIGURE 3.9
Detector Stations

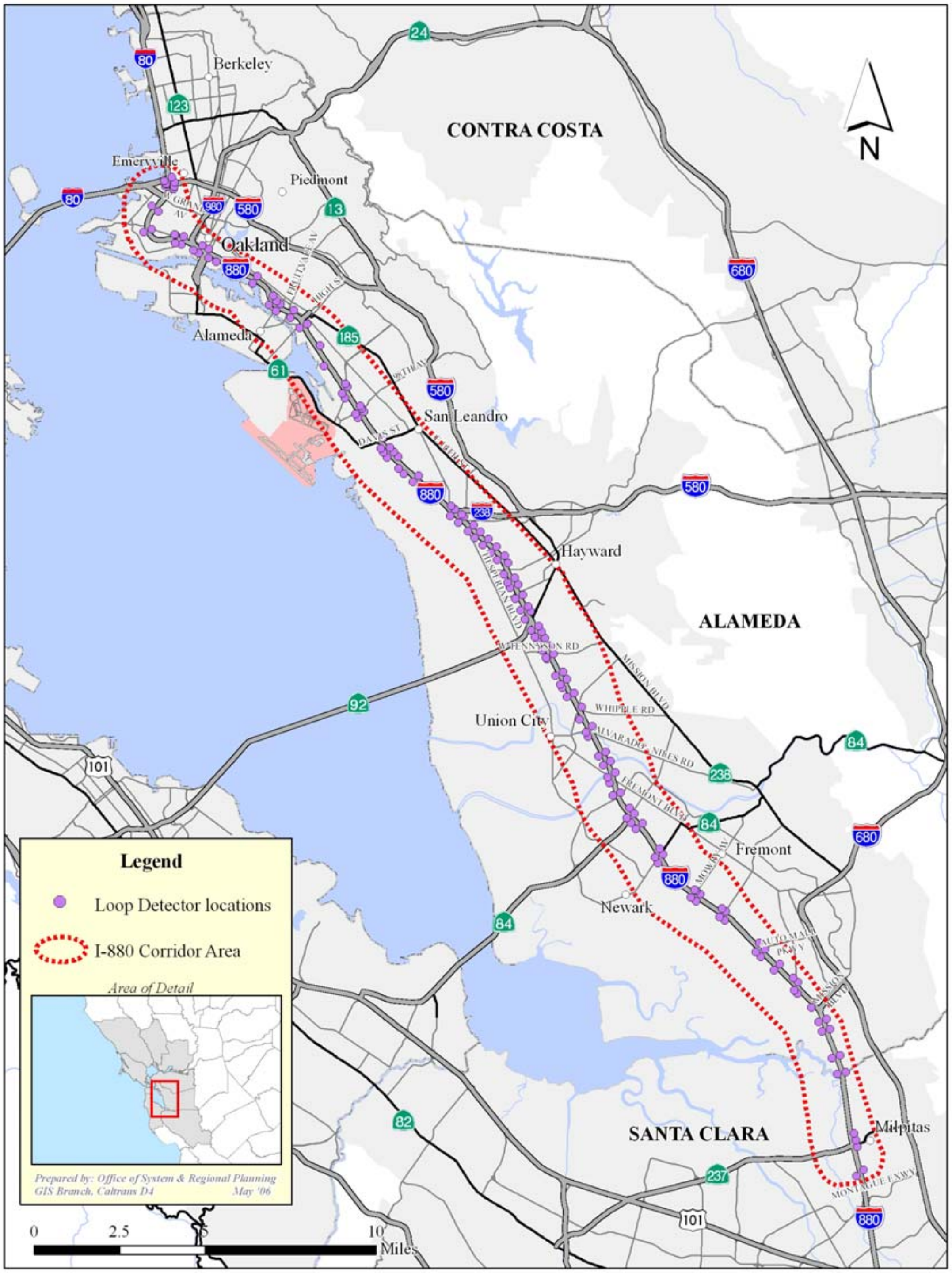


FIGURE 3.10
Ramp Metering Locations

FIGURE 3.11
CCTV Camera Locations

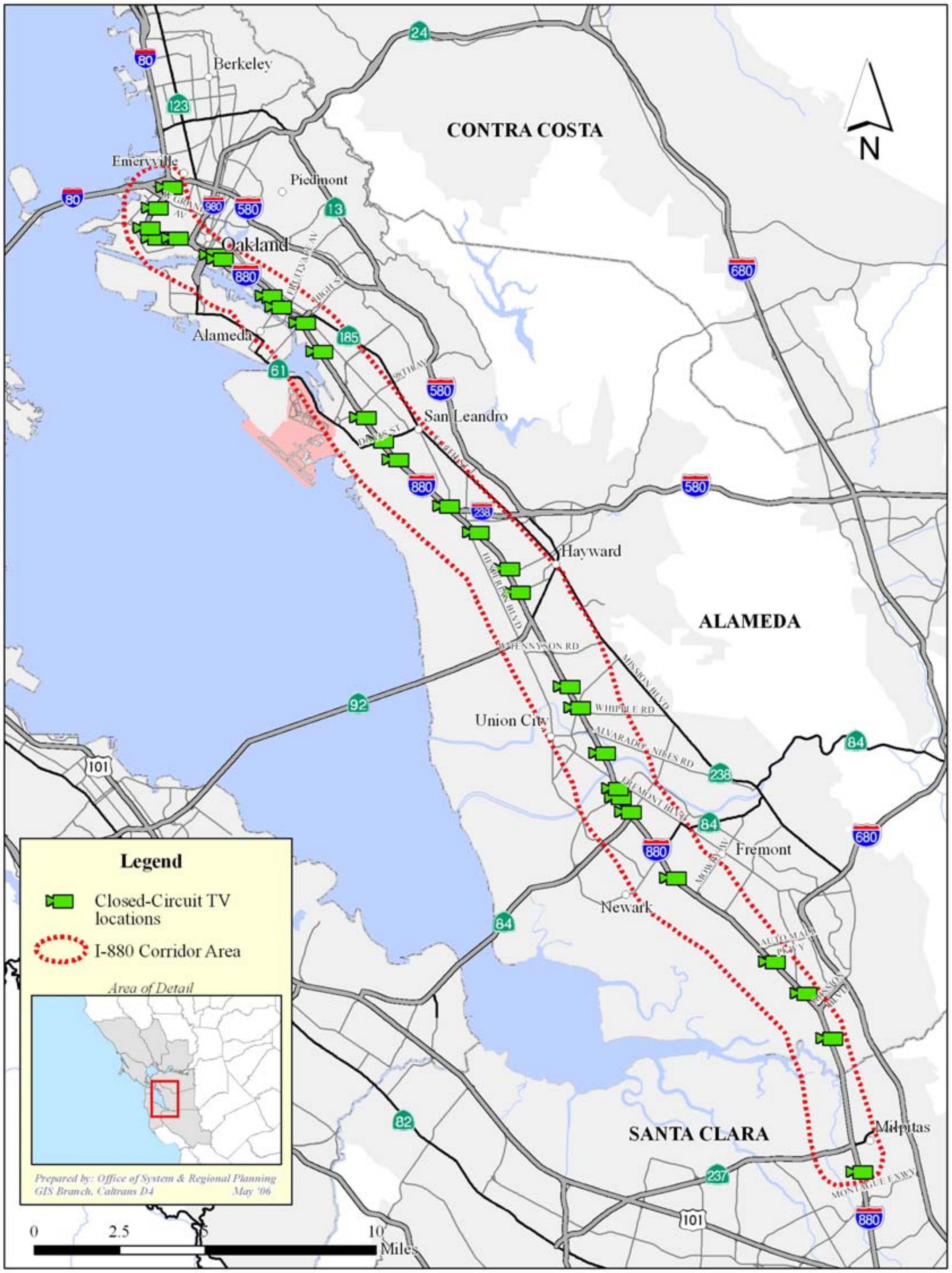
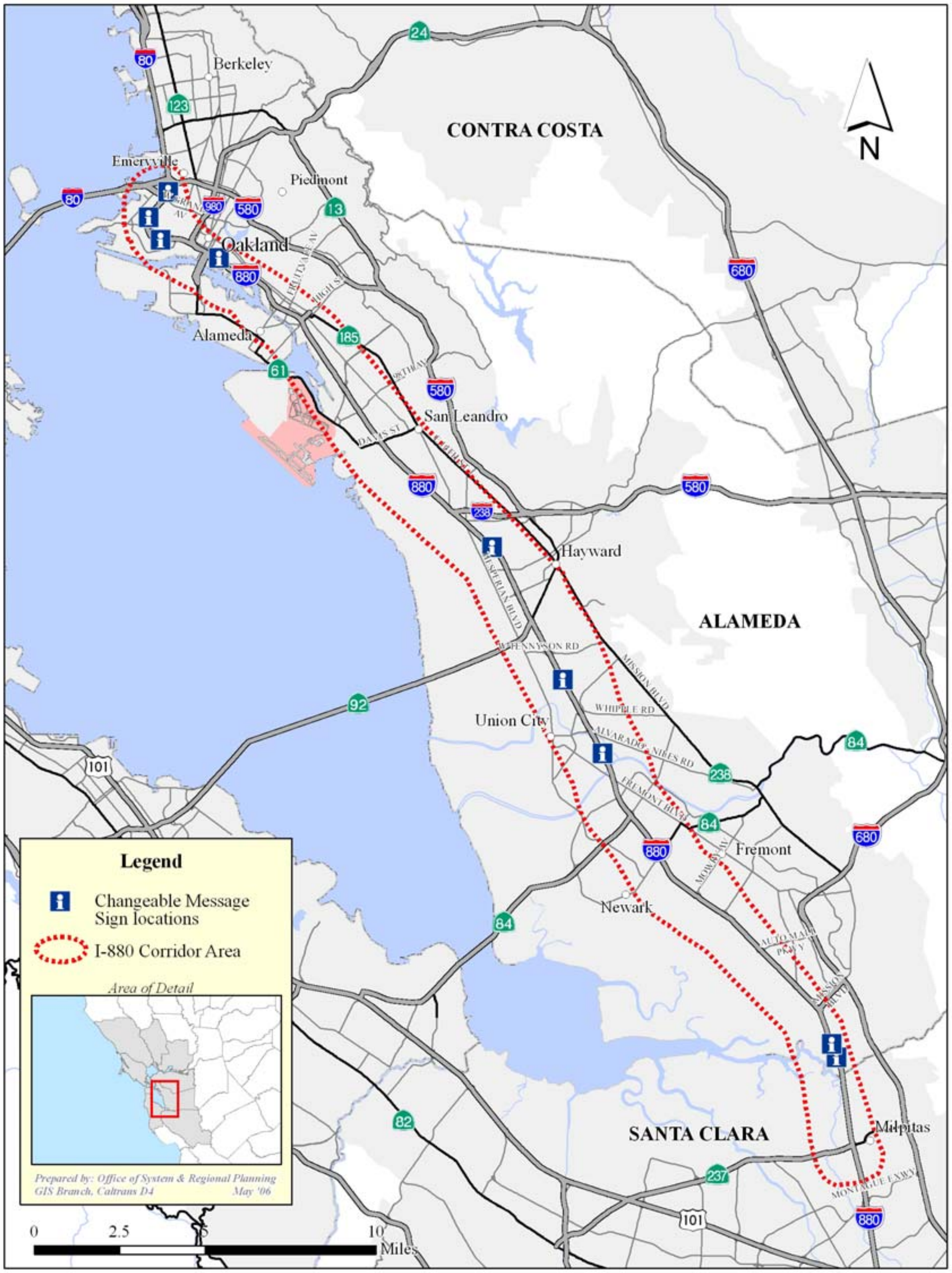


FIGURE 3.12
CMS Locations



There are several planned upgrades or improvement projects to the TMS network infrastructure. MTC and Caltrans are jointly working on a project to upgrade the existing CCTV camera network with the Bay Area Video Upgrade (BAVU) Project. There is also an effort by Caltrans Headquarters to install a statewide version of the ATMS called CATMS in all TMCs.

With approximately 2,000 pieces of field equipment in the inventory and more planned or under construction, a central database and equipment management system are necessary in order to manage the system. The current effort, named the TOS Equipment Management System (TEMS), is a software product that provides Caltrans District 4 and MTC staff with tools to manage the TOS inventory, and help ensure the reliability and accuracy of the TOS and Traffic Management Center (TMC) information. TEMS will consolidate the several existing TOS databases and spreadsheets and provide the uniform information and functionality desired by the users. The goals of TEMS are to provide the MTC and Caltrans District 4 Division of Operations with a readily-accessible, robust repository for TOS equipment data, a practical way to manage TOS inventory and status information, configurations, and track related activities, a uniform, consistent information standard for characterizing equipment; and a flexible design for readily accommodating new technologies that may emerge and new functionality.

3.4.1.3 USING COLLECTED DATA TO MAKE OPERATIONAL DECISIONS

The Caltrans TMC uses Enterprise Transportation Management System (eTMS) software suite, which collects data from field devices and incident data from the incident management module and the CHP CAD, generates the map display, places dynamic icons on the map, calculates and displays travel time estimates, supplies real-time data to external systems such as 511 and PeMS, archives data, emails detector station data to interested parties daily, and provides a user interface for controlling signs, cameras, and ramp meters. In addition to freeway traffic management, the following regional functions are collocated with Caltrans TMC, including:

511 Operators are co-located in the TMC, as well as occupying a section of the TMC that houses its traveler information operations center. Operations include transit and traveler information via the web or phone for drivers, transit riders, and bicyclists for the nine Bay Area counties. The center also receives data directly from Caltrans field elements and is used to provide traveler information to drivers for driving time calculations and incidents.

The Emergency Response Center (ERC) is also co-located in the TMC. Depending on the nature of the emergency and the response that is needed, the ERC may be activated. Once activated, the ERC is the central focal point for all emergency activities in the District. It will provide uniformity of response, and it will provide consistency in disseminating information to Caltrans management, local ERC's, and to the public.

BAIRS (the Bay Area Incident Response System) is a tool that Caltrans Maintenance Dispatchers use in the TMC that integrates incident tracking and tools to improve Caltrans' incident response capability. This allows dispatchers to quickly locate the nearest qualified responder and provides the responder with detailed resource information, helping them to coordinate a more rapid response and resolution. BAIRS has the following functionality: web-based incident log, GIS capabilities, enhanced reporting capabilities, performance metrics, mobile devices, and increased incident information available to both dispatchers and supervisors. In the past this was done with multiple tools, most of which were manual. BAIRS integrates these tools into one system. This provides quicker response times and more up-to-date information on what agency and type of equipment is needed to respond to incidents. The BAIRS application BAIRS is expected to reduce the average traffic incident resolution time from 4 hours to 90 minutes or less. Given that for each minute a freeway lane is blocked, traffic is delayed 4 to 10 minutes, BAIRS will result in a substantial reduction in time spent in traffic for many Bay Area travelers.

Caltrans Headquarters Detector Fitness Group and Caltrans Electrical Systems Group service the traffic monitoring stations. TMC Operators inspect the conditions of CCTVs, CMSs, and HARs are on a weekly or monthly basis and report problems to Caltrans

Electrical Systems and/or Caltrans Electrical Maintenance for service or repairs. The ramp meters are monitored daily by Caltrans Field Operations. Caltrans Electrical Maintenance performs preventive maintenance on the cabinets and signal heads.

The TMC is a large two-story-high theater that houses 19 operator consoles facing a large video wall. Seven consoles in the TMC are used by Caltrans telephone and radio operators to receive problem reports and to dispatch and coordinate field crews for maintenance, traffic management, and motorist assistance. Five consoles are used by Caltrans traffic managers to monitor traffic conditions, especially those associated with incidents, to determine what active management measures are needed and to check that measures are having the desired effect. Four consoles are assigned to CHP officers who provide close coordination between the TMC and CHP’s Golden Gate Communications Center in Vallejo, which receives cellular 911 distress telephone calls and serves as a CHP’s dispatch and command center for incident management. The TMC has six remote terminals connected to the Vallejo center’s computer aided dispatch (CAD) system that enables CHP officers and Caltrans’ operators to view details of incidents affecting the region’s highways.

FIGURE 3.13
Caltrans Transportation Management Center in Oakland

(Source: Caltrans 2007)

Operators in the TMC rely on information provided by TOS field equipment to monitor conditions on the freeways. They also rely on ramp meters, changeable message signs, and highway advisory radios to control traffic flow and to provide information and guidance to motorists, especially during incidents. These responses include dispatching CHP, Caltrans Maintenance, Caltrans TMT, as well as placing messages on CMSs, radio messages on HARs, and messages to the public through the media.

Toll tag readers were deployed on several freeway corridors that measure average travel times of vehicles with the toll tag transponders. Data is also collected from the traffic monitoring locations. Both real-time toll tag and traffic monitoring data are used to calculate travel times and then relayed to the public via CMSs.

3.4.1.4 FREEWAY OPERATION TACTICS

HOV Lanes

Freeway HOV lanes are active during the morning (5 to 9 AM) and afternoon (3 to 7 PM) peak periods on weekdays, and are open to all traffic at other times. (Almost all HOV lanes in Northern California operate during peak periods only, in contrast with the continuous HOV operation found in Southern California.) The mainline HOV lane operates with 2 or more persons (3 or more at the approaches to the Bay Bridge). Currently the HOV lane operates on both the NB and SB directions of I-880, from Mission Blvd in Fremont, to Marina Blvd in San Leandro. There is currently a construction project in southern Alameda County that will extend the HOV system to Route 237 in Santa Clara County.

The ramp meters on I-880 (both directions) are in operation during the morning and afternoon peak periods from 6 to 9 AM, and from 3 to 7 PM. The HOV bypass lane at a metered on-ramp from the local street is in operation 24 hours. Most of the on-ramps from SR-237 in Milpitas to the Broadway I/C in Oakland are metered. Provisions for future metering are installed north of Broadway I/C to I-80.

Ramp Metering Control

Detector data are also used by ramp meter controllers to automatically adjust metering rates as traffic flow changes during the day. A ramp meter detector monitors traffic flow on both the ramps and the mainline lanes. The mainline data at a meter are used directly by the meter, but also serve as general-purpose vehicle detector data that are sent to the TMC. Of the approximately 1100 detector stations on Bay Area freeways, about 280 of them are part of a ramp meter installation.

Currently the ramp meters along the I-880 corridor are local traffic responsive. They operate from metering tables, which take into account the several bottlenecks throughout the I-880 corridor, as well as variable demands at the on-ramps. Communications to the TMC assist Operations field staff in uploading and downloading ramp metering parameters into the field controllers. Meters are in operation for both AM and PM peak periods and on both directions of I-880.

Ramp meters along this corridor were activated following an agreement between Caltrans and local jurisdictions within the corridor to manage the freeway metering strategy without affecting the local street operations. A Technical Working Group (TWG) was formed (comprised of Caltrans, MTC, ACCMA, Port of Oakland, CHP, and the local jurisdictions) to develop consensus on guidelines, operational plans, and policies on I-880.

Initial metering rates were determined by using FREQ, a freeway simulation program, with data collected from traffic monitoring locations. Freeway delays and field observations were also made to quantify before metering was implemented. Once the metering rates and policies were agreed upon by the TWG, metering was initiated on I-880 in October 1996. The freeway and local street operations were monitored after metering was initiated. Queues on the on-ramps were observed and once it extended into the local streets, a faster metering rate was initiated. While this impacted the freeway mainline, study showed HOV users still had significant travel time benefits by using the mainline HOV lane and HOV bypass lanes on the metered ramps.

Incident Management

Incident response and clearance is the highest priority for freeway operations in the Bay Area. The actions to improve incident response and clearance reside in different agencies (such as the Caltrans TMC, the CHP computer-aided dispatch system, the Caltrans Bay Area Incident Response System), with some actions focusing on the incident scene and others on the Regional TMC.

Over the past 20 years, Caltrans has deployed several types of closed-circuit television (CCTV) cameras along Bay Area freeways and camera control systems in the TMC. The camera control systems have been upgraded and integrated to allow TMC staff to quickly connect with and control cameras to confirm reports of incidents and determine the type of emergency equipment that is needed.

Under the MTC SAFE program, CHP has deployed a communications system that facilitates all agencies responding to an incident to communicate with each other. CHP and the four largest Freeway Service Patrol agencies are working together to define and implement a two-way CAD/FSP 'Handshake' interface for use throughout California.

3.4.2 Arterial Highways

3.4.2.1 ARTERIAL FACILITIES

The arterials along the project corridor are typically 4-6 lane divided or sometimes undivided arterials, with access to commercial or residential areas along the project corridor. 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. The Average Daily Traffic (ADT) volumes range between 15,000 to 60,000 vehicles per day, depending on the location along the arterial network.

Most of the intersections along the project corridor are currently 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.

The East Bay SMART Corridors program covers approximately 18 miles of the I-880 corridor arterial network. For these segments, major intersections are equipped with CCTV and monitoring stations to collect and disseminate real-time traffic information to transportation managers and to the public.

3.4.2.2 ARTERIAL ITS INFRASTRUCTURE

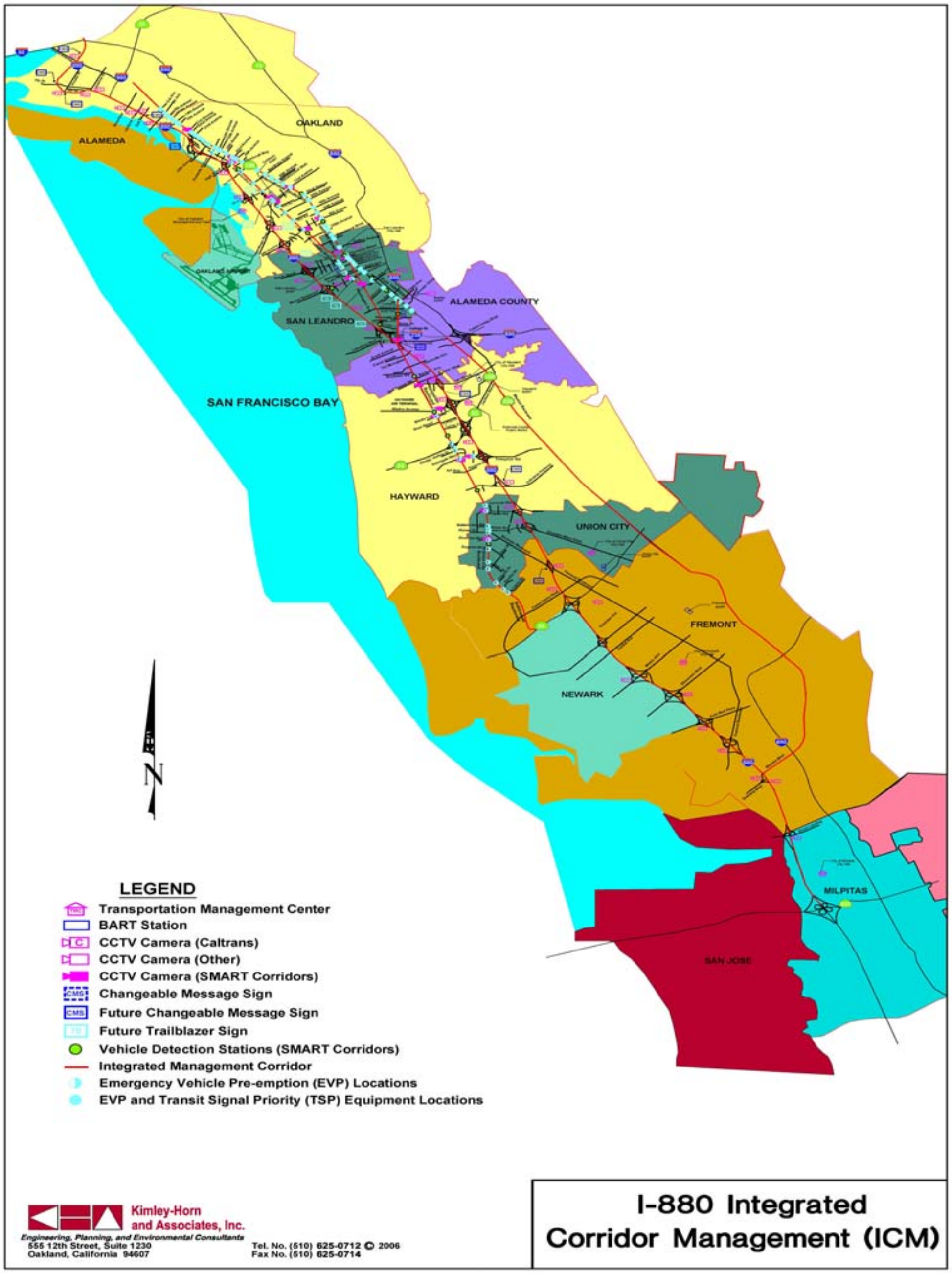
Figure 3.14 illustrates the ITS infrastructure along the 880 SMART corridor including Caltrans operated cameras. Alameda CMA has ITS infrastructure along 880 SMART Corridor arterial network at strategically selected locations. The field ITS devices on arterials include:

- **Vehicle Detection System:** Vehicle Detection System provides the capability to measure volumes, speed and level of congestion on the main and the crossing arterials. Non-Intrusive detectors are alternative to the conventional loops. The most common non-intrusive detectors use radar (RTMS – Remote Traffic Microwave Sensor), sound (PADs – Passive Acoustical Detectors), or video (VIDs – Video Image Detectors), to detect and classify vehicles. Currently RTMS units are installed on Union City Blvd, Hesperian Blvd, E. 14th Street, International Blvd, San Leandro Blvd, High Street, Marina Blvd, Washington Avenue, portions of the project corridor at approximately 2 miles spacing. There are approximately 20 RTMS along the project corridor.
- **Closed-Circuit Television (CCTV) Cameras:** CCTV systems provide remote ability to visually confirm an incident and its impact, and monitor general traffic conditions. With this ability in place, agency staff can quickly determine the appropriate action needed to mitigate traffic impacts when an incident occurs as well as provide valuable information to appropriate emergency service providers and other agencies. Currently, all of the major intersections along the East Bay SMART Corridors are equipped with CCTVs. Approximately 20 intersections are equipped with CCTVs, which consist of 4-fixed cameras installed on signal mast arms. CCTV can also increase information sharing with the media

and the public. The CCTV and monitoring stations are monitored from the central unit and are inspected weekly for functionality. A maintenance contractor provides annual and semi-annual inspection and cleaning for all units.

- **Traffic management system** for the arterial network is a distributed system, where all agencies are interconnected with Center to Center communications (T1 line) to CMA's network. The software that is currently used for the East Bay SMART Corridors program was developed by Bentley Corporation. However, CMA is in the process of upgrading this system to a thin-layer, web based system.
- **Emergency management system** for the arterial network is based on the Opticom pre-emption system. Most of the intersections along the project corridor are equipped with 4-way Opticom receivers at all intersections. The Opticom equipment is triggered when an emergency vehicle arrives at the intersection by changing the signal operation and providing green indicated in the direction of the emergency vehicle travel. There are currently over 100 intersections along the project corridor equipped with this equipment.
- **Transit signal priority system** is used for the Rapid Bus route along the E. 14th Street/International Blvd. The transit signal priority system is based on the low priority Opticom equipment. When the buses approach the intersection, an early green or extended green is granted to the buses to allow the buses to avoid stopping. There are approximately 50 intersections equipped with the transit signal priority along the E. 14th Street/International Blvd corridor.
- **Data and Video exchange system** is in place, where all agencies are interconnected with Center to Center communications (T1 line) to CMA's network. The software that is currently used for the East Bay SMART Corridors program was developed by Bentley Corporation. However, CMA is in the process of upgrading this system to a thin-layer, web based system.

FIGURE 3.14
Arterial Instrumentation Map



The 880 SMART Corridor program participants (Oakland, San Leandro, Alameda County, Hayward, Union City, AC Transit and Caltrans) are connected through a leased, distributed network. The distributed network utilizes high speed T1 lines that are interconnected to via a client-server network configuration, co-located at a managed facility. All participating agencies share traffic management and incident information through the East Bay SMART Corridors network. The system collects real time information along the project arterials, including CCTV images, traffic volume and speed data from the Monitoring Stations, traffic signal coordination data, and incident information. This information is then aggregated, fused and disseminated to all of the agencies. In addition, the CCTV images, congestion information and freeway incident data is published on an internet web site available for public access.

The existing traffic signal systems for each of the agencies are interconnected with the network. The host system transmits real-time signal status, including signal coordination plans, cycle lengths, offsets and split information for approximately 65 traffic signals along the project corridor. The information is aggregated, fused and disseminated to other agencies so that all agencies can view the status of signals of other agencies. However, the agencies cannot change or control the signal control system for other agencies. Other traffic signals along the corridor are mostly interconnected with traffic masters. Caltrans has plans to instrument a wireless communication link between traffic masters along International Blvd, E 14th and the Caltrans D4 traffic control center as part of the implementation of ICM strategies.

3.4.2.3 USING COLLECTED DATA TO MAKE OPERATIONAL DECISIONS

The East Bay SMART Corridors collects real-time traffic information along Union City Blvd, Hesperian Blvd, E. 14th Street/International Blvd, San Leandro Street, and San Leandro Blvd. Traffic data include volume and speed data and are collected every 30 seconds on arterials using RTMS data collection units. Data is transmitted via wireless GPRS system and is aggregated at the ACCMA data center. The data are owned by ACCMA and data exchanges with other networks are carried through a leased T1 line.

Currently, the real time data collected along the project arterials, including CCTV, traffic monitoring station data (speed and volume), level of congestion, and incident information are disseminated via public web site. All of the fire department engines in Alameda County are planned to be equipped with mobile computer units to receive this information through a wireless connection. This will allow the fire departments to access SMART Corridors web site to verify locations of incidents for best routing to the incidents. They also use the cameras to verify roadway conditions en-route to incidents.

3.4.2.4 ARTERIAL OPERATION TACTICS

Actuated Signal Control

Most of the traffic signals along the project corridor are fully actuated. Some traffic signals, especially along East 14th/International Boulevard are semi-actuated. Most of the traffic signals along Union City Boulevard, Hesperian Boulevard, E. 14th Street, International Blvd, San Leandro Street, and San Leandro Boulevard are coordinated during morning, midday and afternoon peak hours. A time-of-day plan is programmed for each peak period. The traffic signals are also equipped with emergency pre-emption equipment for emergency services. The same equipment is utilized for transit signal priority control along the E. 14th/International Boulevard for Rapid Bus service.

Signal Interconnect

The entire corridor between Union City and Oakland, along Union City Blvd, Hesperian Blvd, E. 14th/International Blvd, San Leandro Street, and San Leandro Blvd are interconnected via hardwired or fiber optic interconnect. There are some minor gaps in the interconnect system, where the traffic signal coordination is not needed.

3.4.3 AC Transit

3.4.3.1 AC TRANSIT FACILITIES

AC Currently has approximately 90 pairs of bus stops along the East 14th/International Blvd corridor, connecting to over 20 cross-town routes and major intersections such as 14th Avenue, 23rd Avenue,

Fruitvale Avenue, High Street, Seminary Avenue and 73rd Avenue. AC Transit also has several major transfer points at BART stations: Fruitvale BART, Coliseum BART, San Leandro BART and Bayfair BART. Each of the BART stations serves between 6 to 12 bus routes and provides intermodal transfers between the BART service to the 7,000 transferring passengers. Ridership along the corridor is currently approximately 17,000 per day, but is anticipated to increase with the introduction of Rapid Bus service, described below.

AC Transit is in the process of implementing Bus Rapid Transit (BRT) between Berkeley and San Leandro along the E.14th Street/International Blvd. corridor. Plan is described in 3.1.3.1.

3.4.3.2 AC TRANSIT ITS INFRASTRUCTURE

A number of state-of-the-art transit ITS technologies have been deployed within the AC Transit fleet to enable advanced planning, operation and improved service quality. These technologies are:

- **Advanced Transit Management System**: AC Transit management center located at its Division 2 office in Emeryville has implemented the Orbital "Satcom" Transportation Management System (TMS) which combine GPS satellite navigation and terrestrial communications technologies to enable public transit authorities to better track, manage and dispatch their vehicles. The system polls bus location of every vehicle in the entire 600 bus fleet every 2 minutes. Two way voice communication shares the same communication channel. The Orbital TMS allows transit dispatchers and supervisors to monitor the operations and to pinpoint the location of a specific bus and respond to an emergency situation, send a repair crew or notify passengers of a delay. This system also provides next stop announcements on a number of routes on all AC Transit buses. A sub-fleet of buses are instrumented with automatic passenger counters. The TMS records on-time performance data for all buses, which is used for planning purposes.
- **The NextBus Prediction System:** The NextBus system uses GPS position to predict bus arrival time at the intended stops, using historical data on speed and travel time. The predictions are made available on the Web and to wireless

devices (including signs at bus stops and internet-capable cell phones and Personal Digital Assistants (PDAs)). Within the I-880 corridor, AC Transit has NextBus service enabled on high ridership routes, but does not currently include any TransBay lines. In May 2007, Nextbus became operational on an additional 25 routes, including some Transbay routes that serve the corridor. Also, NextBus message signs are located at the Alameda/Oakland ferry terminal located in the city of Alameda. Approximately 100 NextBus signs are in operation.

- **AC Transit WiFi Service:** AC Transit is in the process of implementing a unique customer service on their TransBay buses - WiFi. AC Transit's NetBus concept utilizes a mix of wireless WAN (WWAN) and wireless LAN (WLAN) technologies. The basic idea behind the NetBus service is to take a 3rd Generation mobile modem, which connects to a mobile carrier's cellular infrastructure through an on-board router, and share the connection between users via WiFi-(802.11). In addition to providing wireless Internet access to patrons, there are other uses of the technology for AC Transit. Although not planned as a feature of the initial installation, the Internet connection can also be used by the driver to send and receive information to and from AC Transit's Central Dispatch. If the need arises in the future, combined with GPS technology, telematics information such as mechanical health status and the exact location of the bus could be relayed back to AC Transit for better and more effective fleet management. Currently, the WiFi access has become available on 79 MCI motorcoaches, all of which are chiefly dedicated to Transbay service (Route descriptions are provided in Appendix G).

3.4.3.3 USING COLLECTED DATA TO MAKE OPERATIONAL DECISIONS

AC Transit collects bus operation data, including vehicle movements, running time, schedule adherence, and prediction reports for its entire fleet every 2 minutes using Automatic Vehicle Locators (AVL). The NextBus system also provides scheduling predictions for a number of routes under contract with the vendor. Boarding and alighting passenger data are collected on a number of buses using

Automatic Passenger Counter (APC), which are cycled through the bus network to provide stop-level data for all routes annually. The data is owned by AC Transit. Historical data are sometimes shared with other agencies, but there is no shared database. When data is shared, it is usually manually provided.

Two consoles at Central Dispatch have video screens available for viewing both SMART Corridor and NextBus systems along with Caltrans CCTV cameras. CHP incidents, which are mostly collected through its field offices and phone calls from drivers, are depicted as icons on the SMART Corridor website, and supervisors access the incident data by placing the cursor over the pop-up icon. This data can be used to detour buses during major incidents. Currently, the Smart Corridor covers International Blvd/E. 14th from 1st Ave to Bayfair, Hesperian Blvd from E. 14th Street to Union City Blvd and Alvarado Road.

AC Transit has been training dispatchers on how to make best use of the SMART Corridor website. Currently, the Central Dispatch operators take any incident data and broadcast the information over the Orbital TMS system. Dispatchers can also text message incident data field staff and supervisors for follow up. If necessary, due to the severity of the incident, Dispatchers will monitor the freeway and arterial congestion, and reroute vehicles that are deadheading as appropriate.

3.4.3.4 AC TRANSIT OPERATION TACTICS

Bus operation for regular bus routes are schedule based. Rapid buses will apply headway based operation policy aided by signal priority systems. Location of the transit signal priority equipped corridor is illustrated in Figure 3.14 on page 60.

3.4.4 BART

3.4.4.1 BART SERVICE IN I-880 CORRIDOR

Two BART lines serve the I-880 corridor, including the A-Line running from Lake Merritt Station to Fremont Station and the L-Line running between Castro Valley and Dublin/Pleasanton. The BART segment along I-880 is approximately 20 miles with 12 stations

(West Oakland, 12th St, 19th St, Lake Merritt, Fruitvale, Coliseum, San Leandro, Bayfair, Hayward, South Hayward, Union City, and Fremont). The BART system is entirely grade-separated, with no interaction with surface traffic.

The BART system has a total of 42,390 parking spaces, among which 11,432 parking spaces are located at 10 stations along I-880 corridor. The 12th Street and 19th Street stations in downtown Oakland do not offer parking.

3.4.4.2 BART ITS INFRASTRUCTURE

BART train operations are entirely automated. The **Automated Train Control System** consists of an Operations and Control Center (OCC), which communicates with all of the train control rooms located in many of the stations. OCC can adjust train operations by making requests in a number of ways; basic operations are the responsibility of the train control room. OCC can adjust station dwell time, and train performance level for example. Trains are located using audio frequency track circuits, and speed commands are sent to trains through the same circuits. Trains have small antenna that send train ID and destination to the wayside, and a similar system is used for precision train berthing.

BART has also developed a communication based train control system that uses the MASH communication system to position trains and to operate train in "moving blocks." The system has yet to be implemented, however. The system has great potential for significantly increasing passenger throughput. The operation data collected by this system has finer resolution than the system BART is currently using.

In addition to train operations, train arrival and system status information is collected from OCC and disseminated on dynamic platform message signs. Information dissemination outside of the BART system is performed manually.

3.4.4.3 USING COLLECTED DATA TO MAKE OPERATIONAL DECISIONS

BART OCC monitors the train movements and power systems in real-time through track circuits and twisted wires at stations, where adjustments to train operations can take place. Route information (through switch positions), signal status and system health information are also collected, as well as passenger origin/destination information.

Due to its segregated nature, the BART system is operated independently from other transit systems. BART operation staff coordinates with AC Transit and other transit agencies when major incidents or system failures occur.

3.4.4.4 BART OPERATION TACTICS

BART adopts classic schedule-based control strategies for passenger rapid rail systems. BART train control center is located in downtown Oakland where dedicated operation, power, emergency response and traveler information staff perform control and monitoring functions. Coordination with Caltrans, AC Transit, the news media and other agencies typically occurs during service disruptions or special event planning, and is conducted manually on an as-needed basis. Strategies are not strictly pre-defined, and are primarily based on professional judgment.

3.4.5 Regional ITS Systems and Services

3.4.5.1 BAY AREA REGIONAL TRAVELER INFORMATION - 511

Traveler information in the San Francisco Bay Area has been readily available through the Bay Area 511 service since December 2002. The service is operated, maintained and updated by the MTC.

511 is a free phone and Web service (www.511.org) that consolidates Bay Area multimodal transportation information into a one-stop resource. 511 provides up-to-the-minute information on traffic conditions, incidents and driving times, schedule, route and fare information for the Bay Area's public transportation services, instant carpool and vanpool referrals, bicycling information and more. It is available 24 hours a day, 7 days a week.

Public Transportation information features include:

- **Transit Agency Information:** Transfers to agency operators, routes, schedules, fares, service announcements, lost-and-found and customer service for more than 40 transit providers.
- **Transit Trip Planner:** 511 TakeTransit™ Trip Planner is an automated Web-based tool which assists in planning Bay Area transit trips. By typing in the starting and ending points, the Trip Planner will return the most efficient routes, including walking maps to and from transit. The Popular Destinations feature offers information on how to travel to famous or familiar Bay Area sites using transit.
- **Commuter Incentives:** Transfers to an operator who provides information about programs that offer financial incentives for commute alternatives, including the commuter tax benefit program and free services for commuters.
- **Airports:** Transfers to an operator who provides information about public transportation, ground transportation, and shuttle services for San Francisco, Oakland, San Jose and Sacramento airports.
- **Paratransit Agency information:** Information for approximately 20 paratransit agencies serving persons with disabilities or the elderly, including shuttle services, public transportation, and customer service.

Traffic information features include:

- **Traffic Conditions:** 511 Traffic provides information via the Internet about travel on Bay Area freeways and expressways. The traffic page includes 511 Driving Times^{SM}, Bay Area traffic maps, and FasTrak™ information. The traffic maps are interactive and help the user to calculate driving times for their routes. The map also shows traffic alerts, incidents, levels of congestion, special events and construction information from CHP, Caltrans, and other transportation agencies.
- **511 Driving Times^{SM}** : 511 Driving Times^{SM} provides actual driving times for specific routes based on real-time traffic information.

- **Airports:** Provides information about traffic conditions, ground transportation and parking rates for San Francisco, Oakland, San Jose, and Sacramento airports. Oakland International Airport also provides, when available, parking-status information.
- **FasTrak™** : Transfers to an operator with information on the FasTrak™ Electronic Toll Collection program.
- **Carpooling and Vanpooling:** The 511 Online Ridematching service can help in finding members for a carpool or vanpool. The service also provides information on starting a carpool and vanpool, the locations of carpool lanes and park-and-ride lots as well as information on incentives for carpoolers and vanpoolers, and rules about diamond/HOV lanes (express lanes on freeways).
- **Bicycling:** 511's Bicycling Page (bicycling.511.org) serves as a resource for bicycling commuters and recreational cyclists. The site provides useful information, including safety tips, bike maps, tips for taking bikes on transit and across Bay Area bridges, information on local bicycling organizations, and announcements that affect the Bay Area's bicycling community.

3.4.5.2 TRANSLINK®

The TransLink® is a transit fare smart card that can simultaneously keep track of value equivalent to cash, transit passes, and/or ticket books. Currently, TransLink® smart card is used to provide transit fare payment. In the future, this technology could provide a broad range of services beyond transit fares. Future uses could include payment for parking, telephone calls, retail purchases and Internet purchases. Note that TransLink data has a latency period of 24 hours. No real-time information is provided.

3.4.5.3 FREEWAY SERVICE PATROL

The Freeway Service Patrol is a regional service of tow trucks patrolling the Bay Area’s most congested freeways during the peak periods, clearing accidents and other incidents, assist motorists in trouble and removing dangerous road debris.

FSP is managed by the Metropolitan Transportation Commission Service Authority for Freeways and Expressways (MTC SAFE) in cooperation with Caltrans and the CHP. Currently, the FSP consists

of a fleet of 84 trucks patrolling 450 miles of the Bay Area's freeways. Patrol routes are selected based on several factors, including a high rate of traffic congestion, frequent accidents or stalls, and lack of shoulder space for disabled vehicles. The service is financed with federal, state and local funds, including a $1 annual vehicle registration fee in participating counties.

3.4.5.4 CHP CAD SYSTEM

The California Highway Patrol (CHP) Statewide Computer Aided Dispatch (CAD) System is currently in use with CHP communications centers throughout the state. The system provides automated dispatching and incident management capabilities. Functions include receiving, reporting and archiving information on 911 calls, incident information and resource availability. It can also dispatch emergency response, request alerts, track incident progress, and help coordinate response plans.

Access to CHP CAD is through CHP communication centers and CHP field units, including CHP facilities co-located at the Caltrans TMC. Filtered information from the CHP CAD is also provided to Caltrans, other public agencies, news media and the public. Besides just serving CHP, the CAD also interfaces with a number of other freeway operations systems including the call box answering center, FSP computer, 511, the Caltrans TMC and PeMS.

3.4.6 Information Sharing Capabilities

The concept and operation of an integrated corridor depends heavily on the information sharing abilities among the various networks in the corridor. In this section, the information sharing capabilities of each network are discussed.

3.4.6.1 FREEWAYS

The main software suite used at the Caltrans District 4 TMC is *eTMS* (Enterprise Transportation Management System), developed by Siemens-Gardner. It collects data from field devices and generates the speed map display, places dynamic icons on the map, supplies real-time data to external systems (such as 511, PeMS, TMC archives), emails detector station data to interested parties, and provides a user interface for ramp meters.

Although the TMC interface supports two-way communications, the implementation at the Caltrans TMC is one-way only. Freeway management data supported by the interface messages include Changeable Message Signs (e.g., message content and status), detector stations (e.g., volume, occupancy and speed), ramp meters (e.g., rate and mode), and incidents (e.g., location, type, status, category, severity, lanes affected, duration).

Detector station data are collected from the field using various data concentrator (DC) computers. Caltrans District 4 is using TOS 2 firmware developed in-house to collect the field data via wireless GPRS modems. Real-time detector station data collected by the TMC is exported to 511 and PeMS using an XML interface. Other agencies can also obtain historical detector data daily by subscribing to an email-based file distribution system.

An example of a sub-regional entity that shares data with the Caltrans D4 TMC is the Silicon Valley ITS partnership (SV-ITS). SV-ITS consists of local agencies in Santa Clara and Southern Alameda County that coordinate key transportation management elements within their jurisdictions. The data exchange network (DEN) is the critical element that makes multi-agency cooperation possible. It consists of a collection of computers linked together to allow for real-time data sharing and exchange between agency control centers. Since each agency has its own unique traffic management system, the DEN translates all data and provides a common interface for all users. The Silicon Valley-ITS DEN is being upgraded to meet the current NTCIP DATEX-ASN standard. This work is being done prior to completion of the concurrent upgrade of the Message Sets for External TMC Communications (MS-ETMCC) standard, which is developing traffic management messages for use with DATEX-ASN. Therefore, although the DEN will use the DATEX-ASN standard protocol, not all of the messages exchanged using that protocol will be standard ones.

3.4.6.2 ARTERIAL NETWORK

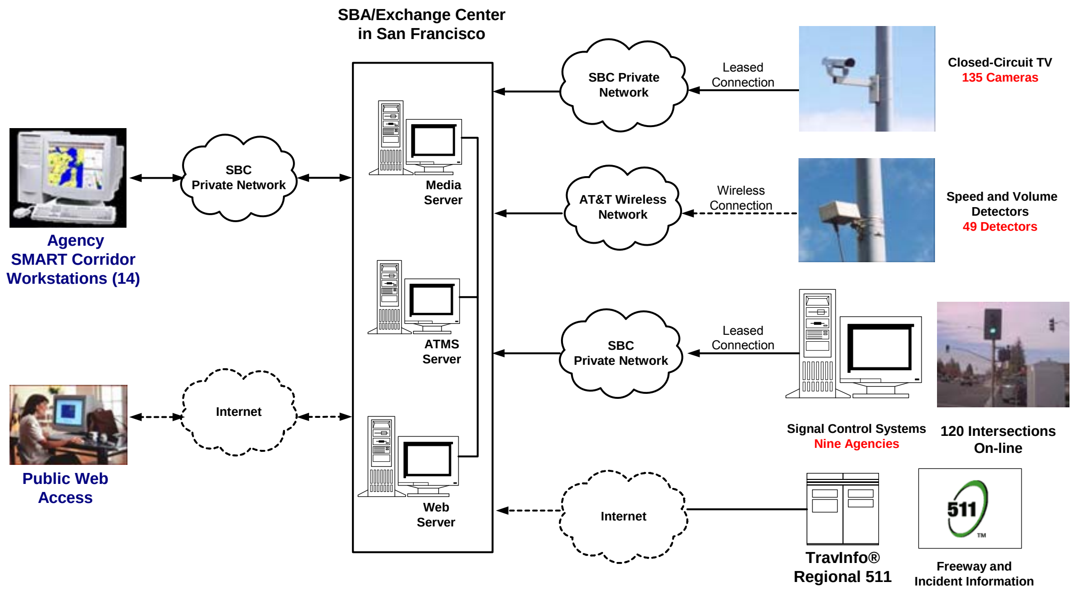
East Bay SMART Corridors program has developed and maintains the arterial network system interconnection. Currently, the project participants (Oakland, San Leandro, Alameda County, Union City, AC Transit and Caltrans) are connected through a leased, distributed network. The distributed network utilizes high speed T1 lines that are interconnected via a client-server network configuration, co-located at a managed facility.

All participating agencies share traffic management and incident information through the East Bay SMART Corridors network. The system collects real time information along the project arterials, including CCTV images, traffic monitoring station's volume and speed data, traffic signal coordination data, and incident information. This information is then aggregated, fused and disseminated to all of the agencies. In addition, the CCTV images, congestion information and freeway incident data is published to an internet web site for public access.

The existing traffic signal systems for each of the agencies are interconnected within the network. The host system transmits real-time signal status, including signal coordination plans, cycle lengths, offsets and split information for approximately 65 traffic signals along the project corridor. The information is aggregated, fused and disseminated to other agencies so that all agencies can view signal status in other agencies. However, the agencies cannot change or control the signal control system for other agencies.

In addition, CMA receives 511 data that includes CHP incident information. This information is then shared with all agencies through the ATMS system. The information can also be shared with the public via a web portal. In addition, the 880 SMART Corridor system has an incident management module that can share incident and construction information among the allied public agencies, but not yet with the public.

FIGURE 3.15
SMART Corridors program network architecture



(Source: Caltrans)

3.4.6.3 AC TRANSIT

AC Transit has two main infrastructure systems that help manage the transit system: Orbital "Satcom" radio and AVL System; and the NextBus prediction system, provide by an external vendor. At AC Transit's Central Dispatch Center, both dispatchers and supervisors use the Orbital and NextBus systems to monitor the fleet operation. This bus AVL information currently is not shared with other agencies.

The NextBus information has become available at selected AC Transit bus stations, some at multimodal hubs such as the Oakland Ferry station.

AC Transit supervisors have been training dispatchers to arterial traffic information from the SMART Corridor website. Currently, Central Dispatch operators take any incident data and broadcast the information over the Orbital TMS system to bus drivers and if the incident is severe, dispatchers may reroute vehicles that are deadheading as appropriate.

3.4.6.4 BART

BART train control center has two main functions: central train control and power monitoring. There is dedicated intra-network communication allowing operation and maintenance personnel to communicate. The BART communication network is built around the train interlocking system. Currently, the system is not connected with any outside networks.

3.4.7 Summary

Section 3.4 summarizes the existing assets in the individual networks. The following Table 3.7 provides a summary of the information.

TABLE 3.7 SUMMARY

	Freeway	Arterials	Bus Service (AC Transit)	Passenger Rail (BART)
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 which 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.	Two main infrastructure systems: Orbital "Satcom" radio and 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 (see Section 3.1.4 for detail). 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 (see Section 3.1.4 for detail).
Data Collection	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**.	**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**.	Boarding and alighting passenger data, running times, schedule adherence, vehicle location, and prediction reports are collected using Automatic Passenger Counter (APC); Automatic Vehicle Locators (AVL), and Nextbus prediction systems. The data are owned by AC Transit, and currently, historical data are sometimes viewed by other agencies, but there is no real-time communication.	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 are collected also. Fare collection information is also collected.
Data Archiving	**Real-time detector station data** are exported to TravInfo and PATH's Performance Monitoring System (PeMS) using an XML interface.	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 7th months back are moved onto a separate archive server on which they are held indefinitely.	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.	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 website has real-time information available such as the location of all of the trains and fare collection information within the system.

3.5 Programmed Near-Term Network Improvements

3.5.1 Highways

3.5.1.1 COORDINATED INCIDENT MANAGEMENT SYSTEM

Caltrans TMC allows coordinated incident management for freeways. Currently, freeway management operators use CCTV cameras to judge incident severity and determine impacts to traffic. As traffic diverts off the freeway and onto the arterial system, it is important for every agency impacted by an incident to be aware of the changing traffic patterns and take necessary measures to participate in monitoring and managing the incident through their jurisdiction. Using the components and devices to be implemented along the Corridors, delays along the arterials can be minimized as drivers bypass the incident.

MTC, in association with the California Highway Patrol and Caltrans, have developed Freeway Concept of Operations plan to improve coordination between the three regional agencies and the local agencies. An Incident Management Program has been developed and implemented. The plan for future improvements include the development of an automated and integrated system to collect incident detection data from several agencies and sources, integrate the data to combine multiple reports of a single incident, and concisely report accurate data to all involved agencies.

3.5.1.2 COORDINATION OF SIGNAL & RAMP METERING

An experiment in the coordination of ramp meters with adjacent traffic signals is planned on Route 85 in the city of Cupertino in the next 12 months. A center-to-center communications link is planned between the TMC and the city's traffic signal system. The signal system will receive data concerning the operation of the ramp meter, and can adjust signal timing accordingly. For example, the green time allocated to movements destined for a backed-up on-ramp may be reduced so that more time can be given to movements not impacted by the metered ramp. These ramp meters and adjacent traffic signals are not within the I-880 ICM corridor, however, the knowledge gained and lessons learned will be beneficial for I-880 ICM deployment.

3.5.2 Arterials

In the near-term, the Alameda County CMA SMART Corridors Program has several new projects and improvements in store so motorists and transit riders can make better travel decisions and reduce their commute times. Communication, coordination and cooperation between local operations and regional agencies will also be improved to better manage regional traffic congestion. SMART Intelligent Transportation System (ITS) devices installed along the corridors will be utilized by the partner agencies to achieve these goals. Through these strategies and solutions, local agencies and emergency service providers will know ahead of time whether to divert traffic or close a lane because of an incident or construction. Ultimately, better management means a more seamless traffic flow for drivers traveling from the local arterials to the freeway and across jurisdictions. Some of these improvements will be implemented along with the International-Telegraph Rapid Bus project, which began service in July 2007.

3.5.3 AC Transit

AC Transit plans to expand the Ardenwood Park and Ride lot located on the Fremont-Newark line at Highway 84 and Ardenwood Blvd. This project will expand the lot from 100 spaces to almost 250 spaces, and also include amenities such as waiting areas and landscaping. This park and ride lot serves the San Francisco Line SB and the Union City-Newark-Fremont to Menlo Park-Palo Alto Lines. The Ardenwook Park and Ride facility is under design.

The East Bay Bus Rapid Project will build bus lanes and BRT stations on arterial streets in the cities of Berkeley, Oakland and San Leandro. The intent of the project is to achieve the speed and reliability of rail using lower cost buses. The project will also include specially designed passenger boarding platforms, shelters, NextBus signs and bus priority at traffic signals. The new service will operate primarily on Telegraph Avenue, International Boulevard and East 14th Street. The rapid bus phase of the project has commenced in June 2007. Construction of the full BRT project is scheduled for completion in 2008.

3.5.4 BART

The San Francisco Bay Area Rapid Transit District (BART) has initiated the Earthquake Safety Program to upgrade vulnerable portions of the original BART system to ensure safety for the public and BART employees. Portions of the original system with the highest traffic will be upgraded not only for life safety but also to ensure that they can return to operation shortly after a major earthquake. As part of this program, the BART Administration Building at Lake Merritt will be restored to a safe and stable condition and a new radio site facility will replace BART's existing radio facility at the Administration building

3.6 Current Network-based Institutional Characteristics

The San Francisco Bay Area is an institutionally complex region, with nine counties, 100 cities, and over two dozen public transit agencies. However, the long history of collaboration among the agencies has built a solid foundation for institutional integration for an Integrated Corridor Management system. Caltrans, CHP and MTC have entered into several formal regional freeway management agreements to coordinate efforts on freeway system management. These include establishing the Service Authority for Freeways and Expressways (MTC SAFE), the Memoranda of Understanding (MOU) to establish TravInfo™, the Center-to-Center Program, and a regional Freeway Concept of Operations. The benefits of these regional programs include deployment and operation of the call box program throughout the Bay Area, operation of the Freeway Service Program's fleet of roving tow trucks on the congested portions of the freeway network, and the provision of timely, accurate multimodal information to travelers. These regional programs directly benefit the I-880 ICM Corridor, including existing traffic data collection and data sharing systems, traffic and transit operation centers, and the operation of call boxes and tow trucks.

The I-880 ICM demonstration project will provide an opportunity to revisit previous decisions on operating the corridor, including the opportunity to investigate effective ways of integrating different systems and coordination and collaboration among institutions that operate these systems. An example of the integration issues to be addressed under the ICM program is the evolution from demand rate metering at each interchange to adaptive operation of ramp meters on a corridor basis to maximize person throughput in the peak period and ensure minimal delays for movement of freight in the off-peak periods.

In this section, we first summarize the currently existing institutional agreements among the agencies, followed by detailed description and discussion of each agreement. Opportunities are identified for the improvement of institutional agreements and the further benefits that could be obtained from the agreements.

3.6.1 Summary of Existing Institutional Agreements

TABLE 3.8 SUMMARY

Agreement	Description
The Bay Area Partnership; Jan 1992	The Partnership is a confederation of the top staff of transportation agencies in the region as well as environmental regulatory agencies. The Partnership works by consensus to improve the overall efficiency and operation of the Bay Area's transportation network, including developing strategies for financing transportation improvements.
I-880 Ramp Metering; Oct 1996	MTC, Caltrans, ACCMA and the local cities worked together to develop the Policy on Cooperative Management of the I-880 Corridor. The policy addresses procedures for resolving disagreements and operating parameters for the meters.
MTC SAFE; 1988	The Metropolitan Transportation Commission Service Authority for Freeway and Expressways (MTC SAFE) encompasses two significant motorist aid projects in the Bay Area – the Call Box program and the Freeway Service Patrol program. Both of these programs require on-going partnership with Caltrans and CHP staff.
TravInfo™/511; Oct 1998	TravInfo™ began as an FHWA Field Operational Test from September 1996 to September 1998, and based on the success of that test, was transitioned to ongoing operation through regional funding.
Freeway Concept of Operations; July 2002	MTC, Caltrans and CHP completed the 20-month long Freeway Concept of Operations project in July 2002. The project was conducted under the direction of the Freeway Management Executive Committee. The purpose of the Concept of Operations is to identify inter-agency strategies to effectively manage recurring traffic congestion, incident response, and traveler information on Bay Area freeway.
Center-to-Center Program; 2005	The purpose of the Center-to-Center program is to implement and operate a Center-to-Center System for the exchange of real-time traffic data and video between the Bay Area's four existing SMART Corridors and the Regional Transportation Management Center, where Caltrans, California Highway Patrol and TravInfo® staff are co-located. The MOU is currently being amended to add the East Bay SMART Corridor, which includes the I-880 Corridor.
Incident Management Program; 2006	MTC, CHP and Caltrans completed the Incident Management Strategic Plan in January 2006. The plan identifies a series of high priority strategies that could enhance existing Bay Area incident management strategies. Implementation of the recommended strategies is in progress.
JUMP Start	The Bay Area Partnership adopted a list of 16 interagency

Agreement	Description
	projects called the "Joint Urban Mobility Program; JUMP Start" for resolving barriers that were delaying the projects.
I-880 Ramp Metering; Oct 1996	MTC, Caltrans, ACCMA and the local cities worked together to develop the Policy on Cooperative Management of the I-880 Corridor. The policy addresses procedures for resolving disagreements and operating parameters for the meters.
I-880 Corridor Management MOU; 2002	The MOU was executed by 10 agencies during the summer of 2002. The agencies were Alameda County CMA, MTC, Caltrans, four cities, two transit agencies and the County of Alameda. The MOU formalizes the commitment of the agencies to cooperatively improve the management and operation of I-880 and the parallel arterials by implementing ITS projects.

3.6.2 Description of Existing Institutional Agreements

The public agencies involved in operating these facilities have had a long history of cooperative traffic management of the corridor, with numerous successes and several new initiatives underway. In recent years, transportation agencies in the Bay Area have developed various agreements and implemented numerous projects to improve the freeway operations by building on the strengths of the key regional agencies. Table 3.8 is a summary and short description of these existing agreements.

1) TravInfo/511

Providing the Bay Area public with information about travel choices is a key strategy in the continuing challenge to reduce the impact traffic congestion. The 511 Traveler Information Program is the culmination of years of effort by MTC, Caltrans, CHP, transit operators and other partners to provide on-demand, real-time information. TravInfo™ began as an FHWA Field Operational Test from September 1996 to September 1998, and based on the success of that test, was transitioned to ongoing operation through regional funding.

The 511 program offers free traveler information available by telephone via the federally dedicated information number and on a web site at 511.org. Information is organized by mode: traffic, transit, ridesharing and bicycling. TravInfo™ collects real-time transportation data from various sources in the Bay Area, and provides the public with accurate, comprehensive and timely information about traffic congestion, driving times, roadway incidents, construction activity and special events through the 511 traveler information phone number and the 511.org web site. TravInfo™ information is disseminated through other channels, such as local radio stations, traffic reports on television and Web sites run by transportation agencies and private companies. Data for the TravInfo™ system come from MTC, the CHP, Caltrans and other Bay Area transportation agencies.

511 provides several types of information for freeway travelers. 511’s Traffic Conditions provides current incidents and average speeds when traffic is moving less than 40 miles per hour. It also provides road closure information from CHP, Caltrans, and other transportation agencies. 511 Driving Times provides point-to-point driving times on routes throughout the Bay Area, based on a combination of probe data, using FasTrak toll transponders, and Caltrans sensors. During 2005, the Bay Area’s drive time

coverage doubled, with the addition of data from approximately 300 miles of freeway around the Bay Area. 511.org added a link to real time traffic video provided by Caltrans. MTC and Caltrans have also initiated a cooperative program to post travel times to key destinations on changeable message signs located at key decision points along the freeway system.

2) East Bay SMART Corridor

The I-880 SMART Corridor was created by the local agencies in cooperation with Caltrans and MTC, and directed by the I-880 Steering Committee with advice from the I-880 Technical Working Group. The agencies worked together informally for several years to implement and operate the SMART Corridor, which extends from Oakland to Union City, and then formalized the arrangement by adopting an MOU in 2002. In 2002, Alameda County CMA led the effort to consolidate the I-880 and San Pablo SMART Corridors into the East Bay SMART Corridor, and also led the effort to develop the agreement on ownership, operation and management of the SMART corridor in 2003. The I-880 Corridor management was created to provide a multi-modal, integrated system, consisting of the freeway, arterial, transit and emergency management systems. The goal of the I-880 Corridor management was to collect real-time information about the project corridor and to share information between the agencies. The real time information is also provided to the public for better decision making. In addition, the program is implementing a Bus Rapid Transit system along the E. 14th/International Blvd.

3) Regional Freeway Management Agreements

The Bay Area has developed several agreements and implemented numerous projects to improve freeway operations by building on the strengths of the key regional agencies. MTC is the transportation planning, coordinating and financing agency for the nine-county San Francisco Bay Area. Key agreements and projects include the MTC SAFE's call box and freeway service patrol programs, 511/511.org, the Freeway Concept of Operations, the Center-to-Center Program, and the incident management program.

In order to better coordinate work on the various joint initiatives, the three agencies established the Freeway Management Executive Committee (FMEC) in 2000 to jointly coordinate freeway operations. For the first year, the meetings involved MTC's Executive Director, the Director of Caltrans District 4, and the Chief of the CHP's Golden Gate Division, as well as the deputies from each agency that were responsible for freeway operations. The

meetings currently involve the deputy from each agency, and occur on the second Friday of the month. The FMEC has been instrumental in developing inter-agency cooperation and consensus on freeway management issues as well as accelerating the deployment of innovative traffic management strategies throughout the region.

4) The Bay Area Partnership

In January 1992, shortly after the passage of ISTEA, The Bay Area Partnership Board convened as a forum to facilitate Bay Area efforts to integrate travel modes and take advantage of the flexibility provided by ISTEA to improve operational efficiency and increase the capacity of existing facilities. The Partnership is a confederation of the top staff of various transportation agencies in the region (MTC, public transit operators, county congestion management agencies, city and county public works departments, ports, Caltrans, U.S. Department of Transportation) as well as environmental protection agencies. The Partnership works by consensus to improve the overall efficiency and operation of the Bay Area's transportation network, including developing strategies for financing transportation improvements. The 32 agencies that initially formed The Partnership did not develop a Memorandum of Understanding or other formal agreements, but rather relied on their shared understanding of the need to work together to ensure that there was sufficient commitment to ensure the success of The Bay Area Partnership.

The Bay Area's numerous natural barriers and rich mix of urban, suburban and rural settings and sub-economies have given birth to a multiplicity of transportation system owners, operators and regulators. This institutional framework ensures that widely varying local needs are met, but also requires that the players work with each other to coordinate services where their systems intersect or overlap. In this complex environment, integration depends on connections that are as much financial, institutional and informational as they are physical - hence the need for a strategic alliance on the scale of The Bay Area Partnership that can focus on the larger picture of how the individual components fit together. One of the initial projects undertaken by The Bay Area Partnership was early deployment of the freeway Traffic Operations System. This included installation and operation of loop detector stations, CCTV cameras, changeable message signs and highway advisory radio, as well as ramp meters, along the length of the I-880 corridor.

5) MTC SAFE

The Metropolitan Transportation Commission Service Authority for Freeway and Expressways (MTC SAFE) encompasses two significant motorist aid projects in the Bay Area – the Call Box program and the Freeway Service Patrol program. The Call Box program, a motorist aid system, is funded through a $1 vehicle registration fee. The FSP program, a roving patrol that assists disabled motorists and removes traffic impediments along Bay Area freeways, is primarily funded through the state highway account. By legislation, SAFE funding for the Call Box program may also be used on other motorist aid projects such as FSP, 511 and freeway traffic operations system equipment. Both of these programs require on-going partnership with Caltrans and CHP staff. Within the I-880 ICM corridor, MTC SAFE operates ninety (90) call boxes and twelve (12) tow trucks that provide coverage along five (5) service routes.

Call Box Program – California Senate Bill 1199, enacted on January 1, 1986 provided the basic foundation for the formation of Service Authorities for Freeways and Expressways, which at the time was the Call Box program. California Senate Bill 592 permitted MTC to serve as the SAFE for all nine Bay Area Counties. California Senate Bill 565 enacted on October 8, 1991, allowed for use of SAFE funds, which are in excess of the amount needed for the motorist aid system of call boxes, to be used for additional motorist aid services or support.

Freeway Service Patrol – California Assembly Bill 3346 enacted on September 28, 1992 established the original enabling legislation for the statewide California FSP program. Since its inception, the program has operated under a general Memorandum of Understanding (MOU) between Caltrans, CHP and MTC SAFE. The most recent MOU was amended on January 1, 2005. Even more recently, Partnership Operating Procedures (February 2006) were developed as a guideline for the FSP Partners on how to handle day-to-day responsibilities.

6) Freeway Concept of Operations

MTC, Caltrans and CHP completed the 20-month long Freeway Concept of Operations project in July 2002 under the direction of the Freeway Management Executive Committee. The purpose of the Concept of Operations is to identify inter-agency strategies to effectively manage recurring traffic congestion, incident response, and traveler information on freeways in the Bay Area.

The final report for this project was an Action Plan to guide and coordinate multi-agency efforts to improve Freeway Operations. The individual actions are grouped into three near-term, high-priority initiatives (Incident Response, Center-to-Center Communications, and Efficient Operations) and two longer-term initiatives (System Sustainability and System Integration). The Center-to Center and Incident Response Initiatives are described below.

7) Center-to-Center Program

The purpose of the Center-to-Center program is to implement and operate a Center-to-Center System for the exchange of real-time traffic data and video between the Bay Area's four existing SMART Corridors and the Regional Transportation Management Center, where Caltrans, California Highway Patrol and TravInfo® staff are co-located. Timely, accurate and reliable data on system performance enables efficient operation and management of those systems, which includes informing travelers about current conditions and travel options. The program includes 1) a Memorandum of Understanding between the participating agencies that defines the policies, procedures and restrictions for data sharing; 2) a fiber-optic Communications Backbone between the systems; and 3) the Interim Center-to-Center System, which is peer-to-peer software that is expected to remain in use for several years until replaced by either a statewide C2C System developed by Caltrans or a multimodal Bay Area system.

The original C2C Memorandum of Understanding was executed in January 2005. It was signed by MTC, Caltrans, and the13 local agencies that are members of three SMART Corridors (Silicon Valley-ITS, SF*go* in San Francisco, and the Tri-Valley SMART Corridor. The MOU is currently being amended to add the East Bay SMART Corridor, which includes the I-880 Corridor.

8) Incident Management Program

MTC, CHP and Caltrans completed the Incident Management Strategic Plan in January 2006. The plan identifies a series of high priority strategies that could enhance existing Bay Area incident management strategies. The identified strategies include:

- **Interagency Coordination Seminars**. Coordination and facilitation of seminars for CHP, Caltrans and local first responders to assess current incident management practices, discuss alternative practices to improve incident clearance and build consensus on enhancements. The

objective of the seminars is to promote and encourage interagency cooperation.

- **Motorist Information and Education**. Improve real-time procedures for disseminating critical incident information to the motoring public. In addition, this recommendation includes the implementation of strategies to educate the public on the "Quick Clearance" legislation.
- **Photogrammetry Demonstration Project**. Implementation of a pilot project to test the use of new equipment to reduce the time it takes CHP to collect investigative incident data at the scene of a collision, thereby improving incident clearance. This pilot will provide CHP with equipment and training to evaluate the effectiveness of the technology.
- **Heavy Duty Towing Incentive for Quick Clearance**. Development of a pilot that explores options to the current system of compensation for tow companies from an hourly rate to a flat rate. The proposed objective of this pilot project is to establish incentive payments for tow service providers that safely clear major incidents within an established threshold time.
- **Development of a Traffic Incident Management Database**. Develop a comprehensive database of major traffic incidents to capture data necessary for evaluating the effectiveness of existing and proposed incident management tools and strategies.

The I-880 corridor was selected as the demonstration site to deploy and evaluate the effectiveness of the recommended incident management strategies. Deployment of these strategies will begin this summer.

9) JUMP Start

At its first meeting, The Bay Area Partnership adopted a list of 16 interagency projects called the "Joint Urban Mobility Program: JUMP Start." The intent was to use The Bay Area Partnership as a forum for resolving barriers that were delaying the 16 projects, thus jump starting their implementation. Four of the 16 JUMP Start projects addressed freeway operations, including Early Implementation of Bay Area Traffic Operations System, Analysis of Freeway Operational Strategies, Develop Tow Truck Patrols on Congested Freeways (which resulted in the Freeway Service Patrols, which are discussed later in this section), and Add Counties to the Freeway Call Box Program (which resulted in Marin and Napa Counties joining MTC Service Authority for Freeways and Expressways).

10) I-880 Ramp Metering

The I-880 Cornerstone Project was the Bay Area's first implementation of ramp metering along an entire corridor. The local agencies expressed several concerns, including the potential for queues from metered on-ramps to extend onto local streets and the potential public concern over the inequity of residents living in the urban core being metered while residents in outlying suburbs received the benefit of a faster freeway trip. MTC, Caltrans, Alameda County CMA and the local cities worked together to develop the Policy on Cooperative Management of the I-880 Corridor. The policy addresses both procedures for resolving disagreements and operating parameters for the meters. Metering rates were set to accommodate existing peak hour volumes, with the intent of dispersing platoons and ensuring no spillover onto local streets, rather than maintaining free-flow speeds on the freeway mainline. The policy was approved by Alameda County CMA and Caltrans in 1995, and presented as an information item to The Bay Area Partnership.

Implementation of ramp metering on I-880 occurred in three phases. The first phase was initiated in October (southbound) and November (northbound) 1996, entailing six interchanges in the center of the corridor. The project was evaluated through a partnership of Caltrans, MTC, City of Hayward and County of Alameda. The second phase was implemented in April 1999 on the northern segment (Lewelling to I-980) and the third phase was implemented in October 1999 on the southern segment (Whipple to Dixon Landing).

11) I-880 Corridor Management MOU

The Alameda County Congestion Management Agency was the lead agency for the Memorandum of Understanding for the I-880 Corridor Management. The MOU was executed by 10 agencies during the summer of 2002. The agencies were Alameda County CMA, MTC, Caltrans, four cities, two transit agencies and the County of Alameda. The MOU formalizes the commitment of the agencies to cooperatively improve the management and operation of I-880 and the parallel arterials by implementing ITS projects. The MOU formally established the I-880 Steering Committee, which consists of elected representatives of the cities and county and staff representatives from AC Transit, Caltrans and MTC, and the I-880 Technical Working Group, which consists of staff from those agencies. The MOU will expire in May 2007, unless the term is modified by the participating agencies.

Both the Steering Committee and I-880 Technical Working Group had been meeting for several years, and had guided the development of the I-880 SMART Corridor. The local agencies in the Technical Working Group had been meeting since 1992, when they came together as the technical advisory committee for MTC's I-880 Corridor Operations Strategic Plan. The MOU states that the Steering Committee is responsible for formulating the policy and institutional issues pertaining to the corridor, approving transportation projects, and updating the members' governing boards on the status of the corridor. The Steering Committee is also charged with providing direction to the Technical Working Group. The Technical Working Group is responsible for providing advice to the Steering Committee.

In 2003, Alameda CMA was the lead agency for the development of an Ownership, Operations and Maintenance Agreement for both the I-880 SMART Corridor and the San Pablo SMART Corridor. The two SMART corridors were combined into the East Bay SMART Corridor. The Agreement reaffirms the commitment of the agencies to cooperatively operate and maintain street and highway improvements and ITS equipment to manage traffic congestion and improve the throughput of people. The agreement defines the roles and responsibilities of the participating agencies for funding operation and maintenance costs, and working together to operate the corridors efficiently. The agreement will continue indefinitely until terminated by the participating agencies, and any agency can withdraw by giving 60 days written notice.

The agreement entailed development of an Operations and Management Manual that established standard operating policies and procedures for day-to-day operations; coordinated signal timing; incident detection, management and response; maintenance schedules, transit and traveler information; and other topics as necessary. The Operations and Management Manual was released in April 2004.

3.6.3 Major Milestones in Institutional Integration

As a result of these inter-agency agreements, successful programs were created and significant number major milestones have been achieved during the past decade. Table 3.9 summarizes these milestones and their benefits.

TABLE 3.9 - SUMMARY

Date	Event	Benefit
1988	MTC SAFE created	Funding mechanism for call boxes and FSP
1992	The Bay Area Partnership established, adopts 16 project JUMP Start Program	JUMP Start includes project for early implementation of freeway Traffic Operations System, which included $13 million I-880 Cornerstone Project
1992	I-880 Corridor Operations Strategic Plan	Consensus to operate new lanes as HOV lanes, and implement ramp metering
1995	Policy on Cooperative Management of the I-880 Corridor	Established policy guidelines and operational parameters for initiation of ramp metering
Fall 1996	Initiation of ramp metering on first segment of I-880, using demand rate metering	Before-and-after evaluation didn't show statistically significant benefits, but consensus was that metering improved speeds
Oct 1998	TravInfo™ Field Operational Test completed	Based on success of FOT, TravInfo™ operations continued using regional funds
April 1999	Initiation of ramp metering on northern segment, using demand rate metering	Evaluation found no diversion to local streets; freeway volumes and speed increased except for southbound in PM
Oct 1999	Initiation of ramp metering on southern segment, using demand rate metering	Evaluation found no diversion to local arterials, 1% - 2% increase in freeway volumes and speeds
2000	Establish Freeway Management Executive Committee	Caltrans, MTC, and CHP executives start holding regular meetings to coordinate management of freeway operations
2002	I-880 Corridor Management MOU	Formally established 1) commitment to cooperative corridor management, 2) Steering Committee, and 3) Technical Working Group
July 2002	Final Report for Freeway Concept of Operations	Defined joint MTC/CHP/Caltrans action plans, including Center-to-Center and Incident Response initiatives
2003	Agreement on Ownership, Operations and Management of Alameda County CMA SMART Corridors	Combined I-880 SMART and San Pablo SMART Corridors into East Bay SMART Corridor, reaffirmed commitment to cooperative management and operation
April 2004	East Bay SMART Corridor Operations and Management Manual	Defines standard operating policies and procedures for day to day operations and incident management
2005	Bay Area Center-to-Center MOU executed	MOU commits parties to peer-to-peer software, shared communication system
2006	Alameda CMA signs C2C MOU	East Bay SMART Corridor begins process to join C2C Program

3.6.4 Opportunities for Improved Institutional Integration

The state, regional and local agencies with jurisdiction in the I-880 ICM Corridor have a long and successful history of working together to cooperatively operate and manage the corridor to manage congestion and improve the person throughput in the peak periods. Nevertheless, there are significant opportunities to further improve the operation and management of the corridor.

(a) The ICM Program provides an opportunity to add additional agencies and representatives from the private sector to this cooperative management effort. Specifically, the Port of Oakland, Oakland International Airport, and the goods movement industry that services those facilities are crucial to the economic vitality of the corridor, but do not currently have a direct voice in the decisions on how to operate and manage the corridor. 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. Representatives of these different private sector groups will probably have different opinions and perspectives on corridor operations, just like the various public agencies. The revision of existing interagency forums to add representatives from different parts of the private sector would result in a more thorough understanding of the impact of different operational strategies, and would create the opportunity to fine tune both system operations and travel behavior to the mutual benefit of all involved.

(b) Several major multi-year highway construction projects will begin on the I-880 corridor within the next year. These projects include the complete reconstruction of the 880/92 interchange ($111,000,000), the seismic retrofit of the Fifth Avenue overhead ($108,000,000), and the seismic retrofit of the High Street interchange ($85,000,000). This work will be scattered throughout the corridor and complex construction staging will require occasional closures of the freeway, detouring traffic onto local streets. Completion of these projects is not expected until 2012, well within the timeframe of Stage Three of the ICM demonstration. The ability to test integrated corridor management 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. In addition, Caltrans has faced challenges in accomplishing even basic maintenance of the freeway due to limited options for closing lanes and detouring traffic. Enhanced integration of the freeway and local systems would undoubtedly improve this situation.

(c) Although there have been successful multi-agency efforts along the I-880 corridor, no institutional agreements exist that govern the integrated operation of the various corridor facilities or systems and services on a real time or dynamic basis. MTC, Caltrans and ACCMA envisions that 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, 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.

(d) Emergency preparedness is an activity that has received substantial emphasis in the Bay Area. Recently, while the Bay Area was commemorating the 100-year anniversary of the 1906 earthquake in San Francisco, transportation professionals have been reminded of the likelihood of a major earthquake in the near future and the needs for emergency response strategies. 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. The ICM demonstration would be able to take advantage of the numerous preparedness activities and exercises to test a variety of corridor management strategies, all of which will require coordination between multiple agencies and networks.

3.7 Overview of Regional ITS Architecture

3.7.1 Summary of Bay Area ITS Architecture

MTC completed the *Regional ITS Architecture and Strategic Plan* in October 2004, and the Commission subsequently adopted it through the *Transportation 2030 Plan*. The Regional ITS Architecture is an integrated part of the San Francisco Bay Area Regional Intelligent Transportation Systems (ITS) Plan, a roadmap for transportation systems integration in the Bay Area over the next 10 years. The architecture is be an important tool used by:

- MTC to better reflect integration opportunities and operational needs into the transportation planning process.
- Operating agencies to recognize and plan for transportation integration opportunities in the region.

- Other organizations and individuals that use the transportation system in the San Francisco Bay Area.

This regional ITS architecture has a time horizon with a particular focus on those systems and interfaces that are likely to be implemented in the next ten years. The architecture covers the broad spectrum of Intelligent Transportation Systems, including Traffic Management, Transit Management, Traveler Information, Emergency Management, and Emergency/Incident Management over this time horizon. The Bay Area Regional ITS Architecture is a living document with changes made based on recommendations of the Regional ITS Architecture Maintenance Committee members. The current update is planned for completion in November 2007.

3.7.2 Intra-network or center-to-field standards deployed

3.7.2.1 FREEWAY

Caltrans District 4 employs a variety of intra-network, center-to-field, and field-to-center protocols and standards as part of its ITS infrastructure. Some of the current interfaces were deployed in the early stages of the ITS development 15+ years ago, such as the Highway Advisory Radio (HAR) and Extinguishable Message Sign (EMS) interfaces while others are currently going through a transition as part of an upgrade project, such as our CCTV interfaces.

Special bandwidth considerations had to be taken into account in the ITS deployment as Caltrans District 4 primarily use leased communication circuits and we do not have a high bandwidth infrastructure. As an example, most of our CCTVs use 128K ISDN circuits for our video and control, but, Caltrans is looking to implement a higher bandwidth solution, such as DSL while upgrading the CCTV system to a more scalable and more easily accessible IP video streaming solution. Similarly, Caltrans has deployed IP addressable wireless GPRS modems to communicate with the Traffic Monitoring Stations and Ramp Meters as part of an earlier upgrade to a more scaleable communications infrastructure.

The District 4 ramp meters and traffic monitoring stations' center-to-field and field-to-center communications are handled via a wireless UDP GPRS network connection and a proprietary Caltrans controller program that utilizes an asynchronous SDLC protocol. We share real-time traffic data with other partner agencies via XML interfaces. The Changeable (Variable) Message Signs communicate via wireless GPRS and POTS using a proprietary SignView 170 controller program. The HAR and EMS elements are controlled using POTS lines and a touch tone DTMF code protocol.

ITS elements along I-880 corridor are listed in the table below. Caltrans District 4 utilizes a variety of proprietary and industry standard protocol interfaces for our ITS infrastructure. The existing CCTV standards consist of NTSC and MJPEG for video and a Cohu/Caltrans proprietary protocol for PTZ. The Bay Area Video Upgrade (BAVU) project, a partnership between Caltrans, the Metropolitan Transportation Commission, and CHP, includes the development of a CCTV prototype IP video streaming solution that utilizes newer technologies based on industry standards such as MPEG4 for video and NTCIP standards for PTZ.

TABLE 3.10
Intra-network and center-to-field standards along I-880

ITS Element	Type of Intra-Communication Network	Protocol	No. of Field Devic es
CCTV	ISDN, DSL, FIBER-SONET	Video: MPEG4, MJPEG, H.261, PTZ: Serial RS232, Cohu/Caltrans D4 proprietary protocol	25
Ramp Meters	Wireless - GPRS, UDP	TOS 2.1.1 (Proprietary Caltrans controller program), asynchronous SDLC Protocol	86
Traffic Monitoring Stations	Wireless - GPRS, UDP	TOS 2.1.1 (Proprietary Caltrans controller program), asynchronous SDLC Protocol	83
Changeable (Variable) Message Signs	GPRS / POTS	SignView 170 3.1 (Controller Program)	5
HAR	POTS	DTMF Code Protocol.	5
EMS	POTS	DTMF Code Protocol.	10

3.7.2.2 ARTERIAL

The East Bay SMART Corridors utilize the TCP/IP protocols for data exchange within the network. Video images are compressed into

MPEG-4 format, and transmitted at 74 kbps to the CMA server, where it is disseminated to the public agencies and public via Microsoft Media Player format. The physical layer connection between the agencies is accomplished through leased high speed T1 lines.

Communication with legacy signal systems: The existing system will communicate with 8 different legacy signal systems that are based on 5 different platforms (QuicNet, Aries, Icons, Streetwise, CT-NET). The communications approach in each of these systems is different. In order to avoid funding major upgrades of these legacy systems, legacy system vendors helped determine the format and definition of data already available at the central computers for each of these systems. Simple database queries are being used to receive the necessary information. If required to utilize emerging ITS Standards for these links, major upgrades of the legacy systems will be necessary.

The connection between the local CMS System and the central computer of a legacy system is based on Ethernet, an established Information Technology (IT) standard. This IT Standard is also recognized and available as User Comment Draft within the ITS industry (expected to be balloted and adopted by October 2002). This decision demonstrates efforts to require and implement emerging ITS Standards wherever possible and applicable.

Communication with DMS and Trailblazer Signs: Typically, two methods of communicating with DMS are used: dial-up or direct connect via multi-drop. Currently, only dial-up is being considered at this time. However, there are several viable approaches to develop dial-up implementations, the major ones being 'routable dial-up' or 'non-routable dial-up'. For specification purposes, the following communications protocols are applicable:

(Routable Dial-up communications)

Data dictionaries:	1201 – Global Object Definitions
	1202 – DMS Object Definitions
Communications:	2103 – PPP 232

Standards	2202 – Ethernet 2301 – STMF (SNMP only) (Non-Routable Dial-up communications)
Data dictionaries:	1201 – Global Object Definitions 1202 – DMS Object Definitions
Communications:	2103 – PPP 232
Standards	2201 – T2 (or Null) 2301 – STMF (SNMP only)

3.7.2.3 AC TRANSIT

The Orbital TMS system uses proprietary communication protocols.

3.7.2.4 BART

BART automated train control system uses proprietary communication protocols.

3.7.3 Center-to-Center ITS Standards Deployed

ITS Standards are the foundation of ITS communication, and, as such, are one component of the Bay Area Regional ITS Architecture. They promote coordination between agencies and between project deployments by standardizing information exchange. This standardization can lead to longer technological lifespans by allowing new technology to evolve without making existing devices obsolete. ITS Standards are constantly evolving with the oversight of Standards Development Organizations (SDO) including American National Standards Institute (ANSI) and Institute of Electrical and Electronics Engineers (IEEE), among others. These organizations provide information about the development stages of the standards, including whether the standard has been approved or tested.

The Bay Area Regional ITS Architecture provides information on recommended standards for Center-to-Center communication. The primary recommended standard protocol for the Bay Area is National Transportation Communications for ITS Protocol (NTCIP).The two main NTCIP standards for center-to-center communication in the Bay Area are DATEX and CORBA, with XML as an emerging standard. The newly developed center- to-center communication systems in the San Francisco Bay Area follow the Regional ITS Architecture and other standards available for ITS applications.

3.7.3.1 FREEWAYS

MTC is leading the program to implement a Center-to-Center System between the Regional TMC and the existing SMART Corridors. The Initial Build of the Center-to-Center (C2C) System will implement real-time, peer-to-peer exchange of traffic-related data between the Regional TMC (Caltrans TOS/TMC and TravInfo® TIC), Silicon Valley – Intelligent Transportation System (SV-ITS), and city of San Francisco ITS system (SF*go*). The Initial build will implement the exchange of sensor data and incident data, and enable the integration and display of the exchanged data at each of the participating centers. The exchange of real time video between the centers is being addressed by the Bay Area Video Upgrade (BAVU) project, which is a joint project of MTC and Caltrans. BAVU will address both the exchange of video between TMCs through a virtual private network, and the sharing of video image with the public via the internet.

The Initial Build will be based on the NTCIP C2C DATEX protocol, and will be a hybrid of the existing DATEX system in use at the Regional TMC and Silicon Valley ITS. The SF*go* TMC will be based on MIST, and will develop a protocol conversion service to translate between the XML/JMS and the NTCIP C2C DATEX protocols. When the East Bay SMART Corridor is integrated into the Bay Area's C2C System, it will also use a XML protocol and a very similar protocol conversion service.

The decision to develop a hybrid DATEX-based, data exchange C2C System for the Bay Area was based on the desire of the participating agencies to have all partner systems communicate over the C2C network without requiring converter applications. As part of previous projects, IBI built a DATEX-based system for the SV-ITS, and PB Farradyne built a DATEX-based system for TravInfo. The hybrid system is intended to resolve all incompatibilities between the DEN and TravInfo® systems, as well as creating a data exchange interface that could be used by future participants in the Bay Area's Interim C2C System.

The C2C Interface Control Document is designed to define the interface that systems will use to communicate with the Interim Bay Area Center to Center System. It is based on the NTCIP C2C DATEX protocol and the TMDD. The documents referenced here are:

- ISO/WD 14827-1 Transport Information and Control Systems - Data Interfaces Between Centres for Transport Information and Control Systems - Part 1: Message Definition Requirements Version 17, dated November 1, 1999.
- ISO/WD 14827-1 Transport Information and Control Systems - Data Interfaces Between Centres for Transport Information and Control Systems - Part 2: Message Part 2: DATEX-ASN Version 20, dated February 8, 2000.
- NTCIP 1102 v01.11 National Transportation Communications for ITS Protocol (NTCIP) Octet Encoding Rules (OER) Base Protocol, dated August 3, 2000.
- National Transportation Communications for ITS Protocol Application Profile for DATEX-ASN (AP-DATEX), dated June 20, 2001.
- STANDARDS FOR TRAFFIC MANAGEMENT CENTER TO CENTER COMMUNICATIONS Volume I Concept of Operations and Requirements - dated December 15, 2003.
- STANDARDS FOR TRAFFIC MANAGEMENT CENTER TO CENTER COMMUNICATIONS Volume II Message Tables and Sequence Diagrams- dated December 15, 2003.
- STANDARDS FOR TRAFFIC MANAGEMENT CENTER TO CENTER COMMUNICATIONS Volume II Companion Annexes – Version 1.5 - dated December 15, 2003.

The C2C System will utilize a fiber optic communication backbone owned by the agencies participating in the C2C Program. The backbone includes fiber strands in the BART right-of-way that are controlled by Caltrans, and connections from the individual SMART Corridor TMCs to the fibers in BART. Silicon Valley-ITS has completed construction of its fiber link, and is in the process of procuring routers and firewalls that meet Caltrans standards. Caltrans revised its standards when it upgraded the bandwidth of its backbone from OC-48 to OC-192. SF*go* experienced a fiber break when it was connecting to the BART fibers, but anticipated completing the fiber system and installing the router, firewall and XML C2C software in the next few months.

3.7.3.2 ARTERIAL NETWORK

Currently the data portion of the East Bay SMART Corridor program is exchanged through standard TCP/IP protocols. The data is

formatted using the NTCIP Traffic Management Data Dictionary (TMDD) standard. The data is also DATEX ready for exchange to other centers, if needed. Video images are compressed into MPEG-4 format, and transmitted at 74 kbps to the CMA network, where it is disseminated to the public agencies and the public via Microsoft Media Player format. The physical layer connection between the agencies is accomplished through leased high speed T1 lines.

The interconnection with other regional systems such as TravInfo®, and in future other regional ITS projects, is a vital part of the overall project. The Center-to-Center ITS Standard, DATEX-ASN.1, is utilized for ease of integration, ease of interoperability, and ease of expandability.

DATEX-ASN has been designed to be used with another IT/ITS Standard, TCP/UDP/IP, which in turn can be used with a multitude of media-specific data link layer protocols such as Ethernet, RS232, fiber optic protocols, etc. Since we do not want to restrict the use of any communications media, we have limited our specifications to DATEX-ASN.1 (NTCIP 2304/NTCIP 2501) and TCP/UDP/IP (NTCIP 2202).

3.7.3.3 AC TRANSIT

The data communications protocols for the District's CAD/AVL system affected data communications between the in-vehicle systems, the central control center's maintenance facilities, radio microwave equipment and the server and various workstations. These various facilities and functions use industry (SAE) standards for data communications. Those standards are: 1) J1708, 2) RS232 (bus headsigns only), and 3) TCI/IP. In addition, data communications between the AVL equipped vehicle and the central control center is performed by an Orbital system proprietary protocol call intelligent group pooling protocol (IGPP). This IGPP is implemented on the bus and is the back bone of the communications operations between the vehicle and the main system database.

3.7.3.4 BART

BART system was built in the 60s and the communication system was developed based on railway standards at the time. BART is aware of the ITS standards and have an Integrated Computer

System Re-architecture (ICSR) plan that defines a future architecture that will be able to accommodate the ITS standard.

3.9 Individual Network and Corridor Problems, Issues and Needs

3.8.1 Freeway System

In the Bay Area, Alameda County has the greatest amount of freeway congestion, with 50,000 vehicle-hours of daily delay. I-880 alone has average daily delays of more than 10,000 vehicle-hours. The corridor has multiple bottleneck locations and a high incident/accident rate.

In order to address the increasing congestion problem, Caltrans is currently conducting a corridor management study for the I-880 corridor. The study builds on Caltrans District 4's corridor analysis efforts to blend long-range planning with near-term operational strategies on 24 corridors in the San Francisco Bay Area. This prior work included a review of possible improvements on the I-880 corridor to prioritize future projects and to incorporate traffic operation strategies into the corridor. The current corridor management study for the I-880 corridor is funded by Caltrans and is being conducted by the California Center for Innovative Transportation (CCIT) of the University of California at Berkeley and a team of consultants. As an important part of this study, micro-simulation models using Paramics for the I-880 corridor have been developed, building on the Alameda County travel demand model. The study is to be completed in the summer of 2006. Extensive research was done with available detection, ramp metering, accident, incident data, and field observations to identify problem areas in the corridor. Intermediate results of the performance evaluation task under this study have already revealed some important findings on recurrent congestion and its potential causes.

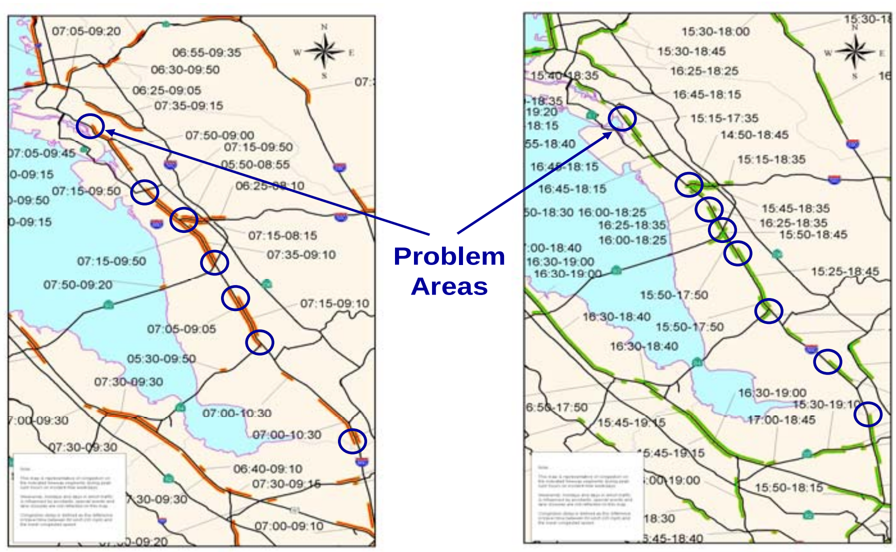
Figure 3.10 shows the problem areas along the I-880 freeway (circled in blue), further described in Table 2 which shows potential causes. Recurrent congestion is the result of demand exceeding capacity at several bottlenecks, related to interchange in-flow traffic from other highways (e.g., 238) and on-ramps (e.g., Tennyson). There are locations at the northern end of the corridor with older interchanges not updated to current standards, and closely spaced ramps with weaving problems. This corridor includes freeway-to-freeway junctions at three locations that lead to transbay toll crossings at the Bay Bridge, San Mateo-Hayward Bridge, and Dumbarton

Bridge. Operational strategies for the I-880 corridor need to be coordinated with operational strategies for the Bay Area toll bridges, and demand management needs to be integrated with traffic management strategies at the arterials and also with intermodal opportunities. Furthermore, trucks comprise between 4% and 11% of the average annual daily traffic in the corridor. Truck traffic is highest at the junctions in Oakland near the Port of Oakland (26,000 trucks and 11% of total traffic), and trucks comprise about 8 to 9% of total traffic at the junctions of Hegenberger Road (to Oakland Airport), SR-112 in San Leandro and I-238 in Hayward.

Non-recurrent congestion is also a major problem on this corridor. I-880 averages over 10 collisions per day and over 100 incidents per day. The most severe incidents often involve heavy trucks, and consequently the incident response and recovery takes longer than average incident response and recovery time across the state. It is estimated that collisions account for 30 percent of overall corridor delay.

FIGURE 3.16
I-880 bottleneck locations identified through simulation model

(Source: Paramics, System Metrics Group)



3.8.2 Arterial System

A parallel study on SMART Corridor conducted by ACCMA has focused on the arterial highways. The study results show that the arterials along the project corridor currently operate at level of service C to E 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 levels of service along these arterials. Therefore, coordination of the operation of the network of arterials, ramp metering and the freeway is crucial to optimizing the overall capacity of the system.

3.8.3 AC Transit

AC Transit system operates on several arterial roadway systems along 880 ICM Corridor with the other traffic. The increasing congestion in the region is the major challenge for AC Transit to operate their buses on time. Improving running time is a high priority for AC Transit to meet their goal of an effective and efficient transit system. As indicated in Section 3.4.3.3, AC Transit collects bus operation data, including vehicle movements, running time, schedule adherence reports for its entire fleet every 2 minutes using AVL associated with the Orbital system. Bus predictions on a number of routes are also provided by NextBus systems. Additionally, Automatic Passenger Counters are used to collect ridership and schedule adherence data.

To improve day to day operations, AC Transit is actively engaged in finding efficient ways to use their resources using the cutting edge of transportation technology.

AC Transit has introduced Rapid Bus service along San Pablo Corridor in collaboration with ACCMA. The 72R Rapid Bus line, a first in Alameda and Contra Costa Counties, was launched in the summer of 2003 has been a tremendous success, both in terms of ridership and travel time to destination. NextBus signs are installed at nearly every stop along the line providing bus arrival information. The Transit Signal Priority (TSP) at the intersections helps reduce the intersection delays for AC Transit buses. As a part of East Bay SMART Corridors program, emergency vehicle preemption and transit signal priority equipment is being installed along the East 14th Street/International Boulevard Corridor. Operational strategies of the AC

Transit could be coordinated with traffic signal operations on other arterials to have integrated traffic management strategies.

The AC Transit's system is based on pre-determined routes and schedules and the system is not flexible to accommodate dynamic schedules and route decisions based on real-time traffic information. Another operational constraint that AC Transit has to face during incidents is that, the service cannot bypass any bus stops unless it is absolutely necessary due to intending riders that may be waiting for the bus. When it is necessary to bypass any bus stops, other means needs to be adopted to convey the message to the riders. AC Transit utilizes information from ACCMA East Bay SMART Corridors website to obtain real-time traffic information on the arterials to make decisions about the re-routing of buses during an incident. AC Transit has the control over the SMART Corridors' CCTV cameras when needed to have more coverage of the traffic conditions. This information is very useful for the AC Transit supervisors to make decisions about the transit operations during an incident. To improve their route making decisions, real-time traffic information on freeways and control over Caltrans Dist 4 cameras on as needed basis will be useful for AC Transit.

The current Orbital software version that AC Transit is using is many versions behind the current version offered by Orbital TMS. Upgrading the current software and the hardware it uses will be essential for AC Transit to improve the efficiency of fleet operation, and prepare for the integration of other operational systems in the future including real time systems.

3.8.4 BART

BART plays a major role in the mobility along the 880 corridor accommodating huge ridership levels as indicated in Section 3.3.2.4. Any kind of disruption in BART service has a huge impact on the corridor not just the commuters. BART operates on a grade-separated system unlike AC Transit and the traffic congestion does not have direct impact on normal operations. However, real-time traffic information in the corridor will help BART to anticipate the needs during an incident and to plan immediate actions. There is no direct information exchange between MTC's 511 and BART in the current operational scenario. For automated and complex operations like BART system, more information is always helpful to make instantaneous decisions.

Along the 880 corridor, the headway between the BART lines is 5 to 6 minutes. Any simple incident will cause huge backup and takes time to

restore back to normal conditions. With the ICM concept, the coordination between different agencies involved and emergency response teams could to be improved to cut down response time.

Most of parking lots at the BART stations along the 880 corridor are full during the weekdays. In the case of emergency where there is a need for a modal shift, BART does not have means to accommodate vehicles at the BART parking lots. In such cases, agreements with agencies who own parking lots in the vicinity of BART station could be considered to accommodate the excess flow.

3.9 Corridor Management Strategies Already Implemented for the I-880 Corridor

The Bay Area Transportation Agencies have already adopted a number of corridor management strategies, namely pre-ICM operation strategies, to improve network efficiency and to mitigate incidents. The highway meltdown incident that recently occurred in the Bay Area tested these strategies at work.

In the early morning hours of April 29, 2007, a tanker fire destroyed two vital freeway connectors in the I-80/580/880 interchange at the north end of the I-880 ICM corridor in Oakland, California. This unfortunate emergency provided the opportunity for the Oakland Pioneer Site Team to apply a variety of strategies:

- 511 Traveler Information System provided pre-trip information to the public for alternate routes and multi-modal transit options. Immediately following the incident, 511 call & web volumes surged and highway traffic volumes decreased.
- In-route dynamic messages signs were activated and 511 phone system "floodgate" announcements were created to promote route shifts between roadways.
- Automated data collection systems provided instantaneous traffic performance information to system operators and to the media.

- Arterial signal timing was manually adjusted to accommodate diverted highway traffic --a function that could be enhanced in the future through remote signal operations.

- Transit agencies modified operations. AC Transit adjusted routes and increased its operational fleet size. BART lengthened trains and deployed parking alternatives for select stations to accommodate increased transit ridership.

Although most of these strategies required manual communication and interventions and are in many ways not yet comprehensive, they have demonstrated potential benefits of ICM strategies. Coordinated network efforts resulted in the successful multi-modal and multi-agency response to the loss of a critical segment of the Bay Area's regional transportation system.

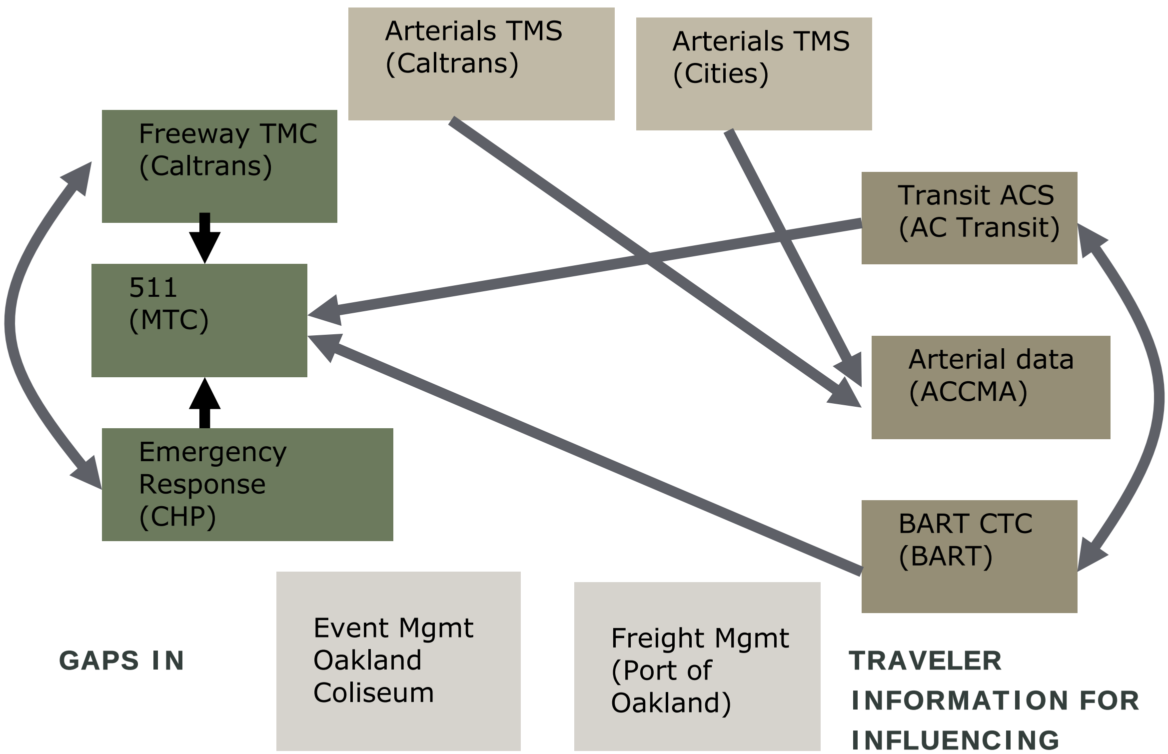
3.10 Gaps

The transportation system operating agencies for the I-880 corridor have realized that gaps exist with respect to the full potential of the existing ITS systems due to the lack of integration of the systems and yet-to-be improved operational coordination among agencies. Higher degrees of integration are needed in order to take full advantage of ITS systems for individual networks and hence to fully utilize the capacity of the transportation infrastructure along the I-880 corridor as a whole. The I-880 ICM stakeholders have identified the following ‘gaps’:

3.10.1 Insufficient information sharing among different transportation systems:

(G1) Gaps in information sharing: Although transportation management systems (TMS) have been widely deployed in the 880 corridor for many years and transportation facilities in the corridor are highly instrumented with real-time data collection systems, because these systems are all independently built and maintained, the information sharing among systems and the capabilities for system coordination and management systems are rather limited. Information exchange is mostly facilitated through voice and manual means. The insufficient information sharing has affected the efficiency of coordination among agencies and the ability to provide integrated multimodal traveler information for travel decision support. Figure 3.17 shows the information sharing among existing operations along the I-880 corridor.

FIGURE 3.17 INFORMATION SHARING AMONG THE EXISTING OPERATIONS ALONG THE I-880 CORRIDOR



GAPS IN TRAVELER INFORMATION FOR INFLUENCING TRAVELERS' DECISIONS AND CHOICES:

(G2) Gap in traveler information: The Bay Area 511 system and individual transportation agencies are currently providing real-time traffic information and transit route and schedule information. Although an advanced trip planner is already available through the Bay Area's 511 system, it cannot directly support choices between modes and networks. Currently, freeway traffic data are being fed into the 511 system, but arterial traffic data are archived at the Alameda CMA. Although AC Transit and BART both have real-time operation information, 511 currently only supports transit trip planning based on schedules.

3.10.2 GAPS IN COLLABORATION AMONG AGENCIES FOR COORDINATED OPERATIONS

(G3) Gap in coordination between freeways and arterial highways: The I-880 freeway and adjacent arterials are operated separately. Specifically, the freeway TMC and arterial traffic control center are two independent control systems. Subsequently, arterial traffic timing is independent from I-880 freeway conditions and ramp metering.

(G4) Gap in coordination between highway and transit operations: AC Transit operation relies on real-time traffic data, but the operations staff must monitor three different systems (AC Transit CAD AVL, 511 and ACCMA website) in order to make operational decisions.

(G5) Gap in coordination between transit systems: There is limited coordination between AC Transit and BART, which has been primarily based on phone calls when incidents or service disruptions occur. There is no operation coordination between AC Transit and the Oakland ferry.

(G6) Gap in coordination between highway and freight operations: There is no coordination between highway operations and the Port of Oakland; therefore truck departures from the Central Valley and Oakland Port are not based on traffic conditions along I-880.

(G7) Gap in coordination for incident response: Currently, incident data is not available to all systems. Responses are not coordinated between different agencies.

3.10.3 GAPS IN COLLABORATION AMONG AGENCIES FOR EVENT PLANNING

(G8) Gaps in coordination for infrastructure construction and maintenance: 511 currently does not have information regarding scheduled maintenance and construction activities for individual networks along the I-880 corridor. Caltrans posts the scheduled maintenance and construction information on the Caltrans website. Each city or transit agency has its own method of reporting this info. Because the information on the web is posted as a planned event, which may be postponed or changed based on real-time conditions, the information may not be 100% accurate.

(G9) Gap in coordination of construction work during emergencies: Currently, the operational agencies along I-880 have limited protocols for emergency

management. However, there is no comprehensive guideline for construction work during emergencies.

These gaps have resulted in inefficiencies in collaboration among transportation agencies and have justified the need for an Integrated Corridor Management System.

3.11 The Needs for ICM

The I-880 corridor stakeholders have identified a set of corridor-level needs specific to the I-880 corridor that would be served by a fully-functioning ICMS.

I. Need for robust information sharing among different transportation systems	**(N1)** Need for cross-systems information Sharing: Information and data sharing among transportation systems is essential for achieving close coordination and integration among agencies, thereby to achieve balanced transportation service and reduced congestion levels for the I-880 corridor. Developing a consistent and reliable means of sharing information will ensure that the corridor can truly be managed in an interactive and dynamic way. By interactive and dynamic, any transportation agency along the corridor can monitor the condition of all networks along the corridor in real time and can interact with the others to achieve coordinated management of the transportation systems as a whole. This need addresses the gap G1.
II. Need for more comprehensive traveler information to influence travelers' decisions and choices	**(N2)** Need for or a corridor/regional based multimodal traveler information system: To encourage mode shift and route shift, a corridor/regional based multimodal traveler information system that supports pre-trip planning and in-trip route shifts is needed. Travelers on the corridor would benefit greatly from having accurate real-time information on whether other routes or modes along this corridor would be better choices for them. The information will facilitate smart travel decisions and encourage the use of transit systems. This need addresses the gap G2.

III. Need for enhanced operational collaboration among agencies

Operational decisions for the corridor are largely done by each mode and network independently. Although there is some coordination, these processes are largely manual and not well integrated. As a result, overall corridor efficiency would be significantly enhanced by instituting true collaboration among all modes and networks.

(N3) Needs for coordination between freeway and arterial operations: Coordination between freeway and arterial highways is needed in order to guide vehicles from one system to the other when either unbalanced demands or major incidents occur on one system, causing significant delay. The coordination between the two systems can help to effectively use existing transportation infrastructure and to mitigate congestion. This need addresses the gap G3.

(N4) Need for coordination between highway and transit operations: Coordination between transit vehicles and arterial traffic control is needed to allow the buses to have minimum intersection delay. Dispatchers at the AC Transit Operation Control Center can also be benefited by traffic condition data from highways and freeways within the operation area in order to provide best guidance to drivers to avoid large incidents and to achieve on-time performance. This need addresses the gap G4.

(N5) Need for coordination between transit systems: Close coordination between AC Transit, BART and the Oakland Ferry is needed to provide better connection protection for major events and for incident mitigation. Real-time information sharing by ICM will facilitate better collaboration when incidents or service disruptions occur. This need addresses the gap G5.

(N6) <u>Need for coordination between highway and freight operations</u>: Coordination between highway operations and the Port of Oakland can help truck drivers make decisions about their departure time and route between Central Valley truck 'hubs' and the Oakland Port depending on traffic conditions along I-880 and the status of the port operation. Therefore, there is a need for ICM to collect the traffic information and port operation status. This information can then be provided to truck drivers and the Port of Oakland. This coordination will not only help truck drivers to arrive at the port on time, but also reduce unnecessary trips during peak hours when their scheduled loadings have been delayed, which consequently will help to reduce congestion. This need addresses the gap G6.

(N7) <u>Need for Coordination between highway control systems and emergency response</u>: Signal pre-emption infrastructure has been available for major intersections along arterial highways parallel to the I-880 corridor. There is a need for emergency vehicles, including not only fire fighting vehicles but also police and paramedics vehicles to have signal preemption capability for the intersections that are preemption capable. Additionally, it is desirable that 'Best route' information be available for emergency service agencies in order to reduce emergency response time. This need addresses the gap G7.

(N8) <u>Need for coordination for incident response</u>: Major incidents can involve hours-long road closures, hazardous materials spills, extreme weather conditions, and multi-vehicle pile-ups. There is a need for coordination among agencies for incident response in order to timely resolve the incidents and re-open the road. The coordination involves better real-time data for incident detection and information exchange among agencies for collaborative responses. This need addresses the gap G8.

IV. Need for enhanced Event Planning and collaboration among agencies	**(N9)** Need for coordination for infrastructure construction and maintenance: Because of the large venues along the corridor, a coordinated special event response strategy would greatly enhance travel reliability. There is a need for coordination of event planning among agencies for effectively managing traffic around infrastructure construction and maintenance areas and for publishing accurate information ahead of time to the public regarding the scheduled construction and maintenance in order to facilitate route and mode shifts. This need addresses gap G9.
	(N10) Need for coordination of construction work during emergencies: The San Francisco Bay Area is particularly exposed to earthquake and fire hazards. There is a great need to develop and implement comprehensive cross-agency guidelines and protocols for transportation agencies to effectively coordinate the post emergency repair and construction. The guidelines and protocols will help to identify the information needs for ICM and coordination of actions to be taken by each transportation agency during and after the emergency event. This need addresses gap G10.

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4. ICM System Concept Of Operations

This chapter begins with a description of the approach taken in developing the Concept of Operations for the I-880 ICM project, then works through the approach step by step. The Vision, Goals and Objectives are defined, and the basic concept behind the project is described. The operational strategies are described, then discussed in the context of the five basic application scenarios and how they can help improve transportation in the corridor.

4.1 I-880 ICM ConOps Development Approach

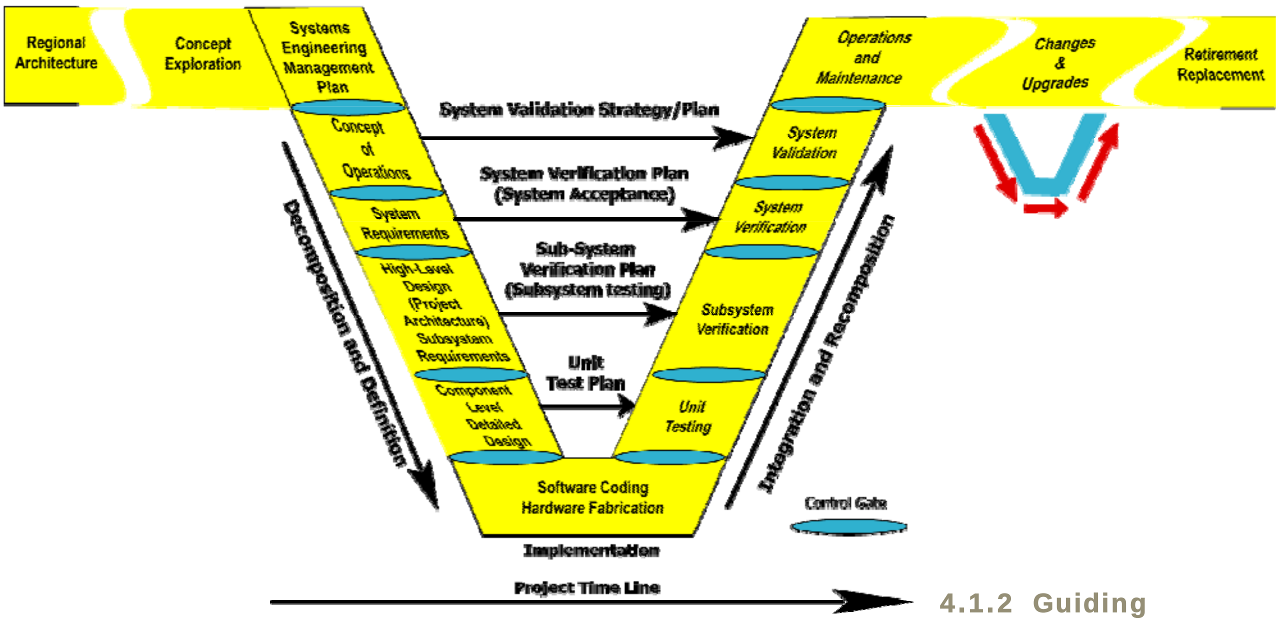
4.1.1 System Engineering Approach

The development of the integrated corridor management (ICM) system has to be founded on a sound system engineering approach because of the inherent complexity of ICM and the need to connect diverse legacy systems in order for it to work, in addition to the applicable federal regulations. Corridor integration cannot be approached haphazardly, but requires careful consideration of both technical and institutional issues, because both of these will determine the needs that must be satisfied and the impediments to satisfying them.

The San Francisco Bay Area is already well served by ITS deployments on the various networks of its transportation system, which have been making important contributions to the performance of the system under normal operating conditions and for managing incidents. The region has even benefited from a first level of integration through its regional 5-1-1 system, which provides real-time information about highway and transit network operating conditions (speeds, travel times and incidents) and its TransLink integrated transit fare payment system. Mention east bay smart corridor? Given this relatively advanced current state of affairs, it is important to consider carefully the most important advances still to be gained through work on the ICM program.

A carefully structured process, based on a systems engineering approach, has been followed to determine how best to proceed in defining the Concept of Operations for the I-880 ICM. This represents the initial stages of the systems engineering model recommended by USDOT for ITS projects, which is shown schematically in the “V diagram” of Figure 4.1.

FIGURE 4.1
USDOT's "V diagram" Schematic of System Engineering Process for ICM Projects



4.1.2 Guiding Principles and Development Process

The I-880 ICM team first defined two guiding principles for the development of the Concept of Operations:

(1) Base it on stakeholders' needs and constraints:

The starting point for definition of the ICM has to be with the stakeholder organizations that can most directly affect and are most directly affected by the transportation operations in the corridor. They need to see the benefits of participating and working together in order for the ICM to succeed, and indeed all have participated in the ConOps development process. A series of workshops has been convened among the senior staff of these agencies at the start of the ICM project to gather their inputs and to give them an opportunity to exchange ideas about their respective needs and constraints. Their inputs were solicited with regard to the most pressing operational needs in the corridor in categories such as: reduction of recurrent congestion, reduction of non-recurrent congestion, incident management, special event management, relieving specific bottlenecks, encouraging mode shifts, and responding to catastrophic events involving natural or man-made disasters. They have been asked to identify the impediments that need to be overcome in order to advance the cause of corridor integration in categories such as: conflicting interests of adjoining jurisdictions; legal, political or administrative constraints against taking needed actions;

technical incompatibilities among systems; and capital and/or operating funding limitations.

(2) Focus on integration needs as opposed to new infrastructure:

Since the emphasis of this program is on integration rather than on implementation of new field devices, the technology options are expected to be relatively limited, so the primary focus of the ConOps development is to understand the current capabilities and to see what new capabilities or functions can be developed within the program scope and to achieve desired benefits by the stakeholders.

Starting from these two guiding principles and following the system engineering approach, the 880 ICM Team followed the following five-step ConOps development process:

Step One

Develop vision, goals and objectives: During the development process, the stakeholders reflected long-term vision, goals and objectives for the I-880 corridor in the context of the Bay Area transportation system, but then recognized the need to carefully choose those that can be accomplished within the lifetime and scope of the I-880 ICM program.

Step Two

Identify operational scenarios: The ICM team studied the full range of operational scenarios for the corridor, identified issues and problems for the existing transportation networks and considered opportunities for ICM to produce benefits.

Step Three

Define candidate ICM strategies: The ICM team identified gaps and needs for the existing systems and operations (documented in 3.9). Using the set of candidate strategies developed by FHWA in the Generic ICM ConOps document as the starting point, through a series of stakeholder workshops and meetings, additional strategies desired by the stakeholders were included and a set of candidate ICM strategies to meet the I-880 corridor’s specific needs were developed.

Step Four

Analyze how the candidate strategies are applicable and beneficial to the I-880 corridor: Based on a set of criteria, the stakeholders participated in a series of exercises to evaluate the technical, operational and institutional feasibility of the candidate strategies developed under Step Three and selected a final set of candidate ICM strategies.

Step Five

Study the implementation issues (reported in Chapter 5): In order to understand the implementation issues, the 880 ICM Team conducted detailed functional analysis to define the actions needed to implement the candidate strategies. Functional analysis is an important element of the system engineering approach. Through functional analysis, both existing and new functions required for implementing ICM are identified and mapped into asset requirements. The functional analysis was complimented by stakeholders' inputs on technical and institutional feasibilities of proposed ICM strategies.

4.1.3 Approach for Selecting ICM Strategies

The major component of ICM ConOps is ICM Strategies. The development of I-880 ICM strategies included a series of exercises with the stakeholders to determine, based on current conditions, what strategies can provide improvements that are urgently needed and whether the strategies are practical for implementation along the I-880 corridor. Working with all the stakeholders, the following considerations were used in the 880 ICM strategy selection:

1) Operational feasibility: The foremost issue in the evaluation of implementability of candidate strategies is whether the proposed strategies are operationally feasible. Some of the candidate ICM strategies are very desirable but may create negative burdens on operations or significantly increase operational costs, so these strategies may still not be practical for implementation.

2) Technical feasibility: Based on the requirements, alternative system configurations and technology options will be analyzed to determine the most appropriate choices for the ICM implementation.

3) Institutional constraints: The I-880 ICM team intends to use the ICM program as a vehicle to improve institutional integration among the stakeholders along the I-880 corridor. However, given the fact that not all

existing institutional gaps among stakeholders can be eliminated through the ICM program due to complexity, time, funding and other constraints, the I-880 ICM team analyzed institutional issues related to the candidate ICM strategies, considering the stakeholders' opportunities and constraints, and prioritized the candidate strategies.

4) Benefits and costs: The stakeholders along the I-880 corridor expect to gain benefits and improvements in a number of areas. The I-880 ICM team evaluated benefits at a relatively high level to get a first order estimate of what kind of benefits the proposed candidate strategies may bring about. The benefits and costs for implementing the candidate strategies will also be evaluated in Stage 2. It is expected that, as some of the strategies require acquisition of a wider range of data under more demanding conditions, while imposing more challenging requirements for component and system robustness, the cost for implementation will also increase. The trade-offs between these increasing costs and benefits will be evaluated to identify the level of capabilities that can be achieved in the corridor, particularly based on the constraints imposed by the existing and available sources of real-time operations data. The results of the trade-off analyses will be shared with the stakeholder organizations to provide them an opportunity to participate in the decision regarding the most appropriate operational scenarios to target for implementation.

5) Compliance with ITS architecture: The ICM design and development will proceed consistent with the Bay Area's Regional ITS Architecture. The existing projects that Caltrans, MTC and Alameda CMA have sponsored have extensively used the regional ITS architecture, and the new ICM functions must apply the regional ITS architecture as well.

4.2 I-880 Corridor Vision, Goals and Objectives

The San Francisco Bay Area has been a national champion for implementing advanced ITS technologies for improving efficiency and effectiveness of the transportation systems. It has become a program objective for the stakeholders along the 880 corridor to use ICM as a tool to further integrate the ITS systems already deployed in the San Francisco Bay Area and to enhance collaborative operations among the operation agencies. Under this program objective, through various workshops and meetings, the stakeholders have formulated ICM visions intending to address the current corridor conditions, deficiencies, and needs, and to help achieve the long-term. The 880 corridor stakeholders also developed the ICM goal and objectives of the ICM program for the 880 corridor is to provide the

information sharing tools to enable the individual network operators within the corridor to manage their respective systems collaboratively and cooperatively.

Vision: The I-880 ICM program will help the existing highway, arterial, rail and bus transit networks along the corridor, operated by separate agencies, to function as an integrated transportation system, enhancing efficiency, mobility and transportation choices for all travelers (people and goods) under all conditions.

TABLE 4.1
880 ICM GOALS AND OBJECTIVES

Goals	Objectives
Improve the efficiency of their individual networks through shared information from, and collaborative operations with, the other networks.	Improve highway efficiency by sharing information between arterial and freeways Improve operation efficiency of transit operation by using information about highway conditions and by improving the interface between highway and transit Reduce waiting times for transfers between transit services through enhanced coordination Reduce delays for truck traffic to and from Port of Oakland
Balance demand across the networks to most efficiently utilize the available capacity.	Reduce recurrent congestion through improved real-time balancing of demand and supply between freeways and arterials.
Enable travelers to make informed choices among transportation options, based on reliable information about travel conditions.	Support travelers' trip planning using improved multimodal real-time information. Advise travelers about modal shift using real-time operations information (connections, traffic interactions).
Respond quickly and effectively to service disruptions that may be planned or unplanned, whether based on human or natural causes.	Reduce non-recurrent congestion through improved incident response and incident information to travelers. Improve the ability of the transportation network operators to respond to service disruptions through information sharing and better information to travelers.

4.3 ICM Application Scenarios

The benefits of ICM will depend on the range of scenarios that its implementation can support, and the benefits are expected to increase for operational concepts that can support the most demanding applications (such as responding to a major earthquake). The needs for ICM must be based on specific application scenarios, because these scenarios can vary widely in the technical requirements they impose on an ICM system.

In order to evaluate the applicability and implementability of ICM strategies, the application scenarios under which the ICM strategies will function must be defined. The identification of needs started with the inputs received from the stakeholder organizations, which were organized and combined into a set of integrated corridor-wide application scenarios. Based on the corridor-level goals and objectives, the I-880 ICM team defined the general scenarios for which its ICM will be designed:

- Normal daily operating conditions
- Highway incidents
- Transit incidents
- Planned events
- Major Events

The scenarios were then used for further defining the ICM strategies and their requirements and will later be used for verification of the effectiveness of each strategy during the modeling and analysis stage of work on the ICM project.

4.3.1 Normal Operations Scenario

The normal operations scenario addresses corridor management activities in response to typical day-to-day traffic flows and recurrent congestion. It is important to note that the I-880 corridor does not routinely face such normal conditions, since it experiences over 100 incidents every day. Of those incidents, 10 to 15 are actual collisions. Moreover, the corridor serves travelers from and to the Oakland Sports Arena and Coliseum, each of which serves over 100 major events every year. Nevertheless, even with these frequent special conditions, the corridor experiences recurrent delays at known bottlenecks that could benefit greatly from the implementation of ICM strategies to provide comprehensive multi-modal information to travelers, enhanced transit service quality, more efficient sharing of roadway capacity among freeways and arterials and facilitated emergency vehicle access.

The I-880 freeway experiences high levels of traffic congestion for much of the day under normal conditions, not only during the typical AM and PM peak periods but also in the middle of the day, as shown in Figure 4.2. Indeed, the total hours of delay during the mid-day period now exceed the hours of delay in the AM peak period. The total estimated weekday delay for the freeway in both directions reached 11,600 hours in 2005. The PeMS database helps reveal the locations along the freeway where the main recurrent delays occur, due to high traffic volumes, merging

maneuvers, and roadway geometrics. These can be seen graphically in the displays of Figure 4.3, indicated separately for the northbound and southbound travel directions.

The AC Transit bus services in the corridor are operating at capacity during peak periods, and the agency cannot afford to add more buses or drivers in its current budget condition. This capacity constraint also limits their ability to make operational adjustments to respond to incidents within their own or the other networks. The peak period capacity of the BART rail transit services in the corridor is limited by the availability of rolling stock, but with additional rolling stock it would be possible to increase the length of trains and hence their capacity. However, ridership might still be constrained by the limitations in the capacity of BART's park-and-ride garages, which are already operating completely full during weekdays. During the off-peak times both transit agencies have excess capacity, although their practical ability to expand operations at those times is still constrained by their operating budgets.

The overall roadway capacity of the corridor is not fully utilized at present because of the lack of coordination between freeway and arterial operations and the lack of information for travelers about real-time arterial operating conditions. Most automobile-oriented travelers also lack information about the public transit alternatives that could potentially be viable for serving their travel needs.

Finally, there is limited direct coordination between the transportation network operators and the public sector operators of the major traffic generators within the corridor, such as the Port of Oakland, which operates both the container port and Oakland Airport.

FIGURE 4.2 (A)
Southbound hours of delay on I-880 by time of day

(Source: PeMS, https://pems.eecs.berkeley.edu/)

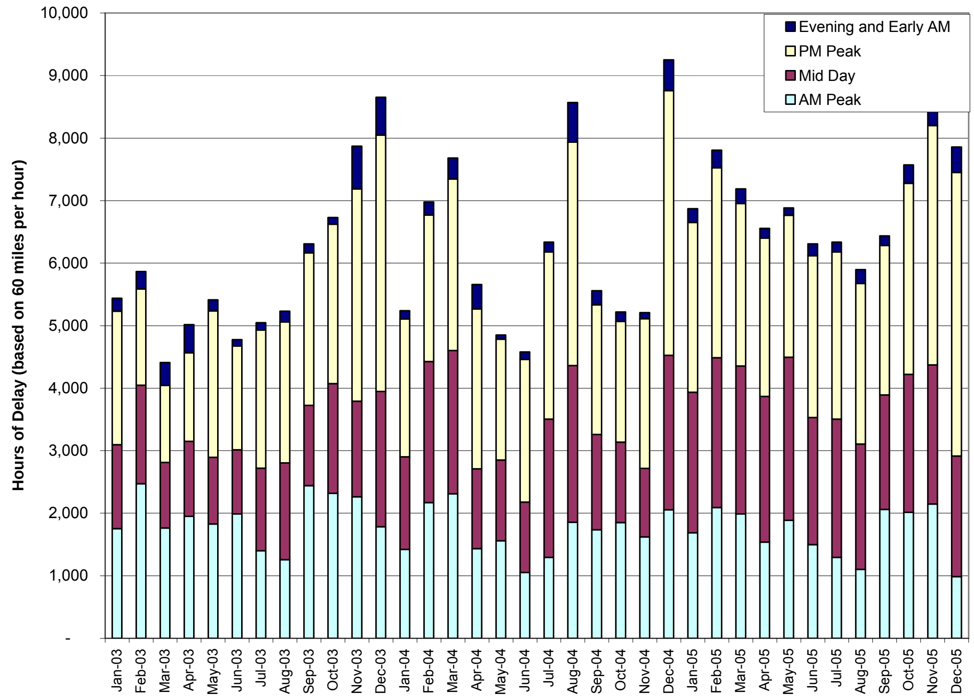


FIGURE 4.2 (B)
Northbound hours of delay on I-880 by time of day

(Source: PeMS, https://pems.eecs.berkeley.edu/)

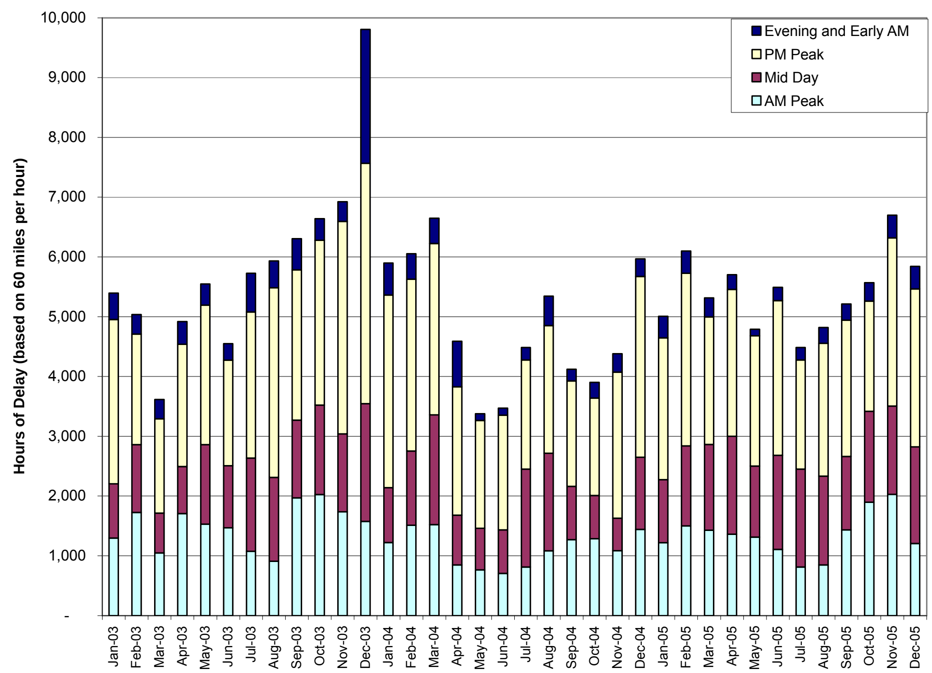


FIGURE 4.3 (A)

PeMS displays of aggregate traffic speeds on I-880 by time of day and milepost, showing normal bottleneck patterns

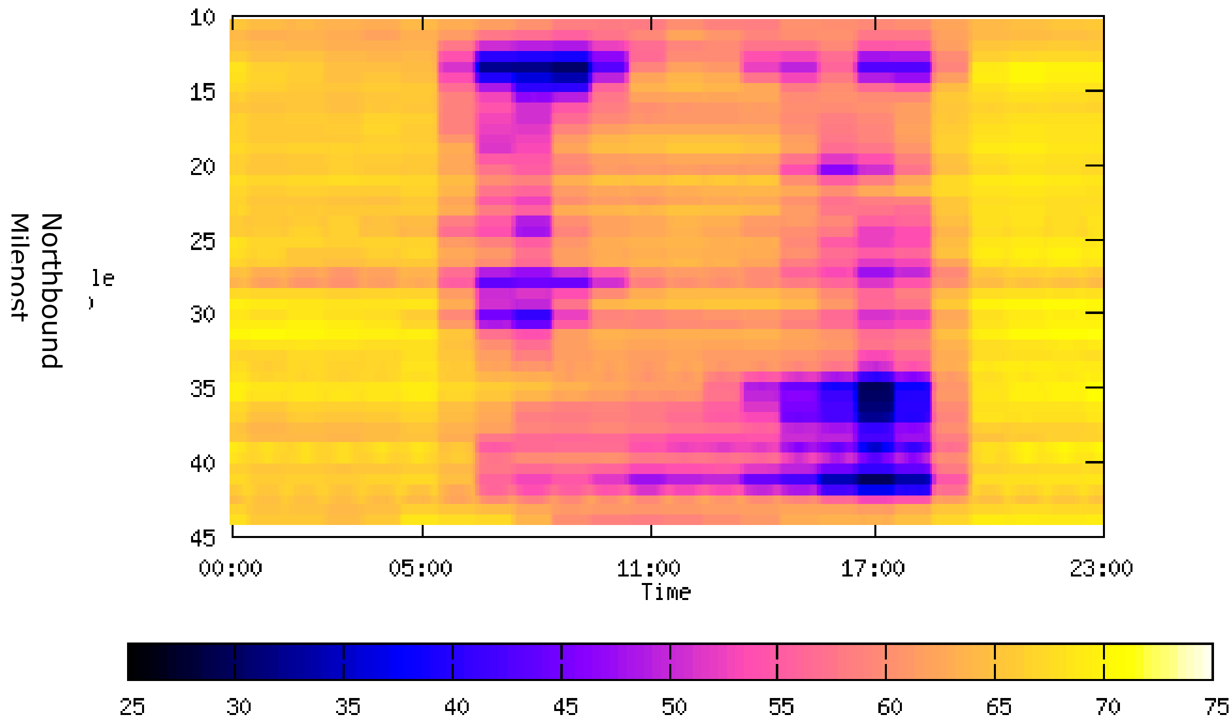
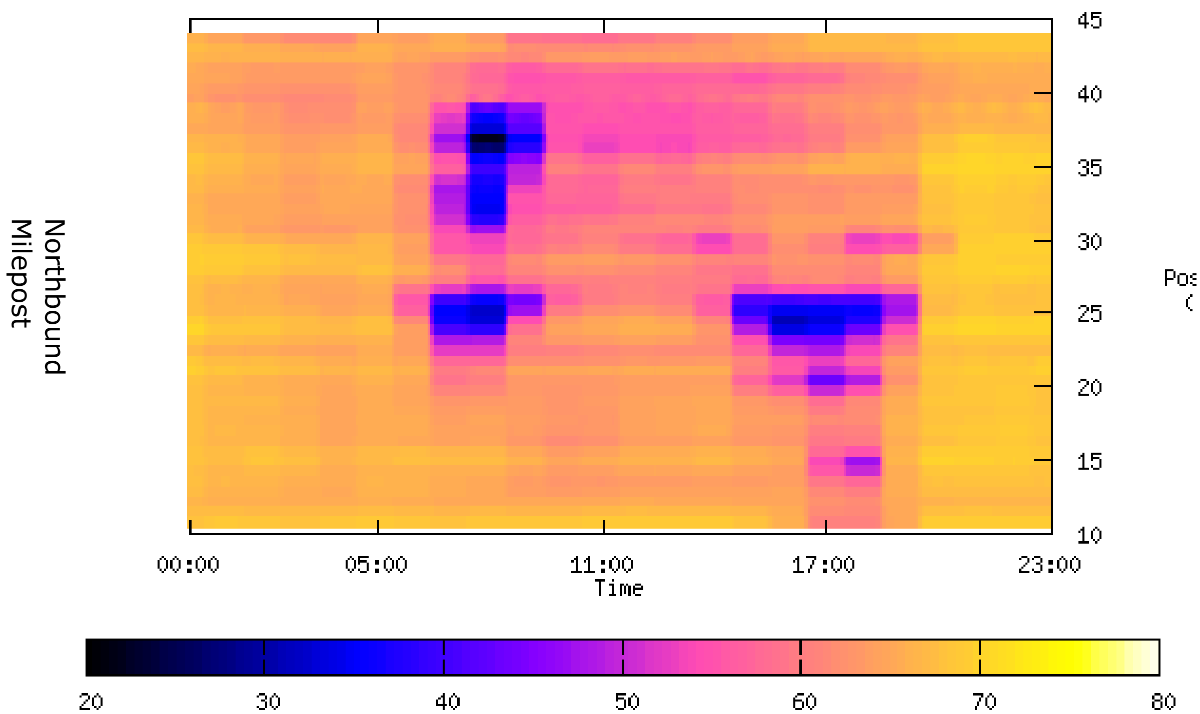


FIGURE 4.3 (B)

PeMS displays of aggregate traffic speeds on I-880 by time of day and milepost, showing normal bottleneck patterns



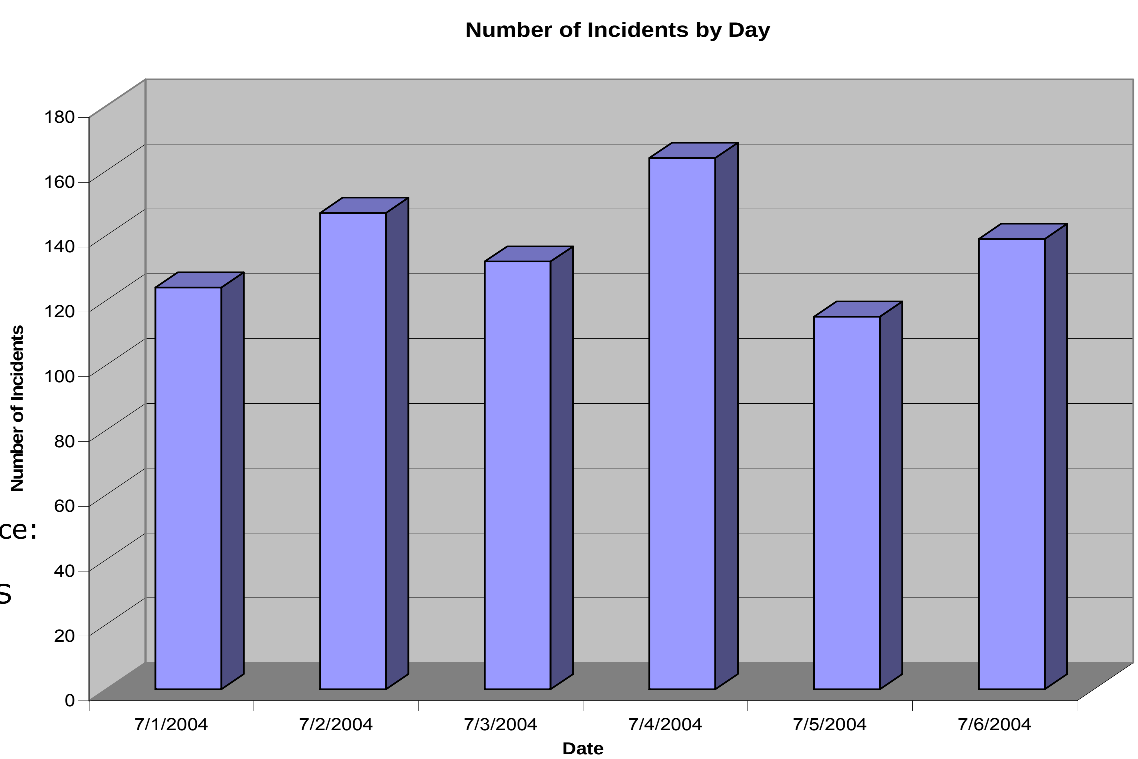
4.3.2 Incident Scenario (Highway and Arterial)

The incident scenario addresses corridor management activities and strategies in response to incident-related non-recurrent congestion.

EXISTING CONDITIONS

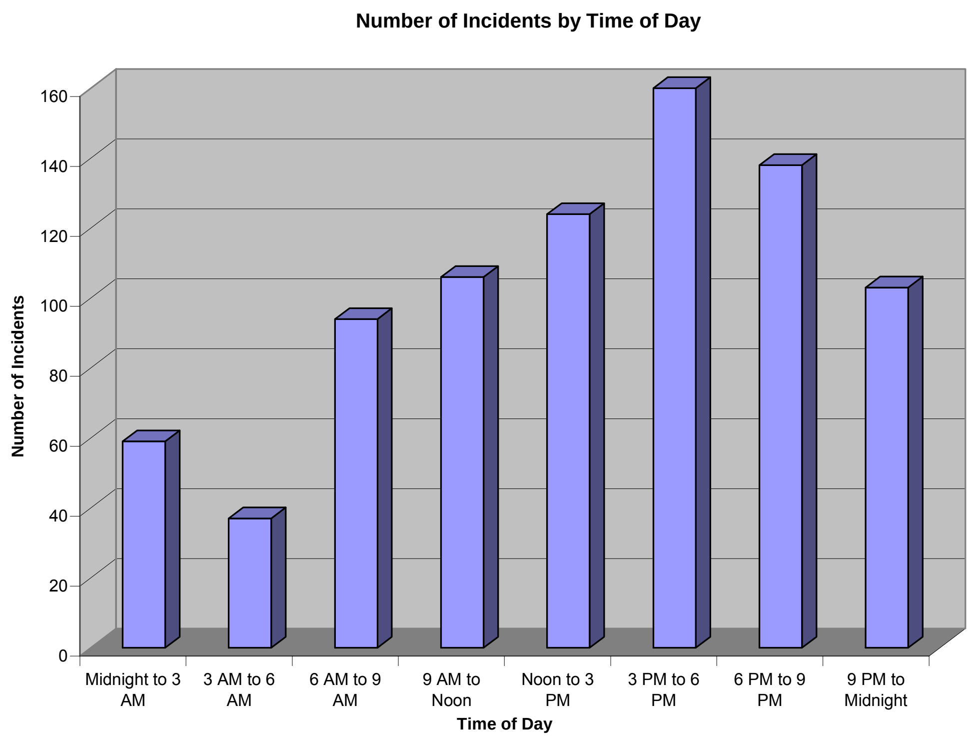
A significant amount of congestion delay on the I-880 freeway is caused by incidents (crashes, breakdowns, spilled loads and other random events). The I-880 corridor experiences over 100 incidents every day. Of those incidents, ten are actual collisions. Figure 4.4 depicts a representative sample of incidents on I-880 during one week in July 2004 and Figure 4.5 shows a summary of I-880 incidents by time of day. Many of these incidents occur in the afternoon, when traffic volumes and congestion are greater than at other times of the day. Figure 4.6 shows the number of I-880 collisions occurring daily between 1999 and 2004. The sources for these data are the TASAS crash database and California Highway Patrol (CHP) logs.

FIGURE 4.4
Sample of number of I-880 incidents per day during the week including July 4, 2004



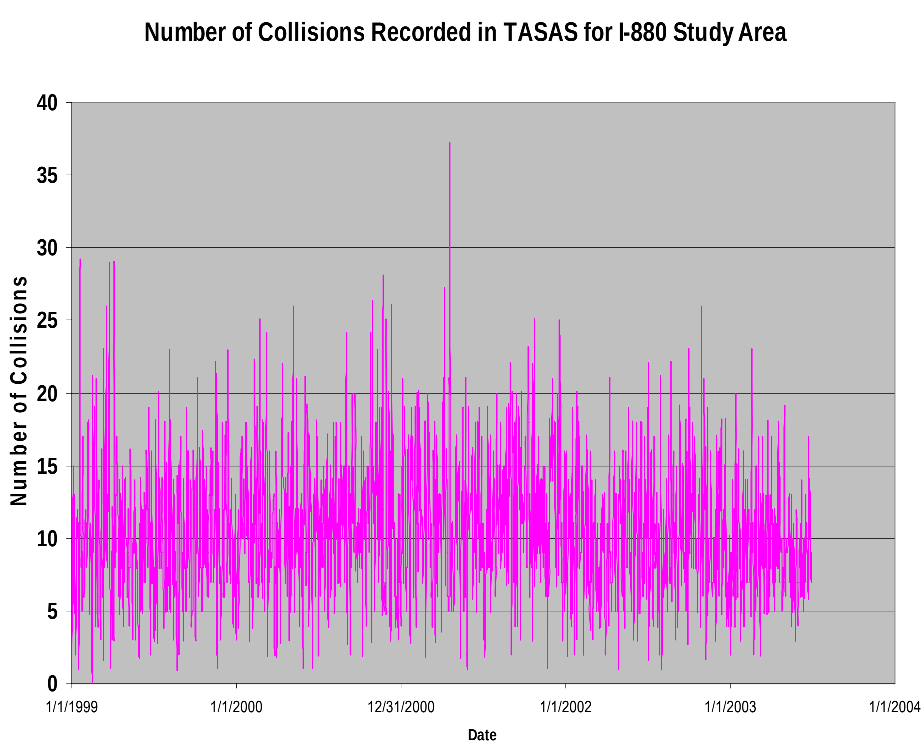
(Source:
PeMS
TASAS

FIGURE 4.5
Distribution of I-880 Incidents by Time of Day



(Source: PeMS TASAS)

FIGURE 4.6
Number of collisions per day on I-880 over five years



(Source: PeMS TASAS)

It is important that effective and efficient management procedures be in place to quickly detect, verify, respond and clear incidents to minimize their adverse impacts to traffic. In 2003 the Bay Area Incident Response System (BAIRS), a computerized incident management tool, was implemented by Caltrans District 4 in the San Francisco Bay Area to improve freeway incident management capabilities. BAIRS uses a real-time web-based set of databases integrated into Geographic Information System (GIS) software to identify and map the location of the incident and the location and availability of Caltrans maintenance supervisors, workers, and equipment. The responding supervisor can locate the nearest maintenance crew, equipment and materials using laptop computers and BAIRS. By providing real-time communication and access to information, BAIRS keeps both the dispatcher and the responding maintenance crew up-to-date with all pertinent information about incidents.

Although BAIRS reduced incident durations by about 15%, the dispatching process and corresponding personnel response times to clear incidents could be improved in the following areas:

- Multiple calls are frequently required to secure appropriate response personnel.
- Contact and availability information is not frequently updated, causing delays in contacting the appropriate party to dispatch.
- Limited information about incidents results in an inability to determine which tools and resources are needed to resolve the incident prior to arriving on-scene.

Further reducing incident response times and incident clearance times will improve safety on I-880, reduce mobile emissions, and shorten emergency vehicle response times to other incidents.

Broader concerns about current capabilities for managing roadway incidents in the corridor include:

- real-time information about impacts of incidents on travel times is not generally available to system operators or travelers
- system operators lack the tools to adjust their operations accordingly in response to incidents
- there is currently no effective way to provide guidance to drivers to minimize their delay if the incident occurs after they have started their trip
- prompt incident detection on arterials is not generally available
- even after an arterial incident is detected, there is no effective way to notify drivers about it.

4.3.3 Incident Scenario (Transit)

The I-880 corridor depends heavily on its two primary transit services, the BART rail transit line and the AC Transit buses. Minor incidents involving these services are nuisances to their riders and in the long term tend to discourage choice riders, while major incidents can adversely affect the entire corridor.

The transit operators have to contend with a wide range of potential incidents, which have different implications when they occur during peak and off-peak operations:

BART rail transit

- station closure (e.g., local law enforcement action)
- brief service interruption (i.e., 15 minutes) any between 15 to 60 minutes?
- major service interruption (one hour or longer)
- capacity reduction, but without interruption
- wildcat strike or work slowdown

AC Transit bus services

- bus crash requiring emergency response and replacement bus and driver
- disabled bus requiring replacement
- local traffic incident causing service delays

- maintenance or equipment problems limiting availability of buses
- wildcat strike or work slowdown

In addition, the AC Transit express bus services operating on the freeway may encounter major freeway incidents that require re-routing of the buses and/or serious schedule delays.

The transit agencies have general procedures in place for handling incidents such as these, but they are limited by resource constraints as well as shortfalls in real-time information. For example, AC Transit is not able to do dynamic dispatching of buses in response to peak-period incidents because they do not have slack capacity to work with. Resource limitations have also tended to force the transit operators into reactive modes of responding to problems rather than enabling them to proactively plan responses, particularly for incidents that require multi-agency cooperation.

Issues of particular concern with regard to transit incidents include:

- need for enhanced coordination between the two major transit system operators
- limited availability to travelers of information about alternative modes
- the transit trip planner in the 511 system is based on nominal transit schedules and does not include a dynamic capability to respond to real-time schedule deviations
- real-time information about service interruptions and connection problems is not available to travelers
- transit-dependent travelers have limited options, even if better information is available to them.

4.3.4 Planned / Scheduled Event Scenario

Planned and scheduled events can place severe demands on the transportation system, but because they are planned and scheduled it should be possible to mitigate their impacts on transportation services by developing and implementing effective strategies. These strategies are likely to depend at least as much on pre-event coordination as on real-time information sharing.

Some of the planned/special events anticipated for the I-880 corridor are generally applicable anywhere in the country, while others are likely to be specific to this corridor. The initial candidate list of such events includes:

- major sporting or entertainment event at the Oakland Coliseum, especially if scheduled on a weeknight, overlapping the evening commute peak
- major weeknight sporting event in San Francisco, impacting evening peak traffic in this corridor
- major travel surge at Oakland Airport, particularly associated with holiday travel periods
- AC Transit or BART strike
- AC Transit or BART service change
- Highway maintenance or construction activity requiring closure of lane(s) and/or interchange(s) in or adjacent to the corridor
- Street fairs causing closures of major streets (generally on holidays or weekends)
- Major holiday events (Fourth of July fireworks displays, pre-Christmas surges at shopping malls).

Each event has its own character, stakeholder organizations and geographic scope, so they tend to require customized approaches. However, in all cases it is better to have coordinated planning among all of the involved organizations far enough in advance to provide time to settle on the most acceptable response strategy and contingency plans. This is likely to require consultations beyond the traditional transportation operating organizations, including as well organizations such as:

- Local police forces and California Highway Patrol
- Local emergency responders (fire, EMS)
- Event venue managers (Coliseum) and organizers (sports teams)
- Oakland Airport and major airlines
- Shopping center management
- Street fair organizers
- Mass media outlets (TV, radio, newspapers).

Some of the scheduled events (especially the infrequent ones) occur in locations that do not normally handle the volume or patterns of traffic that are generated by the special events. This requires particular care in planning, particularly for providing assets that are not normally in place there (officers to direct traffic, portable CMS to provide information, etc.) and to disseminate information to the public.

One particularly significant aspect of special events traffic is that a large proportion of the people traveling for these events are not familiar with the area. They may not know the most appropriate routes to take, where parking is available, what turn restrictions apply at intersections, which transit services can take them there, etc. This places a particular premium on providing comprehensive and easily understandable information to the traveling public. Examples of these **needs** for scheduled events at the Oakland Coliseum include:

- **Real-time data dissemination for traffic** - Motorists may be redirected from the event congestion along I-880 via Changeable Message Signs or Trailblazers deployed by Caltrans, via 511 phone or web messages disseminated by MTC, or via web data disseminated by East Bay SMART Corridors. Motorists can access real-time driving times and notifications of slowdown locations.
- **Real-time data dissemination for transit** - Transit users and potential transit users would have AC Transit and BART travel time estimates via station and stop displays, station announcements, and announcements on 511.
- **Alternate routes** - Motorists may be redirected from the event congestion along I-880 primarily onto the adjacent SMART Corridors leading up to the Coliseum. These arterials include San Pablo Avenue from the north, International Boulevard and San Leandro Street in close proximity to the Coliseum area, and Hesperian Boulevard from the south. These parallel arterials could then in turn be monitored by the video cameras located along the SMART Corridors.
- **Real-time parking information** - There are 9 parking lots in the immediate vicinity of the Coliseum area, as well as additional lots in the surrounding areas. Dissemination of this information to motorists attending the scheduled event via CMSs, trailblazers, PDAs or by phone would reduce congestion both along I-880 and adjacent local streets by directing motorists quickly to available spaces.
- **Impact to Oakland Airport travelers** – The Oakland International Airport is located in close proximity to the Coliseum and is operated by the Port of Oakland. Thus, the Port of Oakland, Caltrans, and the City

of Oakland could coordinate any messages disseminated via CMS or other means, to facilitate announcement of delays along I-880, or alternate routes to the Airport.

- **On-site traffic control** – During scheduled Coliseum events, both the CHP and City of Oakland police may have roles in on-site traffic control. Two-way communication of traffic conditions (to assist the officers in traffic control and directing traffic towards less congested routes, and also from the office to the management center to provide real-time information on traffic conditions at their locations) could be provided via a combination of cameras and wireless devices interfaced with the network.
- **Advance static data dissemination for traffic and transit** – On the MTC 511 phone and web sites, and on the ACCMA web site, advance notification could be provided regarding the scheduled event. Travelers could be advised to expect delays, and also to consider taking transit to the scheduled event.
- **Data sources** – A combination of various data sources would provide real-time traffic and transit information. These data sources include Caltrans sensors, SpeedInfo and FasTrak feeding data to the 511 system, video cameras along parallel SMART Corridors, and real-time information from on-site personnel (such as traffic-directing police officers through wireless communication or other means).
- **Traffic Control** – The following could be enhanced for the scheduled event since the responsible agencies would be notified in advance of the event:

    Signal timing along adjacent arterials and leading up to I-880 ramps could be enhanced by the City of Oakland and/or the Oakland Police Department to accommodate the additional expected flow

    Ramp metering could be enhanced by Caltrans to accommodate the additional expected flow

    Transit Signal Priority could be enhanced to help move additional transit vehicles through the Coliseum area

    Coordinated operation could be achieved between signals and ramp meters

- **Interagency communication** – For a scheduled event, impacted Transportation Management Centers (TMCs) would have predefined strategies and a predefined schedule for coordinated traffic control and data dissemination. These agencies specifically include the Caltrans District 4 TMC, the Oakland TMC and related facilities, the Port of Oakland TMC, and the East Bay SMART Corridors TMC, and MTC's 511 Traveler Information Center (TIC).
- **Emergency response and emergency vehicle pre-emption** – Although the event is a planned/scheduled event, the additional congestion could increase the likelihood of an incident. Emergency responders such as CHP, Oakland Police Department and Oakland Fire Department would have immediate notification of any incidents related to the actual scheduled event. Also, emergency responders would be given priority on the adjacent arterials in order to reach any incident scene.
- **Data Archiving** - Data archiving by Caltrans, MTC (511), ACCMA, PeMS and CHP could improve operations in preparation for, and during, future scheduled events.

4.3.5 Catastrophic Event Scenario

Major events are generally unpredictable and have widespread impacts on the transportation system as well as on other aspects of the regional economy, so the transportation system responses need to account for the likelihood of other services being disrupted. Examples of major event scenarios for the I-880 corridor could include:

- large fire requiring closure of major transportation arteries (such as the Oakland Hills fire of October 1991, which closed I-580 and a BART line)
- widespread flooding, blocking major transportation arteries
- terrorist attack destroying infrastructure and requiring sudden evacuation
- major earthquake (such as the Loma Prieta earthquake of October 1989, which destroyed the section of I-880 immediately to the north of the ICM corridor).

Major events such as these unfold in stages, which are quite different from each other and require different transportation responses:

1) Immediate aftermath, with the potential for public panic and the need to evacuate people from dangerous areas promptly and safely.

2) Recovery operations, tending to injured people and trying to limit damage (firefighting, sandbagging for floods, preventing structures from collapsing, etc.).

3) Repairing damaged infrastructure and restoring utility services (electric, telecommunications, water and gas). Since this may take considerable time, this stage is also likely to overlap with a gradual return to normal operation of the regional economy, with people returning to work. Goods movement may be substantially impacted by the need to remove debris and bring in new building materials.

4) Returning to normal operations in stages, as the regional economy recovers.

Because the I-880 corridor is immediately adjacent to the Hayward Fault, the most dangerous earthquake fault in the San Francisco Bay Area, the logical candidate example to consider is a major earthquake on that fault. Seismic research, based on historical data, indicates a 62% probability of an earthquake of magnitude 6.7 or greater, which is capable of causing widespread damage, striking the region before 2032. This could be a disaster of national economic significance, potentially comparable to Hurricane Katrina in New Orleans, and in that sense is probably a uniquely drastic scenario among the ICM Pioneer Sites. The impacts of such an earthquake could include:

- loss of electrical power for hours or even days, disabling traffic signals, most telecommunications, fueling stations for motor vehicles, and power for BART trains;
- structural damage to elevated BART tracks and/or stations;
- derailing of BART train during earth motion;
- structural damage to I-880 freeway where built on elevated structure or at grade on land fill;
- collapse of freeway overpasses, disrupting arterial traffic as well as freeway traffic.
- The time needed to recover and restore these types of damage could vary widely, so different parts of the transportation system could become usable at different times after the event.

Some of the key challenges to managing this scenario include:

- The priorities and constraints faced by the public authorities will change multiple times as the corridor management activities progress through the different stages of emergency response and recovery, requiring timely information and decision making agility.
- The patterns of damage could occur in infinite combinations, making it impossible to anticipate them all in detail. These are likely to include localized losses of structures, power, communications, people and vehicles.
- With some sources of information likely to be disabled by the event, there will be large uncertainties about the true condition of the transportation infrastructure, vehicles, and personnel.
- The transportation needs of the corridor will change significantly throughout the event and recovery, depending on the extent and geographical distribution of the disruptions to commerce and work patterns.

MTC is already working towards integrated coordination of responses to catastrophic events by various transportation agencies throughout the San Francisco Bay Area, and has developed agreements for resource sharing, timely communication, and unified public information. ICM should be able to support multiple sources of information about the true condition and operations of the transportation networks within the corridor, helping to improve operational effectiveness and flexibility for responding to a major event and facilitating the cooperation among the operators of the different networks.

4.4 Development of Candidate ICM Strategies

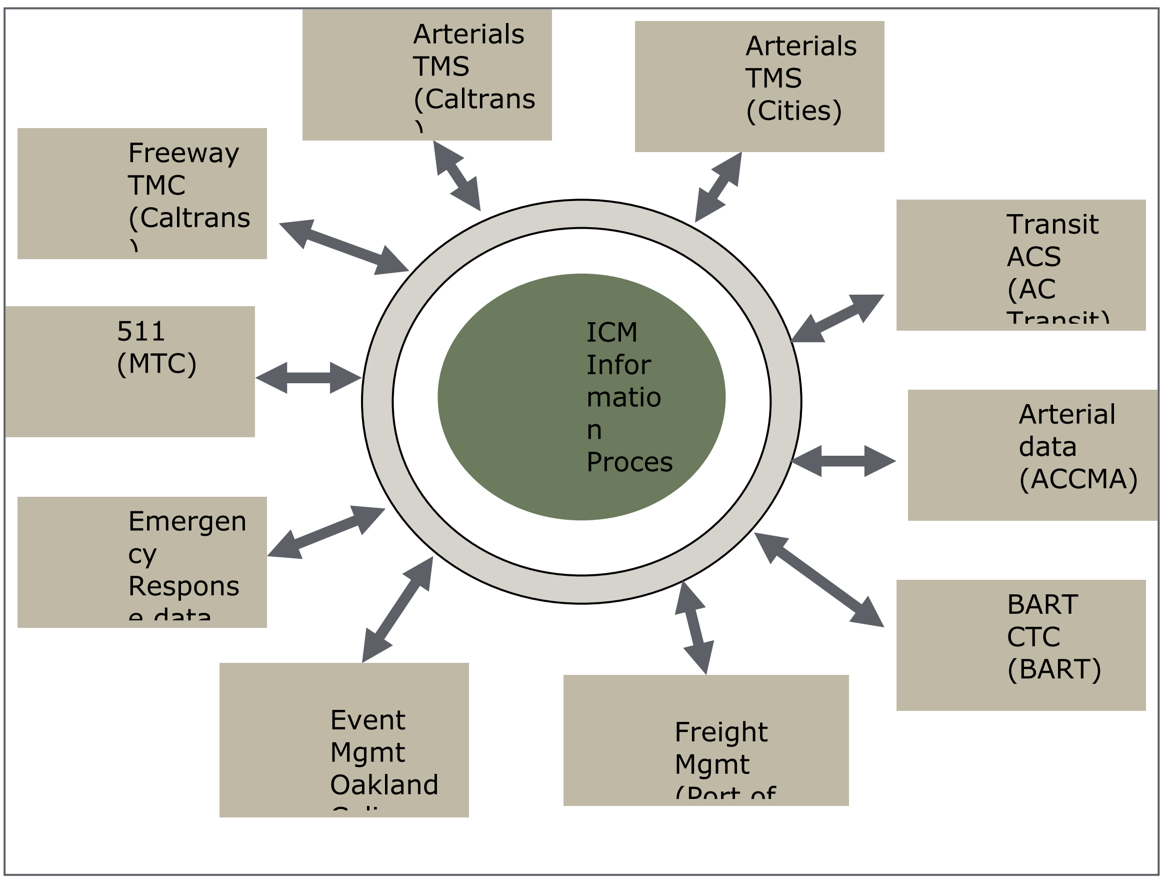
The proposed 880 ICM system will be built upon on the existing ITS systems already deployed for the networks that operate along the I-880 corridor. The focus of the ICM ConOps is therefore placed on the integration of the existing ITS systems, which will facilitate data sharing capabilities, enhanced real-time cross-network coordination and operations involving various agencies and jurisdictions using a set of transportation management strategies.

4.4.1 Information Sharing

Addresses the gaps G1 and needs N1 discussed in sections 3.10 and 3.11)

Information sharing is an enabler for ICM, which enable improved coordination and operations among the transportation networks and therefore facilitate management of the total capacity and demand of the corridor. Communication links among operating agencies, system interfaces, and bridging functions will be critical for ICM, by which information and system operations and control functions can be effectively shared and distributed among networks and their respective transportation management systems and by which the impacts of operational decisions can be immediately viewed and evaluated by the affected agencies and across networks.

FIGURE 4.6
Proposed 880 ICM Information Sharing Scheme



The proposed I-880 ICM information sharing scheme is shown in Figure 4.6, changing from existing information sharing shown on Figure 3.17 to allow full information sharing among I-880 stakeholder agencies. Note that the ICM processing will likely be implemented by a number of physically distributed information processing functions. However, these distributed information processing functions will be designed to seamlessly perform ICM needed information sharing.

4.4.2 Candidate ICM Strategies

In developing the ICM candidate strategies, the I-880 ICM Team conducted a series of workshops with the stakeholders to determine those strategies that can be realized based on the current infrastructure and ITS system condition, strategies that can address the gaps and needs identified under Section 3.9.

In order to quickly ramp up the ConOps development process and at the recommendation of USDOT representatives, the I-880 ICM team referenced the list of candidate strategies provided by FHWA in the Generic ICM Concept of Operations document, eliminating those that are not applicable to the I-880 corridor and adding additional ICM strategies that will provide benefits for the corridor. Appendix B is a working table used by the 880 ICM Team to conduct exercises on candidate selected scenarios.

The I-880 ICM Team initially selected 29 candidate strategies for consideration. In addition to soliciting stakeholders inputs, in an effort to determine which ones should be further analyzed, the initial set of candidate strategies were evaluated by the project consultant team based on five criteria – significant traffic impact, high benefit/cost ratio, minimal institutional or political challenge, little technical complexity, and improved national competitiveness (see Appendix C for the rating results). When the non-numerical scale of the rating sheets was converted to a simple linear scale with a range of possible combined scores from -60 to +60, all of the 14 strategies under active consideration scored within the relatively narrow range of -2 to +20. At the January 18 meeting, the stakeholders suggested keeping this full set for functional analysis, since they believed all the 14 strategies could bring significant benefit to the corridor and shouldn't be eliminated prematurely.

Based on stakeholders' inputs and preliminary analyses (as reported in section 5.3), 14 candidate strategies were selected for the I-880 ICM. These strategies are categorized into three groups, including:

- The "Influencing Travelers' Decisions and Choices" strategies aim at providing travelers with accurate information either pre-trip or en-route so that they can make informed decisions about mode of travel and/or route of travel.
- The "Facilitating Collaboration among Agencies for Operational Improvement" strategies focus on better coordination of operations and incident response among different agencies, so that existing capacities

on these networks can be fully utilized to reduce congestion and to improve travelers' trip experience.

- The "Facilitating Collaboration among Agencies for Event Planning" strategies coordinate maintenance and construction works on different networks to minimize their impacts on the transportation system.

The Candidate I-880 ICM strategies are:

I. Influencing travelers' decisions and choices/traveler information strategies (Addresses the gap G2 and need N2 discussed in sections 3.10 and 3.11)

Decisions about route choice and mode choice can be made prior to the trip or during the trip. The I-880 ICM stakeholders recommended four strategies for filling the gaps in pre-trip and en-route trip planning.

Strategy 1

A corridor-based multimodal advanced traveler information system (ATIS) that supports travelers pre-trip.

Encourage travelers to shift mode and use public transportation has been a goal for Bay Area transportation agencies for many years. The I-880 stakeholders believe that an accurate and easily accessible multimodal trip planner that can help to plan trips with more than one mode of transportation will help travelers to determine route, mode and travel time. It could potentially encourage mode shift the most, and therefore is a high priority strategy for the I-880 ICM. Strategy 1 will involve real-time information about integrating the I-880 freeway, adjacent arterials, AC Transit, BART, ferries and park and ride into the Bay Area 511 system to provide the traveler information through various easily accessible media.

Strategy 2

Promote route shifts between roadways via en-route traveler information devices (e.g. DMS, HAR, "511") advising motorists of congestion ahead, directing them to adjacent freeways or arterials.

When incidents occur either on the I-880 freeway or major arterials, diverting some traffic to the other roadway will help to reduce the total delay. Strategy 2 will detect traffic conditions on freeways as well as arterials and dynamically advise motorists the duration of the delay, to move to an adjacent roadway and which entrance or exit to use.

Strategy 3

Promote modal shifts from roadways to transit via en-route traveler information devices (e.g. DMS, HAR, "511") advising motorists of congestion ahead, directing them to high capacity transit networks and providing real-time information on the number of parking spaces available in the park and ride facility.

Strategy 3 will advise motorists about the condition of the congestion and about the availability of park and ride facilities near BART or AC Transit stations. This strategy is particularly useful when major congestion events occur. The stakeholders realized that this strategy may be more helpful for travelers on their trips to the office, but probably will not be very effective for their trips back home.

Strategy 4

Promote shifts between transit facilities via en-route traveler information devices (e.g. station message signs and public announcements) advising riders of outages and directing them to adjacent rail or bus services.

Strategy 4 is intended to facilitate passenger transfers between BART, AC Transit and WTA ferry when a service abnormality occurs in one of these systems.

II. Facilitating collaboration among agencies for operational improvement (Addresses the gaps G3-G8 and needs N1-N7 discussed in sections 3.10 and 3.11)

In order to address the gaps identified in 3.9, multiple aspects of coordination are needed among the transportation agencies operating in the I-880 corridor. A total of 10 strategies are identified for facilitating coordination among operating agencies for operational improvements.

Strategy 5

Coordinated operation between freeways and arterial traffic signals

This strategy will establish coordination between ramp metering and arterials, which will help to reduce vehicle queuing and delays at freeway on-ramps and therefore reduce delays for arterials as well at intersections connected to ramps. In collaboration with Strategy #4, this strategy will also facilitate coordinated operation between highways and arterials to mitigate congestion under incident situations.

Strategy 6

Enhance arterial signal timing with advance information about special events at Oakland Coliseum.

This strategy will enable special signal plan for arterial traffic signals during special events at the Oakland Coliseum.

Strategy7

Signal priority for AC Transit buses

This strategy has already been implemented along International Blvd and East 14th Street. Additional bus signal priority-enabled intersections are planned for other arterial corridors.

Strategy 8

AC Transit adjusts bus operations based on real-time information about highway incidents and special events

This strategy will allow AC Transit to receive real-time information about highway incidents and, based on the severity of the incidents, to make decisions to adjust its routes, schedules and operations to maintain operations instead of being stuck in the traffic. As AC Transit has the obligation to serve all the bus stops unless a certain street is closed, this strategy is primarily designed for express buses that run on the freeways and for buses running on arterials only when a major highway incident occurs.

Strategy 9

Transit hub connection protection for special events or major incidents

This strategy allows AC Transit to provide connection protection for pre-planned special events and emergencies due to major events. Specific transit hubs/connection points such as the Coliseum will be selected for a demonstration of transit connection protection on routes that have long headways. Connection protection for BART stations under normal operating situation is not appropriate, as delays at one station can affect the arrival time at the downstream stations.

Strategy10

Port of Oakland advises arriving and departing trucks about port delays and estimated travel times

The main freight distribution centers are located in the Central Valley of California, and most of the trucks take I-880 and I-238 between there and the Port of Oakland. Container traffic along these corridors is expected to triple by the year 2020. The Oakland Port is currently implementing an electronic identification system to reduce truck waiting times. This strategy will allow truck drivers to be informed about port delay and estimated travel times prior to their departure from the freight distribution centers so that they can better plan their trips and minimize their congestion losses.

Strategy 11

Signal preemption or "best Route" for emergency vehicles

This strategy intends to facilitate all emergency response vehicles (i.e., fire trucks, police, paramedics) with signal preemption capabilities. It also intends to provide 'best route' information in order to reduce emergency response time. The ICM team will work with these stakeholders to determine if this is doable within the ICM scope.

Strategy 12

Multi-agency or multi-network incident response teams and service patrols and training exercises.

Currently, MTC, Caltrans, and CHP are working together for a workshop and training program toward a closer collaborative working relationship and to develop collaborative incident response plans. The first phase of this program involves first responders (CHP, and Caltrans). The second phase will involve local agencies.

This ICM strategy intends to facilitate communication and coordination among agencies to help the first responders to identify types of incidents and the equipment needed to respond to the incidents.

III. Facilitate Collaboration among Agencies for Event Planning (Addresses the gaps G9-G10 and needs N9-N10 discussed in sections 3.10 and 3.11)

Though the 880 ICM will focus on technological and operational integration around real-time information sharing, the ICM Team believes that guidelines and protocols, particularly those that deal with infrastructure construction and maintenance, will be needed to support the strategies dealing with real-time operations.

Strategy 13

Coordinate scheduled maintenance and construction activities among corridor networks.

Strategy #13 will allow a standardized repository for reporting on routine maintenance closures of freeways and local arterials, accessible to other agencies. This will be very helpful for network operators as well as travelers.

Strategy 14

Guidelines for construction work hours during emergencies.

During emergency recovery as a result of a major event (e.g. earthquake), infrastructure repair and construction work is expected. This strategy will support the development of guidelines for coordination of different transportation agencies for procedures and coordination protocols.

4.5 Analysis of Candidate ICM Strategies

With the stakeholders' participation, the I-880 ICM Team consultants analyzed the candidate strategies to assess their applicability, implementability and benefits of the candidate strategies.

4.5.1 Assessment of Candidate ICM Strategies against issues and ICM goals

The candidate strategies were analyzed against the gaps and needs as well as 880 ICM goals and objectives. Table 4.2 shows the mapping between gaps/needs and strategies. Table 4.3 shows the mapping between strategies and goals. These tables indicate that the selected candidate I-880 ICM strategies all contribute to reducing gaps and achieving the goals and objectives set for the I-880 corridor.

TABLE 4.2
The mapping between the gaps and needs

Gaps and Needs	Strategies
Gaps in traveler information for influencing travelers' decisions and choices	
N2) Needs for a corridor/regional based traveler information system	Strategy #1 A corridor-based multimodal advanced traveler information system that supports travelers pre-trip planning Strategy #2 Promote route shifts between roadways via en-route traveler information devices advising motorists of congestion ahead, directing them to adjacent freeways or arterials. Strategy #3 Promote modal shifts from roadways to transit via en-route traveler information devices advising motorists Strategy #4 Promote shifts between transit facilities via en-route traveler information devices advising riders of outages and directing them to adjacent rail or bus services.
II. Gaps in collaboration among agencies for operational collaborations	
N3) Needs for coordination between freeway and arterial operations	Strategy #5 Coordinated operation between freeways and arterial traffic signals Strategy #6 Enhance arterial signal timing with advance information about special events at Oakland Coliseum.
N4) Needs for coordination between highway and transit operations	Strategy#8 AC Transit adjusts operations based on real-time information about highway incidents and special events
N5) Needs for coordination between transit systems	Strategy #9 Transit hub connection protection for special events or major incidents
N6) Needs for coordination between highway and freight operations	Strategy # 10 Port of Oakland advises arriving and departing trucks about port delay and estimated travel times
N7) Needs for coordination between highway control systems and emergency response needs	Strategy #11 Signal preemption or "best Route" for emergency vehicles
N8) Needs for coordination for incident responses	Strategy #12 Multi-agency or multi-network incident response teams and service patrols and training exercises.
Gaps in Collaboration among Agencies for Event Planning	
(N9) Needs for coordination for infrastructure construction and maintenance	Strategy #13 Coordinate scheduled maintenance and construction activities among corridor networks.
N10) Needs for coordination of construction work during emergencies	Strategy #14 Guidelines for construction work hours during emergencies.

TABLE 4.3
Relationships between candidate strategies and corridor Goals

	Improve efficiency of individual network	Balance demand across the networks	Enable travelers to make informed choices	Respond quickly and effectively to service disruptions
#1 A corridor-based pre-trip ATIS database	●	○	●	O
#2 Promote route shifts between roadways via en-route traveler information device		●	●	●
#3 Promote modal shifts from roadways to transit via en-route traveler information devices	○	●	●	●
#4 Promote shifts between transit facilities via en-route traveler information devices		●	●	●
#5 Coordinated operation between freeway and arterial traffic signals	●	●		O
#6 Enhance arterial signal timing with advance information about special events at Coliseum				●
#7 Transit signal priority	●	○		O
#8 AC Transit adjusts operations based on real-time about incidents and special events				●
#9 Transit hub connection protection for special events or major incidents		●		O
#10 Port of Oakland advise trucks travel time based on real-time traffic information			●	O
#11 Signal pre-emption or "best route" for emergency vehicles	●			●
#12 Multi-agency or multi-network incident response teams and service patrols and training exercises	●			●
#13 Coordinate scheduled maintenance and construction activities among corridor networks	●	●		●
#14 Guidelines for construction work hours during emergencies or special events	●			●

○ Strategy indirectly supports objective
● Strategy directly supports objective

4.5.2 Analysis of Candidate ICM Strategies

The candidate ICM strategies were further analyzed from the following perspectives:

- What are the current operations
- The objective of the strategy
- How the strategy would work under different scenarios
- Expected benefits
- Information sharing requirements
- How this strategy is measured
- Stakeholders involved
- Technical implementation challenges
- Institutional implementation challenges

The analysis is documented in worksheets. The next few worksheets provide detailed descriptions of the I-880 ICM candidate strategies involving using real-time information. The analysis helps to facilitate the understanding of the proposed strategies.

Strategy #1		A corridor-based advanced traveler information system (ATIS) database that provides information to travelers pre-trip.
What is the current operation?		511 Traveler Information System (MTC) real-time speed and predicted travel times. Real-time transit arrival data for select Muni and AC Transit (NextBus).
Objectives of this ICM Strategy		1) To provide travelers and transportation managers with accurate real-time and historic traffic conditions along the 880 corridor for them to make pre-trip decisions to adjust route, mode, time of travel or operations. 2) To improve user access to pre-trip traveler information. 3) To improve individual travel time and overall congestion levels by showing effect of trip delay, route change or mode shift.
How would it work under different scenario and what are expected benefits?	Normal Operation	Under normal conditions, agencies provide and share access to enhanced real-time and historic traffic information to help travelers better estimate trip time and to make better decisions on transit scheduling. E.g., the 511 web portal could provide 880-specific traffic and transit conditions, personalized travel time predictions, historic travel time comparisons, alternate routing suggestions, alternate mode choices, real-time transit arrivals, weather conditions, parking reservations.
	Scheduled Events	Agencies provide and share information on duration of special events and the affected network. The 511 web portal could provide 880 specific conditions, personalized travel time predictions, historic travel time comparisons based on similar events, routing suggestions, alternate mode choices, schedules of upcoming events.
	Incidents (Highway and Arterials)	Agencies provide and share information on incident and the affected network. The 511 web portal could provide 880 specific conditions, personalized travel time predictions, historic travel time comparisons based on similar incidents, routing suggestions, and alternate mode choices.
	Incidents (Transit)	Agencies provide and share information on transit incident and the affected network. The 511 web portal could provide alternate routing or mode choices, service interruption information time estimates.
	Major events	Agencies provide and share information on the extent of the emergency and the affected network. Based on regional protocols, coordinated emergency operation service plan should include 511. The 511 web portal could provide 880 specific conditions, emergency communications, routing suggestions, and alternate mode choices.
Information sharing requirements (Specify information type, accuracy and updated rate)		Traffic condition information along corridor, including real-time and historical speeds, bottleneck locations and queue lengths Incident information, including real-time and historical incident data Predicted travel time, including real-time and historical travel times
How this strategy is measured (MOEs)		Percentage of corridor lane-miles and transit fleets with accurate real-time speed and travel time data Percentage of transit fleets with real-time arrival data Number of agencies that can share real-time traveler information Percentage of information consumers who believe information is helpful
Stakeholders involved (and their functions)		MTC (operations & management of 511, information dissemination); Caltrans (providing freeway traffic and incident information); AC Transit (sharing real-time location info); BART (sharing real-time location info); Alameda County Congestion Management Agency (providing arterial traffic and incident info); California Highway Patrol; Media (information dissemination)
Technical implementation challenges		1) Upgrade existing 511 system to improve user access, communicate/integrate with historical travel time and incident data, add new functionalities of matching/mining historical data, and to implement personalized travel times; 2) Additional detection and monitoring coverage required beyond 880 corridor to provide better travel time accuracy for alternate routes; 3) Reliable and efficient models to generate accurate predicted travel time and appropriate alternate routes under incident or congestion scenarios
Institutional implementation challenges		511 Strategic Plan leaves open possibility of alternative business models for delivery of traveler information; Possibility of resistance from transit agency staff of real-time location info, fearing monitoring of individual's record of schedule adherence

Strategy #2		Promote route shifts between roadways via en-route traveler information devices (e.g. CMS, HAR, "511") advising motorists of congestion ahead, directing them to adjacent freeways or arterials.
What is the current operation?		Limited coordination between Caltrans Traffic Operations System (including Changeable Message Signs and Highway Advisory Radio), MTC 511 system, local news media and Information Service Providers.
Objectives of this ICM Strategy		Divert traffic demand from congested locations to areas of the roadway network with excess capacity. Improve individual travel time and reduce overall congestion levels by providing travelers with travel times and alternative route choices en-route.
How would it work under different scenario and what are expected benefits?	Normal Operation	Expansion and enhanced coordination of TOS (CMS and HAR), 511 and other agency's detection and information dissemination capabilities to provide coordinated real-time traffic conditions combined with travel times, alternative routing suggestions and assistance. Result would be increased diversion away from congested locations.
	Scheduled Events	In addition to Normal Operation, improve coordination with event organizers to implement coordinated response of TOS, 511 and other agency's detection and information dissemination capabilities. Result would be early warning of traffic impacts for planned special events and dissemination of alternative routing information.
	Incidents (Highway and Arterials)	In addition to Normal Operation, expand and enhance coordination of TOS, 511 and other agency's information dissemination capabilities to quickly provide incident information, revised travel times and alternative routing information to roadway users.
	Incidents (Transit)	Expand and enhance coordination of TOS and 511 with transit agencies to quickly provide transit incident information to transit operators. Bus transit operators can utilize incident information to quickly make service routing adjustments as needed.
	Major events	Following regional emergency protocols, coordinate TOS, 511 and other agency's information dissemination capabilities to quickly provide emergency routing information to the public and divert traffic away from hazards.
Information sharing requirements (Specify information type, accuracy and updated rate)		Traffic information along corridor Traffic information on parallel arterials and alternative routes, including speeds, bottleneck locations and queue lengths if any, ramp metering logic, traffic signal timing planning and coordination Incident location and severity information, including whether it is related to traffic or transit network, incident type, location, date and time, severity and estimated delays, roadway condition, weather condition, etc.

Strategy #2	Promote route shifts between roadways via en-route traveler information devices (e.g. CMS, HAR, "511") advising motorists of congestion ahead, directing them to adjacent freeways or arterials.
	Predicted travel time, including predicted travel times along corridor, on alternative routes, and via transit
How this strategy is measured (MOEs)	Improved individual travel time Reduced overall travel delay (under special events, incidents or major events) Responsiveness to changes due to events and changes of roadway/traffic conditions
Stakeholders involved (and their functions)	MTC (operations & management of 511, information dissemination) Caltrans (TOS operations) Alameda County Congestion Management Agency (providing arterial traffic and incident info) California Highway Patrol (incident response) Port of Oakland (information dissemination) Media (information dissemination)
Technical implementation challenges	Integration of multiple existing systems (e.g., 511, Caltrans CMS) into a unified system that can smoothly interchange corridor level traffic information (such as real time traffic conditions, incidents, and travel times) and disseminate the information to the public via different channels in a timely manner Development of reliable models to predict corridor level travel times, incident detection, alternate routes recommendations, etc. Development of reliable methods for assisting drivers to take the alternative routes, e.g., using the alternative route signing system.
Institutional implementation challenges	Local government concern over potential diversion of excess demand on freeways to local streets There is a need for updating operations guidelines to incorporate enhanced interagency coordination strategy for information delivery The operation is more complex than the current approach; more training of traffic and transit operations personnel for response planning will be needed Logistics of coordinated response among agencies, especially for incident and emergency management, will require detailed interagency agreements.

Strategy #3		Promote modal shifts from roadways to transit via en-route traveler information devices (e.g. CMS, HAR, "511") advising motorists of congestion ahead, directing them to high-capacity transit networks and providing real-time information on the number of parking spaces available in the park and ride facility.
What is the current operation?		Some promotion of alternative modes through media and information service providers. Other static promotion of alternative modes through traditional media outlets (print, radio, employer incentives). Pilot demonstration of Smart Parking at Rockridge BART on SR-24.
Objectives of this ICM Strategy		Divert traffic demand from congested locations of the roadway network to high-capacity transit networks. Improve transit ridership and reduce overall congestion levels by providing travelers with guidance to alternative mode choices and transit status en-route.
How would it work under different scenario and what are expected benefits?	Normal Operation	Expand, enhance and coordinate outlets for providing travelers with en-route guidance to alternative mode choices and transit scheduling/status linked to real-time traffic conditions and congestion hotspots. Information dissemination outlets include CMS, HAR, 511, media and information service providers. The result would be Smart Parking deployments at all BART and major transit hubs in the 880 corridor, providing true coordination between the freeway system, transit stations/park & ride lots and transit scheduling.
	Scheduled Events	In addition to Normal Operation, implement enhanced coordination of transit scheduling with event organizers in pre-planned locations, including real-time parking availability and driver guidance to available parking and transit connection. Result would be rapid transit response to divert freeway traffic to transit for planned special events.
	Incidents (Highway and Arterials)	In addition to Normal Operation, implement rapid transit response to major roadway network incidents, including coordination of transit scheduling with incident response at transit stations/park & rides, including real-time parking availability and driver guidance to available parking and transit connection. Result would be rapid transit response to divert traffic from roadways to transit during major incidents.
	Incidents (Transit)	In addition to Normal Operation, provide information to roadway users of major transit incidents, including guidance to alternate transit stations/park & rides, including real-time parking availability. Result would be additional flexibility of transit network in the event of major transit disruptions, retention of transit ridership during service interruptions.
	Major events	Following regional emergency protocols, coordinate TOS, 511 and transit agency's information dissemination capabilities to quickly provide emergency transit routing information to the public, divert traffic away from hazards and facilitate mass evacuations if necessary.
Information sharing requirements (Specify information type, accuracy and updated rate		Traffic information along corridor, including real time speeds, bottleneck locations and queue lengths Traffic information on parallel arterials and alternative routes, including real time speeds, bottleneck locations, and queue lengths Transit scheduling Transit station/P&R facility locations

Strategy #3	Promote modal shifts from roadways to transit via en-route traveler information devices (e.g. CMS, HAR, "511") advising motorists of congestion ahead, directing them to high-capacity transit networks and providing real-time information on the number of parking spaces available in the park and ride facility.
	Real-time transit vehicle location and arrival times Incident information, including whether it is related to traffic or transit network, incident type, location, date and time, severity and estimated delays, roadway condition, weather condition, etc. Predicted travel time, for both corridor, alternative routes and transit networks Travel information on transit networks, including schedules, delays, trip times, parking space availability (for BART)
How this strategy is measured (MOEs)	Improved transit ridership Improved transit customer satisfaction Reduced overall travel delay (under special events, incidents or major events) Responsiveness to changes due to events and changes of roadway/traffic conditions
Stakeholders involved (and their functions)	MTC (operations & management of 511, information dissemination) Caltrans (TOS operations) AC Transit (sharing real-time location info) BART (sharing real-time location info) Alameda County Congestion Management Agency (providing arterial traffic and incident info) California Highway Patrol Media (information dissemination)
Technical implementation challenges	Integration of multiple existing systems (e.g., 511, Caltrans CMS) into a unified system that can smoothly interchange multi-modal traffic information (such as real time traffic conditions, incidents, and travel times for both traffic and transit networks) and disseminate the information to the public via appropriate channels in a timely manner Development of reliable models to predict corridor level travel times, transit parking space availability, incident detection, etc.
Institutional implementation challenges	Possibility of resistance from neighborhoods with major transit stations, fearing parking overflow in local streets (especially during major incidents). Transit agencies may need to consider appropriate access control schemes for available parking to control demand during normal operations, including parking pricing and reservation systems. There is a need for updating operations guidelines to incorporate enhanced interagency coordination strategy for information delivery The operation is more complex than the current approach; more training of traffic and transit operations personnel for response planning will be needed Logistics of coordinated response among agencies, especially for incident and emergency management, will require detailed interagency agreements.

Strategy #4		Promote shifts between transit facilities via en-route traveler information devices (e.g. station message signs and public announcements) advising riders of outages and directing them to adjacent rail or bus services.
What is the current operation?		Manual coordination among transit agencies providing information on transfer locations and schedule coordination.
Objectives of this ICM Strategy		Improve transit ridership and convenience of transit usage by providing travelers with guidance with transfers among alternative mode choices as well as real-time transit status en-route.
How would it work under different scenario and what are expected benefits?	Normal Operation	Expand, enhance and coordinate outlets for providing travelers with en-route transit trip guidance, transit scheduling/status and transfer assistance. Information dissemination outlets include station information message systems, 511, media and information service providers. Result is hoped to be networked station information systems, Smart Parking and TransLink deployments at all major transit stations & park & ride facilities in the 880 corridor.
	Scheduled Events	In addition to Normal Operation, implement enhanced coordination of transit operations and connectivity with event organizers in pre-planned locations, including timed connections and rider guidance for transit connections. An example would be coordinated ferry, BART and AC Transit response to a major festival on Treasure Island. The result would be coordinated interagency transit response to planned special events.
	Incidents (Highway and Arterials)	In addition to Normal Operation, implement rapid transit operations response to major roadway incidents that impact transit operations. This would include coordination of transit scheduling with incident response at transit stations/park & rides, including real-time transit status, alternative routing availability, rider guidance to alternative connections, and updated travel time estimates.
	Incidents (Transit)	In addition to Normal Operation, provide information to transit users of major transit service interruptions, coordination of transit scheduling with incident response at transit stations/park & rides, including real-time transit status, alternative routing availability, rider guidance to alternative connections, and updated travel time estimates. Result would be additional flexibility of transit network in the event of major transit disruptions and retention of transit ridership during service interruptions.
	Major events	Following regional emergency protocols, coordinate TOS, 511 and transit agency's information dissemination capabilities to quickly provide emergency transit routing information to the public, divert traffic away from hazards and facilitate mass evacuations if necessary.
Information sharing requirements (Specify information type, accuracy and updated rate)		Traffic information along transit routes, including real time speeds, congestion locations and duration Incident information, including whether it is related to traffic or transit network, incident type, location, date and time, severity and estimated delays, roadway condition, weather condition, etc. Real-time transit vehicle location and arrival times Transit routing and scheduling information Predicted transit travel time

Strategy #4	Promote shifts between transit facilities via en-route traveler information devices (e.g. station message signs and public announcements) advising riders of outages and directing them to adjacent rail or bus services.
How this strategy is measured (MOEs)	Convenience of transit use (customer satisfaction) Improved ridership Retention of transit usage for travelers with multiple transfers to reach destination (under special events, incidents or major events) Responsiveness to changes due to events and changes of transit and traffic conditions
Stakeholders involved (and their functions)	MTC (operations & management of 511, information dissemination) Caltrans (TOS operations) AC Transit (sharing real-time location, routing and scheduling info) BART (sharing real-time location, routing and scheduling info) Alameda County Congestion Management Agency (providing arterial traffic and incident info) California Highway Patrol Media (information dissemination)
Technical implementation challenges	Information integration of all transit modes and development of a unified system to automatically coordinate transit agencies in case of recurrent congestion, incidents, and major events. Development of reliable methods to automatically generate alternate transit route and transfer locations based on real-time transit conditions
Institutional implementation challenges	Possibility of resistance from transit agency staff of real-time location info, fearing monitoring of individual's record of schedule adherence There is a need for updating operations guidelines to incorporate enhanced interagency coordination strategy for information delivery The operation is more complex than the current approach; more training of traffic and transit operations personnel for response planning will be needed

Strategy #5		Coordinated operation between freeway and arterial traffic signals
What is the current operation?		Currently there is direct linkage between arterial signal timing (on State, county, and city arterials) and ramp metering on the 880 freeway. Caltrans can and presumably does use arterial signal timing plans from the various jurisdictions in setting the ramp meter plans at individual on-ramps on the 880. However, the systems are not directly linked and total travel times that encompass both arterial and freeway travel are not optimized. It is unclear whether arterial signal timing currently considers ramp meter rates at all (need to check with different jurisdictions)
Objectives of this ICM Strategy		To optimize overall corridor travel times by integrating arterial signal planning systems with ramp metering systems.
How would it work under different scenario and what are expected benefits?	Normal Operation	Detection on both arterials and freeways provide traffic conditions that in turn modify arterial signal timing and ramp metering to optimize overall travel times. Note that significant detection may be needed on the 880 arterials to enable this strategy.
How would it work under different scenario and what are expected benefits?	Scheduled Events	When arterial configurations are modified for special events (e.g., a ball game at the Coliseum), the ramp metering system needs to understand these changes so that overall travel times can be optimized. Most likely, there will be pre-defined configurations that will be used so that the ramp metering systems can properly understand the traffic conditions sent by the arterial detection systems.
How would it work under different scenario and what are expected benefits?	Incidents (Highway and Arterials)	Same as under normal operations.
How would it work under different scenario and what are expected benefits?	Incidents (Transit)	Same as under normal operations.
How would it work under different scenario and what are expected benefits?	Major events	Same as under normal operations.
Information sharing requirements		Arterial configuration in operations Real-time information on freeway traffic conditions Real-time information on arterials traffic conditions
How this strategy is measured (MOEs)		Overall travel time on both freeway and arterials Total delay on both freeways and arterials
Stakeholders involved (and their functions)		Caltrans County of Alameda Cities (Fremont, Union City, Oakland, Hayward)

Technical implementation challenges	This strategy requires significant detection capabilities on both arterials and freeways. Mid-block detectors on arterials will be needed. Caltrans, the county, and the cities do not all use the same arterial software, which makes it difficult to add specific real-time optimizations of signal timing plans. Many arterial signals only connect to a central hub upon request. This would slow down the real-time optimization of signal timing plans. The same lack of continuous communications will make it difficult for ramp metering systems to receive traffic conditions on the arterials.
Institutional implementation challenges	A multi-agency participation agreement needs to be established that defines thresholds of performance on arterials. Cities are likely to require such an agreement before they sign off on this strategy. If possible, an agreement on using one single software platform for arterial signal timing may be required. Fortunately, there is a system developed by Caltrans (CTnet) that could be used without additional capital costs.

Strategy #6		Special Events Signal Timing
What is the current operation?		Existing time of day signal timings are implemented along the project corridors. As these timing are static in nature, the system cannot react to real-time major fluctuations in traffic demand.
Objectives of this ICM Strategy		To accommodate a short-term increase in traffic volumes by adjusting signal timing parameters and reducing delays as a result of planning special events.
How would it work under different scenario and what are expected benefits?	Normal Operation	Existing time of day signal timings are implemented along the project corridors. With Special Events, the operation is same as normal operations, except local Police Departments may put the signals on flashing operation and manual direct traffic.
	Scheduled Events	See Above
	Incidents (Highway and Arterials)	Same as normal operations.
	Incidents (Transit)	NA
	Major events	NA
Information sharing requirements (Specify information type, accuracy and updated rate)		Incident information on Freeways on other Agency roadways
How this strategy is measured (MOEs)		Reduction in delay Reduction in secondary incidents
Stakeholders involved (and their functions)		Local Agencies Caltrans
Technical implementation challenges		Integrate local agencies traffic management systems and add a Traffic Adaptive/Traffic Responsive Module
Institutional implementation challenges		Local agencies not willing to allow diversion to local roads as a result of normal freeway congestion.

Strategy #7		Signal Priority for Transit
What is the current operation?		Transit signal priority system is used for the AC Transit Rapid Bus route along the E.14th Street/International Blvd. There are approximately 50 intersections equipped with the transit signal priority along the E.14th Street/International Blvd corridor
Objectives of this ICM Strategy		To address negative impact on buses caused by moving traffic from freeway to arterials by providing transit signal priority To provide reliable resources for modal shifts.
How would it work under different scenario and what are expected benefits?	Normal Operation	Expanded network of transit signal priority at local intersections. When the buses approach the intersection, an early green is granted to the buses to allow the buses to avoid stopping. The result would be decrease in transit travel time, thereby providing reliable resource for modal shifts.
	Scheduled Events	N/A
	Incidents (Highway and Arterials)	Depending on the types of incidents, signal priority may be disabled under situations where incident clearance has higher priority.
	Incidents (Transit)	Unless signal priority system is disabled, TSP should work in same way as normal operation
	Major events	Depending on the types of events, signal priority may be disabled if it begin to disrupt emergency operations.
Information sharing requirements (Specify information type, accuracy and updated rate)		Caltrans and local agencies to share Transit Signal Priority information with Easy Bay SMART Corridors Program
How this strategy is measured (MOEs)		Reduction in transit travel time
Stakeholders involved (and their functions)		Local Agencies ACCMA MTC Caltrans
Technical implementation challenges		NA
Institutional implementation challenges		Agreements for institution arrangements

Strategy #8		AC Transit adjusts bus routes, schedules and operations based on real-time information about highway and arterial traffic and special events
What is the current operation?		AC Transit Operation does not directly have real-time traffic and incident information. Traffic information may be relayed by bus drivers through ACS.
Objectives of this ICM Strategy		To provide AC Transit Operation traffic conditions along AC bus routes in order for them to make real-time decisions to adjust operations - provide more info about how to make such adjustment is to be included - specific example to be included
How would it work under different scenario and what are expected benefits?	Normal Operation	Under concurrent congestions, real-time traffic information will help AC Transit Operation to better estimate trip time and to make decisions on bus dispatching schedule (with more specifics and examples for 880)
	Scheduled Events	AC Transit Operation will route buses based on traffic conditions (with more specifics and examples)
	Incidents (Highway and Arterials)	When highway incident occurs, AC Transit Operation will adjust bus routing to avoid excessive delays (with more specifics and examples for 880)
	Incidents (Transit)	N/A
	Major events	Real-time traffic information allows transit operations to be able to dispatch buses based on needs, the condition of the roadways and traffic information (specifics and examples for 880)
Information sharing requirements (Specify information type, accuracy and updated rate)		Traffic information along bus route Incident information Predicted travel time
How this strategy is measured (MOEs)		Better schedule adherence Improved ridership (under major events) Responsive to changes due to events and changes of roadway/traffic conditions
Stakeholders involved (and their functions)		Caltrans (providing traffic and incident information) AC Transit (real-time operation adjustments)
Technical implementation challenges		Integrate traffic information with ACS Modify ACS software to enable decision support based on real-time traffic and incident information
Institutional implementation challenges		There is a need for updating operation guidelines to incorporate this new operation strategy The operation is more complicated than current approach and training of operation personnel and bus drivers is needed There can be resistance from unionized workers

Strategy #9		Transit hub connection protection for special events during major incidents
What is the current operation?		1. Transfer between AC Transit buses: Bus schedules are developed to minimize the waiting time between different routes a adjacent bus stops 2. Transfer between AC Transit bus and BART: 3. Connection information for riders: - Schedule is available for each individual route, but connection information is not given. - Currently no real-time connection information is available.
Objectives of this ICM Strategy		To minimize the transfer waiting time among AC Transit Buses BART trains for special events or major incidents
How would it work under different scenario and what are expected benefits?	Normal Operation	Service plan coordination: BART and AC Transit establish a protocol which identifies a process through which an effective connection protection plan for each special event is made prior to the event. In operation, AC Transit buses needs to follow predetermined schedule. Adjustment of the schedule at one station can affect the arrival time at downstream stations. Therefore, it is not practical to do connection protection under normal operation scenario.
	Scheduled Events	For scheduled events, AC Transit and BART will develop a coordinated service plan, including connection protection protocols: a. AC Transit and BART share real-time operation info for relevant buses and trains that involves special event transportation. AC Transit operation center will decide and inform drivers to hold buses for a TBD time period in order to facilitate connection. b. Provide real-time information to AC Transit bus drivers and based on a predetermined operation protocol, drivers will decide to hold buses for connection.
	Incidents (Freeway and Arterials)	When highway incidents occur, Caltrans shares incident information with BART and AC Transit. Based on this information. This adjusted schedule, together with real time operation information will be shared between the two agencies and will be used for connection protection operation: Operation procedures are the same as described in (a) and (b) in the scheduled event.
	Incidents (Transit)	BART and AC Transit will exchange connection information and perform connection protection using a pre-agreed protocol. Operation procedures are the same as described in (a) and (b) in the scheduled event.
	Major events (unplanned)	Immediate after the major event (such as earthquake) occurs, information about conditions of highways and BRT will become available to all operation agencies. Based on protocols, coordinated emergency operation service plan will be made.

Strategy #9	Transit hub connection protection for special events during major incidents
Information sharing requirements (Specify information type, accuracy and updated rate)	Schedule information (bus routes intersecting with BART, train schedule, real-time information on buses, schedule adherence and/or predicted bus arrival at each stop Real time information on Train (schedule adherence and/or predicted train arrival at each station, service breakdown information (where, what and predicted recovery time) for BART, real time information on freeway and arterials)
How this strategy is measured (MOEs)	Reduction of average transfer waiting time, with minimum impact to schedule adherence Increase of ridership
Stakeholders involved (and their functions)	AC Transit, BART, Caltrans and MTC/511
Technical implementation challenges	Information is mostly available. Technical challenge includes: AC Transit ACS has the capability of making real-time adjustment of the operation service but not being used at this time Data communication among AC Transit, BART and Caltrans is not available Operational constraints AC and BART have to become adaptive to problems or changes in other systems
Institutional implementation challenges	There is a need for AC Transit and BART to develop a connection protection protocol How much flexibility AC and BART have for real-time adjustments to become adaptive to problems or changes in other systems

Strategy #10		Port of Oakland Truck Information
What is the current operation?		Congestion and incident information is available to commercial vehicle operators (CVO) via the 511 system. No other information real-time feedback is available from the Port of Oakland to other agencies.
Objectives of this ICM Strategy		Create two-way information sharing between Port of Oakland and other agencies. Port of Oakland can provide port delays and incident information to ACCMA, Caltrans and 511 systems. Real-time port operation delays, congestion, incident and travel time information can be provided to the commercial vehicle operators via CMS board at locations near Port of Oakland and at the Central Valley freight center, so that truckers can adjust their departure times, based on current conditions.
How would it work under different scenario and what are expected benefits?	Normal Operation	Information about port delay, highway conditions and estimated travel time will be communicated to truck through CMS or other effective means so that truck operators can make decisions on their departure time.
	Scheduled Events	NA
	Incidents (Highway and Arterials)	Same as normal operations.
	Incidents (Transit)	NA
	Major events	Same as normal operations.
Information sharing requirements (Specify information type, accuracy and updated rate)		Between Port of Oakland, ACCMA, MTC and Caltrans.
How this strategy is measured (MOEs)		Reduction in trucking total travel times and delay Reduction in overall congestion as a result of schedule changes by the trucking industry
Stakeholders involved (and their functions)		Port of Oakland ACCMA MTC Caltrans
Technical implementation challenges		Requires CMS signs near Port of Oakland and at Central Valley freight center to disseminate information
Institutional implementation challenges		Agreements for institution arrangements

Strategy #11		Signal Pre-emption System for Emergency Services
What is the current operation?		Main arterials along the project corridor are equipped with Opticom Emergency pre-emption equipment. Most of the equipment is predominately location on the main line and sometimes on crossing arterials on major intersections. Fire Department apparatus are equipped with emitters. Intersections are trigged as they approach the intersection. Some of the Fire Department apparatus are equipped with Mobile Data Terminal (MDT) units that are connected to the East Bay SMART Corridors web site.
Objectives of this ICM Strategy		Dynamically recommend a preferred route, based on real-time congestion information. Provide comprehensive real-time congestion information to mobile fire trucks so that a more optimum path can be selected. Additionally, other emergency service providers (Ambulances and Police) can be equipped with similar MDTs.
How would it work under different scenario and what are expected benefits?	Normal Operation	Emergency response personnel can be informed what is the best route based on real-time traffic conditions. Preemption will be provided at local intersections.
	Scheduled Events	NA
	Incidents (Highway and Arterials)	Same as normal operations.
	Incidents (Transit)	NA
	Major events	Same as normal operations.
Information sharing requirements (Specify information type, accuracy and updated rate)		Caltrans and local agencies need to share congestion information and incidents with East Bay SMART Corridors program
How this strategy is measured (MOEs)		Reduction in response time
Stakeholders involved (and their functions)		Local Agencies (Fire Departments) ACCMA MTC Caltrans
Technical implementation challenges		Integration of Fire Department CAD system to the 511 and East Bay SMART Corridors program Installation of MDT on all fire departments apparatus
Institutional implementation challenges		Agreements with Emergency Service providers for system integration

Strategy #12		Multi-agency or multi-network incident response teams and service patrols and training exercises
What is the current operation?		FSP provides incident response 6-10AM and 3-7PM BAIRS (Bay Area Incident Response System) provides incident response outside of FSP hours
Objectives of this ICM Strategy		To improve incident detection, verification, response, clearance
How would it work under different scenario and what are expected benefits?	Normal Operation	Faster incident clearance
	Scheduled Events	Faster incident clearance
	Incidents (Highway and Arterials)	Faster incident clearance. Three areas of improvement have been identified: Improve response time for supervisors to come to incident scene and verify conditions Provide special heavy-duty incident response trucks (either roving or stationary) to assist with removal of trucks or in case on multi-vehicle accidents Improve accuracy of incident logging at CHP CAD system
	Incidents (Transit)	N/A
	Major events	Faster incident clearance
Information sharing requirements (Specify information type, accuracy and updated rate)		Incident information including location, number of lanes blocked, etc.
How this strategy is measured (MOEs)		Time elapsed for incident detection, verification, response, clearance Delay caused because of incident
Stakeholders involved (and their functions)		Caltrans (providing traffic and incident information, BAIRS) FSP
Technical implementation challenges		Improve accuracy of incident logging at CHP CAD system
Institutional implementation challenges		Better coordination between supervisors responsible for incident verification

4.5.3. Potential Benefits of 880 ICM Strategies

The strategies that will be developed for the ICM demonstration will facilitate aggressive and proactive integration and management of major transportation corridors, and therefore will become a tool for Caltrans, MTC, ACCMA and the local cities to effectively manage their transportation networks to best utilize existing capacity, mitigate congestion, and achieve higher productivity. Specifically, the ICM system should provide the following improvements in the I-880 corridor:

- Enhance the ability of the partner agencies to provide true integration of multiple operational components of the corridor. Although the operators of each transportation network in the corridor have expressed the desire to integrate their operations with the other networks, this has not fully occurred because the necessary analysis and design work has not yet been conducted.
- Better management of **non-recurrent congestion** caused by major incidents, unexpected weather events, unexpectedly high travel demand, and major construction and maintenance activities by allowing the full capacity of the corridor to be utilized through improved integration.
- Provide improved capabilities to manage daily **recurrent congestion** in the corridor. Specifically, the ICM could benefit the operation of the existing freeway ramp meters by allowing the system to adapt to evolving conditions on both the freeway and arterial system.
- Improve incident clearance times (including coordination with CHP and Freeway Service Patrol to tow disabled vehicles).
- Increase transit mode share.
- Improve the reliability (or predictability) of travel time.
- Provide travelers with real-time information and routing options based on changing conditions.

The ICM strategies proposed for further evaluation in the I-880 corridor build on existing systems that represent the foundation for integration.

For instance, freeway ramp metering and arterial signal coordination are key systems that help reduce travel times, bottleneck queues, and overall delay. Integrating these two systems (or sets of systems) offers additional benefits to both the person movement and goods movement markets.

These two systems also rely on the detection systems that provide valuable data for the traveler information systems in the corridor and on the regional 511 Traveler Information System. For instance, the changeable message signs (CMS) on the corridor currently provide travelers with estimated travel times to key destinations (e.g., downtown San Francisco). The proposed ICM strategies would expand such en-route traveler information to the airport and sea port to provide truck drivers and arriving air passengers with pre-trip travel time estimates to key destinations.

So in essence, the proposed strategies leverage existing investments in systems and field equipment by integrating and expanding the set of strategies currently employed in the corridor.

It is expected that the benefits of selected strategies will vary in type and magnitude. Some benefits will be quantified by one or more system performance outcomes and associated measures (metrics), which include:

- Mobility (travel time, speed, delay, bottleneck queues)
- Reliability (variation in travel time, on-time performance, buffer index)
- Productivity (percent utilization during peak demand conditions)
- Safety (number of accidents, accident rates)

Other strategies will focus on improving the effectiveness of specific business processes. These improvements will also impact system performance, but will include additional measures such as:

- Incident clearance times
- Wait times at ramps
- Magnitude of road traffic shifts
- Magnitude of modal shifts
- Percent truck traffic during peak demand conditions

Finally, additional qualitative benefits are expected from some of the selected strategies. For instance, en-route traveler information (e.g., travel times to key destinations) do not always lead to route or mode shifts. However, they do provide information to drivers that benefit their work (e.g., calling the office to postpone a meeting for a few minutes) or personal lives (e.g., knowing that one will be on time for a personal event).

The rest of this section provides more detailed examples of the aforementioned benefits. Where possible, an estimate is provided for the magnitude of benefits based on previous studies and associated evaluations. The following table summarizes the types of benefits expected for each set of related strategies.

TABLE 4.4
Summary of the types of benefits expected for each set of related strategies

Set of Related Strategies	Strategies Included	Types of Benefits
Traveler Information Strategies	■ A corridor-based advanced traveler information system (ATIS) database that provides information to travelers pre-trip. ■ En-route traveler information devices owned and operated by network agencies (e.g., DMS, 511, transit public announcement systems) being used to describe current operational conditions on another network(s) within the corridor. ■ Promote route shifts between roadways via en-route traveler information devices (e.g. DMS, HAR, "511") advising motorists of congestion ahead, directing them to adjacent freeways or arterials. ■ Promote modal shifts from roadways to transit via en-route traveler information devices (e.g. DMS, HAR, "511") advising motorists of congestion ahead, directing them to high capacity transit networks and providing real-time information on the number of parking spaces available in the park and ride facility.	■ Moderate mobility and reliability benefits derived from modal shifts, route shifts, and change in time of travel ■ Increased transit usage during unusual congestion ■ Reduced emissions from modal shifts ■ Customer satisfaction from improved information
Roadway/Transit Coordinated Operations Strategies	■ Signal priority for transit (e.g. extended green times to buses that are operating behind schedule). ■ AC Transit adjusts bus routes, schedules and operations based on real-time information about highway traffic and special events	■ Transit travel time and reliability improvements ■ Increased transit usage ■ Reduced emissions ■ Moderate mobility and reliability improvements for roadways (to the extent modal shifts occur)
Freeway/Arterial Operations Integration Strategies	■ Coordinated operation between ramp meters and arterial traffic signals. ■ Modify arterial signal timing to accommodate traffic shifting from freeway. ■ Modify ramp metering rates to accommodate traffic shifting from arterial. ■ Enhance arterial signal timing with advance information about special events	■ Significant mobility and reliability improvements ■ Improved productivity of the roadway system (i.e., higher throughput during peak demand conditions), possibly leading to peak period contraction

Set of Related Strategies	Strategies Included	Types of Benefits
	at Coliseum.	■ Reduced emissions ■ Strategies and associated algorithms can benefit other corridors in the Bay Area and beyond ■ Possible cost reductions from automation
Transit-Transit Operations Integration Strategies	■ Transit hub connection protection (holding one service while waiting for another service to arrive). ■ Promote shifts between transit facilities via en-route traveler information devices (e.g. station message signs and public announcements) advising riders of outages and directing them to adjacent rail or bus services.	■ Reduced transit passenger travel time ■ Improved customer satisfaction ■ Reduced non-recurrent delays
Freight Operations Strategy	■ Port of Oakland advises truck travel time based on real-time traffic information.	■ Reduced travel times and reliability for trucks ■ Reduced truck traffic during incident events on corridor ■ Improved reliability on corridor
Emergency Response and Special Events Integration Strategies	■ Signal pre-emption or "best route" for emergency vehicles. ■ Multi-agency or multi-network incident response teams and service patrols and training exercises.	■ Reduced fatality rates due to faster emergency responses ■ Reduced secondary accidents ■ Improved incident clearance times reducing impacts on traffic ■ Improved reliability on the corridor ■ Reduced emissions
Planning Integrated Operations Strategies	■ Coordinate scheduled maintenance and construction activities among corridor networks. ■ Guidelines for construction work hours during emergencies or special events.	■ Reduced non-recurrent delays due to construction ■ Reduced emissions

The evaluation of these strategies will include algorithm development, travel demand modeling, simulation modeling, air quality assessments, cost estimation, benefit-cost analysis, and additional stakeholder discussion, likely resulting in institutional changes/improvements. Below are short discussions on a number of system improvements and estimated targets from ICM implementation.

Estimated Total Weekday Delay Reduction Target – 10 percent

It is anticipated that current conditions will improve in significant ways. For instance, Table 4.5 shows the average total delays for the corridor over the last few years. Note how the mid-day delays have increased significantly. Total delays averaged more than 11,000 hours for weekdays. The initial estimate shows the strategies proposed should reduce these delays by about 10 percent. These reductions include both recurrent delay reductions as well as non-recurrent delay reductions (e.g., from improved incident clearance times).

TABLE 4.5
Delay Trends for Weekdays on the I-880 Corridor

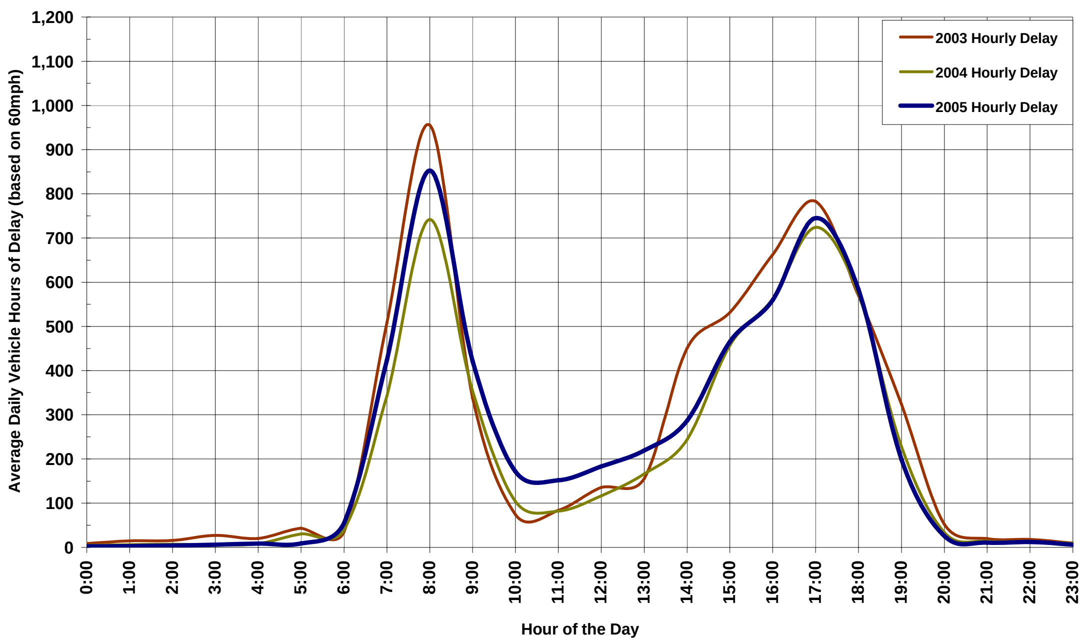
	Northbound Direction				
Year	AM Peak	Mid Day	Evening and Early AM	PM Peak	Total Daily
2003	1,499	1,237	552	2,547	5,835
2004	1,124	1,067	360	2,317	4,867
2005	1,331	1,434	285	2,351	5,402
	Southbound Direction				
Year	AM Peak	Mid Day	Evening and Early AM	PM Peak	Total Daily
2003	1,924	1,397	276	2,249	5,846
2004	1,728	1,427	291	2,375	5,821
2005	1,678	1,848	232	2,444	6,202
	Total Corridor				
Year	AM Peak	Mid Day	Evening and Early AM	PM Peak	Total Daily
2003	3,423	2,634	828	4,796	11,682
2004	2,852	2,494	651	4,691	10,688
2005	3,009	3,282	517	4,795	11,604

Peak Period Contraction Target – 10 to 15 percent

Figure 4.7 shows the delay by hour for the corridor. Note how the peak afternoon period lasts longer than the morning commute period (not unlike other corridors). It is predicted that the strategies will reduce the length of the peak delay periods by improving flows through the corridor bottlenecks.

As flow improves (even at reduced speeds), the total number of vehicles "served" by the corridor increases, reducing the total time needed to fully serve the corridor demand. The initial estimate is that the strategies proposed may target a reduction of peak congestion period by 10 percent in the morning peak and 15 percent in the afternoon peak.

FIGURE 4.7
Delay by Hour for Weekdays on the 880 Corridor
(Source: PeMS, https://pems.eecs.berkeley.edu/)



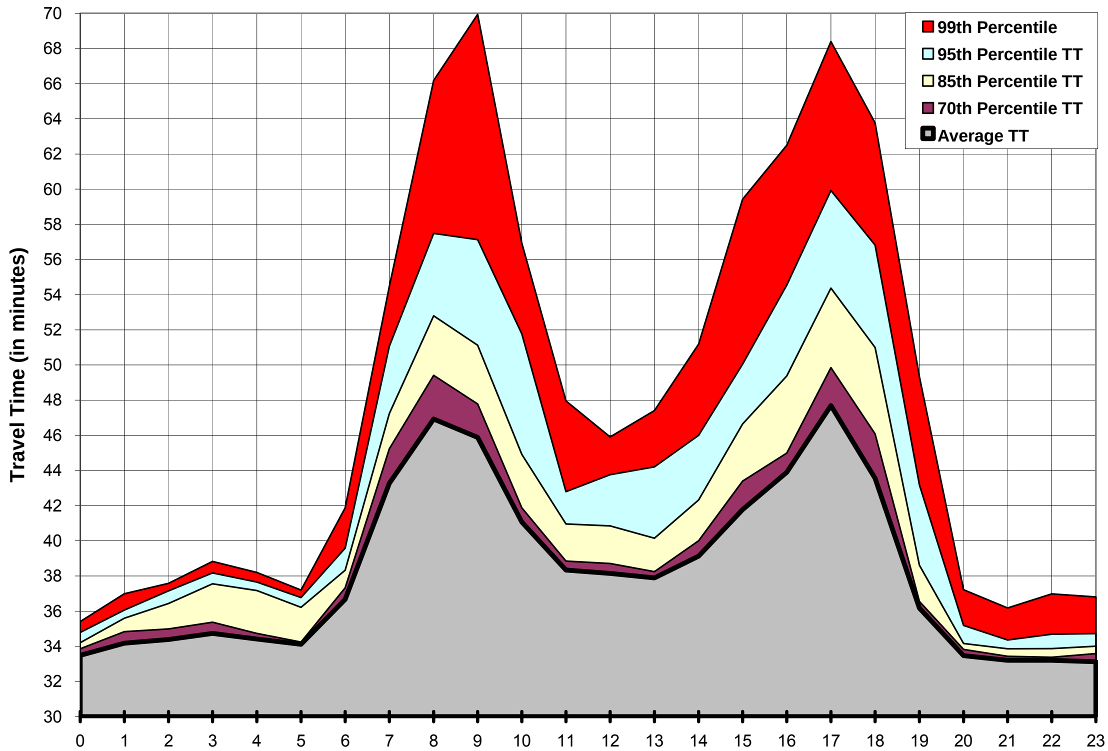
Reliability Improvements – 10 percent

Travel times on the freeway component of the corridor vary greatly as shown on Figure 4.8, which shows the travel time distribution for the southbound travel direction by time of day. Many of the proposed strategies target the narrowing of the red and light blue bands in the exhibit, which represent the highest 15 percent of travel times experienced on the corridor. Every measure used for reliability would show an improvement if these two bands narrow. For instance, if the red band narrows from 70 minutes to 64 minutes and the light blue band also narrows, measures such as the buffer index (used nationally) and the percent variability (used in California) would both reflect this improvement. Based on previous efforts, the overall improvement in reliability for the proposed strategies is estimated at 10 percent.

FIGURE 4.8

2005 Southbound Travel Time Distributions on the I-880 Corridor

(Source: PeMS,
https://pems.eecs.berkeley.edu/)



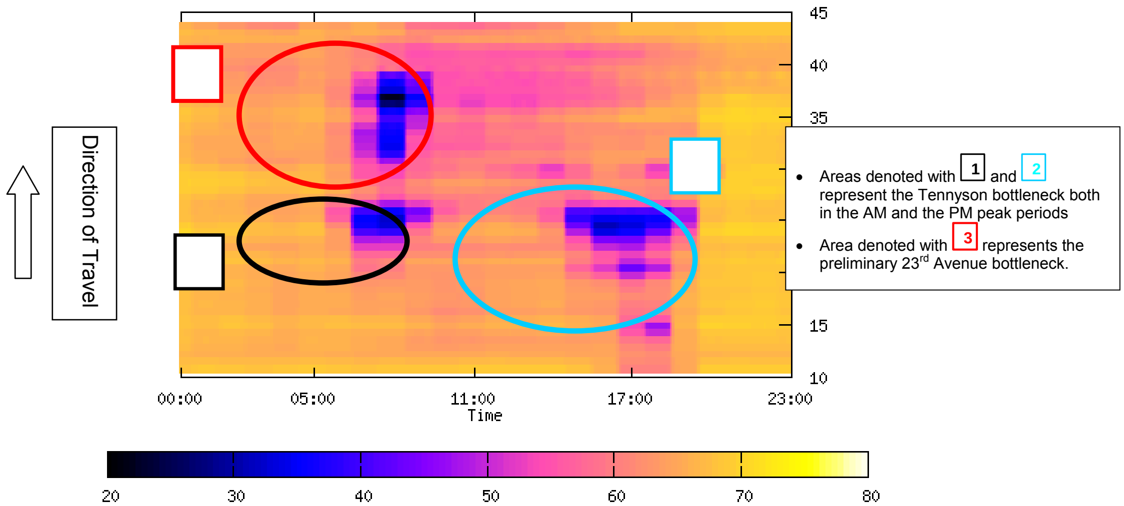
Bottleneck Queue Lengths – 10 to 20 percent

The major causes for congestion and resulting delays in the corridor relate to a number of specific bottlenecks. This is illustrated in figure 4.9, which represents a speed contour diagram for northbound direction of travel on the freeway. The diagram displays average weekday speeds by location (post mile) by time of day for the entire month of October, 2005. Note that there are three bottleneck areas with queues ranging from two miles to as much as eight to nine miles.

FIGURE 4.9

Northbound Speed Contour Map for October, 2005 for the Corridor

(Source: PeMS, https://pems.eecs.berkeley.edu/)



The bottleneck at Tennyson affects both AM and PM peak traffic. The PM peak queue length is around three miles long (from around post mile 26 back to around post mile 23). Previous analysis suggests that the cause behind this bottleneck is a major on-ramp with heavy demand that causes significant merges and weaves within an extremely short auxiliary lane. A picture of this merge is shown on figure 4.10. We believe the our proposed strategies such as on-ramp integration with arterial signaling should help alleviate some of these merges and weaves and together with a planned extension of the auxiliary lane is estimated to reduce the queue length and duration of the bottleneck by 10 percent.

FIGURE 4.10

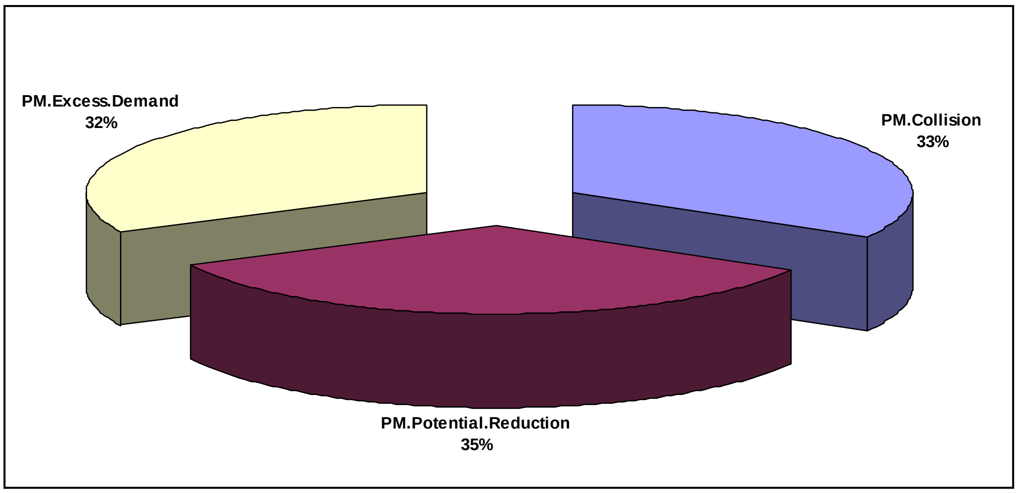
Tennyson On-Ramps and Resulting Bottleneck

(Source: Caltrans 2007)

Collision Related Delays Reduction – 10 percent

Collisions are a major cause of delays on the 880 corridor. On an average day, the corridor experiences between 10 and 15 collisions as reported by the California Highway Patrol and logged into the Caltrans accident database (TASAS). Through research and analysis of speed data, the times and impact of these collisions were used to derive the incremental delays due to these collisions. Algorithms were developed by UC Berkeley PATH research to automate the analyses within PeMS. The results are shown on figure 4.11.

FIGURE 4.11
I-880 Corridor Delay Breakdown by Cause for the PM Peak Period



As can be seen from the exhibit, collisions account for approximately a third of total congestion on the freeway during the PM peak period. Our incident management strategies should reduce collision clearance times. This in return should reduce the incremental delays. It is expected that these strategies will likely reduce these delays by at least 10 percent. Other strategies, such as increased traveler information, improved ramp metering coordination, and physical projects already programmed could further reduce these delays by reducing the number of collisions overall.

Signal Timing Coordination-delay reductions and increase in travel time

The goal of signal coordination is to get the greatest number of vehicles through corridor with the fewest stops in the safest and most efficient manner. According to a paper presented at the 2001 TRB Annual Meeting, a TRANSYT-7F model which estimated 163 projects reported an average of 7.7% reduction in travel time. 13.8% reduction in stops and 7.8% decline in fuel use. New signal coordination timing plans were developed and implemented on the San Pablo Ave Corridor which is a part of ACCMA East Bay SMART Corridors. The timing plans were updated, implemented, fine-tuned, and travel time runs were conducted to assess the benefits of updated signal timings on travel speed. The average results of four travel time runs are tabulated below.

TABLE 4.6
TRAVEL TIME IN NORTHBOUND DIRECTION (MINUTES)

Period	Before	After	Time Saved	% Change
AM Peak	35.3	32.7	2.6 minutes	7% less
Midday	35.5	34.2	1.3 minutes	4% less
PM Peak	42.1	38.9	3.3 minutes	7% less

TABLE 4.7
TRAVEL TIME IN SOUTHBOUND DIRECTION (MINUTES)

Period	Before	After	Time Saved	% Change
AM Peak	37.3	36.2	1.1 minutes	3% less
Midday	39.0	34.3	4.7 minutes	12% less
PM	42.2	38.9	3.3	8%

Peak			minut es	less

The benefits of updated signal timing coordination are based on how well the existing signal timings are coordinated. The expected benefits of traffic signal timing modification for the I-880 ICM corridor could be 10% to 20% increase in travel speed with reductions in delay between 10% and 15%.

Transit Signal Priority-Reduction in Transit Delays

The desired outcome of the transit signal priority (TSP) is to reduce the overall run time for a bus along its route. TSP is providing a significant travel time advantage to the *San Pablo Rapid* route in the Bay Area, probably in the range of 15 to 19 minutes for each one-way run through the corridor. This would equate to a route travel time of 54 minutes with TSP versus 72 minutes without TSP, or a 25% reduction. The actual transit travel time savings measured was 17%. Considering other TSP projects in the area and their benefits, the expected reduction in transit delays through TSP application for the I-880 ICM Corridor should be in the magnitude of 9 to 10 percent.

With the application of TSP, AC Transit has replaced regular bus service along the San Pablo Ave Corridor with rapid bus service, which attracted between 25% and 33% more riders than regular service. Similar benefits can be expected with the same kind of application in the I-880 ICM Corridor.

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5. ICM Implementation Issues

The I-880 ICM Team conducted a series of analysis to assess the technical and institutional feasibility of the candidate ICM strategies and to identify assets that will be needed implement and support these strategies. The technical feasibility and assets analyses were conducted through a functional analysis of the ICM system in the framework of the ITS architecture. The institutional framework has been established through consultation with the local stakeholders.

5.1 Functional Analysis

ICM strategies will be implemented through a series of existing and new functions. In order to evaluate the technical feasibility of the candidate ICM strategies, the I-880 ICM team's systems approach included a functional decomposition and functional analysis. The functional analysis provides a breakdown of the relevant transportation networks into individual functional elements, which gives a systematic view of how the existing ITS systems for the transportation networks along the I-880 corridor are configured functionally. It also helps to determine the functional capabilities that are needed to implement each of the ICM candidate strategies and whether these already exist or still need to be implemented. It further suggests how an ICM that implements the proposed strategies for the I-880 corridor should be architected and how the functions should be allocated.

The functional analysis establishes the foundation for asset assessment that maps functions to physical components, thereby ensuring that each function has an acknowledged owner and determining what new subsystems, devices or software integration are needed in order to implement the proposed ICM strategies. Because most of the functions are needed by more than one ICM strategy, the functional analysis helps determine how resources must be allocated for implementing the ICM strategies, considering stakeholders' priorities and budget constraints.

The detailed functional analysis is documented in Appendix F. Based on the functional analysis, new functions that are needed for ICM are identified, as shown in Table 5.1. It is important to note that most of the new functions are required by more than one candidate strategy. The fact that there are significant synergies among the candidate 880 ICM strategies indicates that the assessment of asset requirements and needs must be made across strategies rather than simply done for each individual strategy. The asset assessment based on functional analysis will provide higher fidelity cost estimates and better support for decisions on strategy selection.

TABLE 5.1
New Functions Required for ICM

	New ICM Functions/Allocation	Strategies that the new ICM functions support	Status	Asset Requirements and Needs
	Arterial FasTrak readers (511)	1,2,3,5,8,11,12	Currently, there are no FasTrak readers along arterials. ICM team suggests to install FasTrak readers along major arterials along 880	Fastrak readers at every 5 miles along arterial
	Arterial Data Archiving (Caltrans/511)	1,2,3,5,6,8,11,12	Currently traffic data are not archived at Caltrans. However, communication link is available. ICM Team suggest to archive the arterial data.	Data may needs to be archived at both Caltrans and MTC. New data storage devices may be needed Data base software needs to be developed/modified to include arterial traffic data
	Incident detection (Caltrans/511)	1,2,3,5,10,11,12	Incident detection currently is done mainly by phone calls. ICM Team suggests to develop incident detection algorithms for real-time detection of incidents.	Primitive incident detection has been available at 511 (using speed threshold). Updated incident detection software is needed
	Collaborative Ramp Metering/Arterial Control (Caltrans)	5,6,11	This is a new function. It needs to be developed for ICM application.	Communication from arterial traffic masters to center and from ramp meter control box needs to be completed. New ramp metering/arterial coordination strategy and control software needs to be developed
	Arterial PeMs (Caltrans)	1,2,3,5,6,7,8,11	PATH has developed arterial PeMs. It needs to be	Arterial PeMs software needs to be implemented.

	New ICM Functions/Allocation	Strategies that the new ICM functions support	Status	Asset Requirements and Needs
			improved and implemented for arterials along I-880 corridor.	
	Travel Time Estimation (511)	1,2,3,5,10	Arterial travel time estimation is not available at this time. It is suggested that the travel time estimation is developed either using FasTrak readers or through Arterial PeMs.	Travel time estimation software for arterials needs to be developed and implemented on 511.
	Arterial Incident detection (Caltrans/511)	1,2,3,6,11, 12,14	Arterial incident detection is also not available. It is desirable that such function can be developed.	Arterial incident detection software is not available and needs to be developed. This is being considered as a new development item.
	Transit Management (AC Transit)	2,3,8	AC Transit currently Transit Management System (ACS) needs to update its software in order to achieve functionalities required by ICM strategies.	AC Transit ACS software upgrade is needed.
	Bus travel time estimation (511)	1,2,4,9	Currently, AC Transit bus travel time estimation is available for bus stops through NextBus. It is desirable that bus travel time estimation is available for all buses at all stops.	Bus travel time estimation is for limited stops. Extension of this service to key bus stops along major arterials is needed.
	Connection protection (AC Transit)	3,4,9	Connection protection is done manually for special case only. It is desirable that a decision support tool	AC Transit ACS system may have the rerouting function. AC Transit needs to investigate if such function is

	New ICM Functions/Allocation	Strategies that the new ICM functions support	Status	Asset Requirements and Needs
			is available to assist the transit operations.	available.
	Travel info for trucks (Oakland Port)	10	Currently, no information is available.	A software synthesizes the estimated waiting time by Port of Oakland's ID system and travel time prediction along 880 needs to be developed.
	511 Web-based Multimodal trip planner (511)	1	Currently, automobile travel and Transit travel can be obtained separately. My 511 will be able to compare auto travel with transit travel. ICM Team recommends to develop a true multi-modal trip planner.	The following developments are needed: Real-time data feed from AC Transit, BART and Arterials Multimodal trip planner Friendly user-interface
	Arterial CMS (Caltrans/511)	2,3,7	Currently, there is no arterial CMS available. Arterial CMS will be needed for a number of strategies.	Arterial CMS needs to be installed in advanced at major diverging points
	Display @Bus Stops (AC Transit)	3,6,4,9,14	Currently, AC Transit has limited number of displays at bus stops.	AC needs to install next bus signs at major bus stops.
	CMS (Oakland Port)	10	Currently, there are no CMS signs for truck drivers. CMS signs will be needed before entering 880 corridor and at the exits of the Port.	Port of Oakland needs to install CMS signs at the Central Valley Freight center

*Note: Key for the Function Numbers:
A = Data Gathering D = Processing
B = Receiving Data
C = Data Archiving E = Interface with Users

In addition to the new ICM functions listed in Table 5.1, communication links among the different ITS systems are essential for implementing the ICM strategies. Both new ICM functions and the new communication links, mostly in the nature of integration, will be developed as part of the ICM program.

The I-880 ICM Team has done a preliminary assessment of the feasibility of these new ICM functions and believes that they are technically feasible. However, 'the devil is in the details'. The implementation of many of these functions requires multi-agency collaboration and involves changes to current operational approaches and protocols. There is a need for collaborative work on further detailed analysis and design to determine how each of the strategies can be implemented.

Note that, in addition to contributing to the ConOps development process, the functional analysis also serves a number of important roles in the remaining ICM program:

In the requirements definition phase, functional analysis will serve as a basis for mapping functions to system requirements.

The functional analysis provides the basis for the requirements allocation that guides the system implementation and testing.

The functional analysis serves as a tool for traceability of the ICM strategies.

5.2 ICM New Asset Requirements and Needs

Following the functional analysis, and working with the stakeholders, the I-880 ICM Team conducted an assessment of ICM requirements and needs. Both the existing and new functions required to implement ICM strategies are mapped into assets (The detailed function to asset mapping table is too big to be included in the report). The right column of Table 5.1 identifies asset requirements and needs for the new ICM functions.

In addition to the new functions, communication links among ITS systems will be needed. Integration of functions and systems will be the major efforts. Again, this integration effort will be shared among multiple strategies.

Note that these new ICM functions will be mapped into the Bay Area ITS architecture at the implementation stage and will be implemented in accordance with the Bay Area Regional ITS Architecture, as discussed in Section 5.3.

The I-880 ICM stakeholders were anxious to understand the capital resource needs at each corresponding agency for implementation of the ICM strategies, so as to determine the financial feasibility of each strategy. Given the fact that the final performance and functional requirements will be developed in later stages of the ICM program, there are significant uncertainties regarding the costs for the development of each function and the integration work. However, the I-880 ICM Team made an estimate based on engineering judgment. Table 5.2 is the cost estimate per function/integration work.

TABLE 5.2
Preliminary Cost Estimate for New ICM Functions and Integration Work

	New ICM Functions/Allocation	Estimated Cost	Notes
	Arterial FasTrak readers (511)	$200 K	For a total 20 readers @ $10 K per location
	Arterial Data Archiving (Caltrans/511)	$100 K	For data storage and software development
	Incident detection (Caltrans/511)	$200 K	Software development
	Collaborative Ramp Metering/Arterial Control (Caltrans)	$500 K	Development of strategies, control software and system
	Arterial PeMs (Caltrans)	$100 K	Software development
	Travel Time Estimation (511)	$100 K	Software development
	Arterial Incident detection (Caltrans/511)	$200 K	Software development
	Transit Management (AC Transit)	$2000 K	Software upgrade for ACS. Will be partially cost shared by other sources
	Bus travel time estimation (511)	$100k	Extension of the existing Next Bus or development of new estimation software
	Connection protection (AC	$0	Assume ACS already has this function

	New ICM Functions/Allocation	Estimated Cost	Notes
	Transit)		
	Travel info for trucks (Oakland Port)	$100 K	Including hardware and software for performing this function
	511 Web-based Multimodal trip planner (511)	$350 K	Development of multimodal trip planner and user interface
	Arterial CMS (Caltrans/511)	$1250 K	5 CMS @ 250 K each, potentially cost- share item
	Display @Bus Stops (AC Transit)	$400k	Installation of new dynamic signs at major bus stops
	CMS (Oakland Port)	$250 K	One @$250 K
	Wireless comm. between signals and traffic control	$50 K	Comm. from traffic masters and central
	Communication among different centers	$200 K	Software drivers and data sharing capabilities
	Integration of various strategies	$1000 K	Software development, interface, etc.

Note that the capital costs are associated directly with the functions and the assets needed to implement the functions, not with the strategies. As Table 5.1 showed, each function supports multiple strategies and the function only needs to be implemented (and paid for) once. For example, Function A12, at an estimated cost of $200 K (Table 5.2), supports Strategies 1,2,3,5,8,11 and 12 (Table 5.1). That cost cannot be allocated intelligently to the individual strategies because it is required regardless of whether all seven of those strategies are implemented or only one is implemented. These significant synergies among the strategies are not recognized if the costing is estimated at the strategy level rather than the functional level.

5.3 Alignment with Regional ITS Architecture

The Bay Area ITS Architecture is a regional ITS planning document updated approximately every three years to match the Regional Transportation Plan (RTP) update cycle. The existing Architecture was completed in October 2004 and is currently being updated, with a scheduled completion date of November 2007.

The first approach to show consistency with the regional ITS Architecture is to find the project on the project inventory, which is maintained on the Metropolitan Transportation Commission's (MTC) website http://misc.mtc.ca.gov/ITS-inventory/stakeholders.html. The latest available inventory was completed in 2002.

If the project is not listed by name in the project inventory, it may still be consistent with the Architecture. The Architecture includes a list of "Potential Regional Bay Area ITS Projects" developed to represent the long-term needs of the region as identified by the stakeholders during the Architecture development, which can be found in Table 8 of the existing Architecture (See Appendix G). These are regional projects with a general description to represent many future ITS projects.

An ITS project is consistent with the Architecture if it matches one of the above project descriptions. The I-880 ICM project is not listed by name in the Architecture. The general project descriptions match some components of the I-880 ICM, but not all. The general project descriptions that best match the I-880 ICM include the following:

> REG1 – Integrate the Caltrans Transportation Management System with other traffic management systems around the Bay Area region, as appropriate, to allow for coordinated operations and information sharing.
>
> REG4 – Integrate transit operations/management system of the various transit operators in the Bay Area region with other transit and traffic management systems and centers.
>
> TM2 – Expand and modify the functionality of the Caltrans Traffic Operations System (TOS).
>
> TM7 – Deploy projects for interoperation and coordination at agency boundaries.
>
> TI1 – Conduct projects to incorporate and integrate real-time transit information, roadway construction information, road weather information, arterial data, and other data sources in to 511.
>
> EM3 – Conduct a project to develop system interconnect from the Bay Area Incident Response System to other Bay Area region systems/stakeholders.
>
> EM4 – Implement emergency vehicle preemption in selected locations and along key corridors, as appropriate, throughout the Bay Area.

The ICM strategies that are not currently expressed in the Architecture are the ones that will integrate operations of different networks, for instance, integration of freeway and arterial operations. These integration strategies require new information flows and communication systems not currently found in the Architecture. Thus, the I-880 ICM project requires an update to the regional architecture. This can be done through the normal maintenance process by answering the following questions (see Appendix H for more details):

What stakeholders are involved? Are they all stakeholders listed in the Architecture?
For the I-880 ICM project, all stakeholders are included in the Architecture.

Which market packages does the project serve?
The I-880 ICM project may include the following market packages in the existing Architecture, depending on the ICM strategies implemented:

ATMS 1 – Network Surveillance

ATMS 2 – Probe Surveillance

ATMS 3 – Surface Street Control

ATMS 4 – Freeway Control

ATMS 6 – Traffic Information Dissemination

ATMS 7 – Regional Traffic Control

ATMS 8 – Incident Management Systems

APTS 1 – Transit Vehicle Tracking

APTS 5 – Transit Security

APTS 7 – Multi-modal Coordination

APTS 8 – Transit Traveler Information

EM 2 – Emergency Routing

EM 4 – Roadway Service Patrols

ATIS 1 – Broadcast Traveler Information

ATIS 4 – Dynamic Route Guidance

ATIS 6 – Integrated Transportation Management/Route Guidance

MC 01 – Maintenance and Construction Vehicle Tracking

MC 08 – Work Zone Management

What ITS Standards will be used?

This will be decided for the I-880 ICM project as planning and design progress.

What are the impacts on planned ITS projects?

This will be addressed as the project progresses. The ICM project will coordinate with other planned ITS projects.

The I-880 ICM project will need to be submitted for inclusion into the Regional ITS Architecture. Because the Architecture is currently being updated, it should be submitted as a "planned" ITS project (a project that is being planned in the next 10 years). If the I-880 ICM project is not submitted for inclusion into the Architecture during the appropriate period in the updating process, it can be submitted for inclusion during the maintenance of the Architecture.

5.4 Implementation Issues

To be a success, the management and operations within the I-880 ICM corridor should adopt a corridor perspective rather than a collection of individual stakeholders or agencies. In the existing situation, there is information sharing among various stakeholders, but the decision-making authority lies within the individual agencies. A well-defined dedicated institutional structure with defined processes, policies, and roles and responsibilities is needed to successfully operate the corridor as an integrated system. This section identifies I-880 ICM corridor technical and institutional issues related to the ICM system implementation.

5.4.1Technical Issues

Because ICM is built on the basis of the existing ITS systems with minimum new systems or components, the technical challenge will focus on cost effective communication among the existing ITS systems and the integration of the different systems. As part of the integration, as the existing ITS systems were not initially designed to serve ICM purposes, modifications and upgrading to the existing ITS systems may be needed. The stakeholders provided significant inputs regarding the technical challenges for the I-880 ICM, as captured below in the context of the strategies.

Strategy 1

A corridor-based multimodal advanced traveler information system (ATIS) that supports travelers pre-trip.

The existing 511 system is a central tool for presenting traffic-related information to travelers and other interested parties. Further development of the system is needed to add multimodal features and to improve user

access, communicate/integrate with historical travel time and incident data, to add new functionalities of matching/mining historical data, and to implement personalized travel times. Integration of the 511 system with other existing systems (e.g., Caltrans CMS) into a unified system is needed to smoothly exchange corridor-level traffic information (such as real-time traffic conditions, incidents, and travel times) and disseminate information to the public via different channels in a timely manner.

To provide travelers with accurate and reliable traffic information, additional detection coverage on freeways and arterials (including mid-block detectors) as well as beyond the I-880 corridor is required; furthermore, new models need to be developed to generate accurate predicted corridor-level travel time and appropriate alternate routes under incident or congestion scenarios.

A Transit Connectivity Study is currently on-going at MTC. This study will bring real-time transit operation data into the 511 system for dissemination. According to the agreement between the transit agencies and MTC, the data could also be shared among the transit agencies. This study will provide a good platform and starting point for many of the information sharing strategies identified for the corridor.

Strategy 2

Promote route shifts between roadways via en-route traveler information devices (e.g. DMS, HAR, "511") advising motorists of congestion ahead, directing them to adjacent freeways or arterials.

The real-time traffic condition information is available. Arterial traffic conditions along major arterials under the Smart Corridor program are archived at ACCMA. Caltrans has a total of 4 CMS signs along the I-880 freeway and none for arterials. In order to promote route shift, it is necessary to install CMS signs along arterials as well.

Strategy 3

Promote modal shifts from roadways to transit via en-route traveler information devices (e.g. DMS, HAR, "511") advising motorists of congestion ahead, directing them to high capacity transit networks and providing real-time information on the number of parking spaces available in the park and ride facility.

To facilitate mode shift, efficient communication with travelers is also essential, for instance, signs that indicate the availability of transit parking spaces, signs that direct traffic back to the freeway from the arterial, and/or indication of alternate transit routes and transit transfer locations.

Strategy 5

Coordinated operation between freeways and arterial traffic signals

For arterial signal timing, Caltrans, the county, and the cities use different software packages, which makes it difficult to add specific real-time optimizations of signal timing plans. In addition, many arterial signals only connect to a central hub upon request and this would slow down the real-time optimization process. To coordinate ramp metering with adjacent arterial signals, continuous communications are also necessary. The ICM team recommends beginning to implement this strategy on Caltrans operated arterials (International Blvd., East 14th Street and Mission Blvd.), as Caltrans has the ability to make the changes for all of its signal controllers (Model 170) along these arterials.

Strategy 8

AC Transit adjusts operations based on real-time information about highway incidents and special events

Reliable methods need to be available to assist AC Transit's Transportation Supervisors to adjust bus routes on freeways based on real-time traffic information and scheduled events. In current operations under emergency situations, communications between transit agencies are manual and are typically done through telephone calls; for ICM, integration of information about all transit modes and development of a unified system are needed to automatically coordinate transit agencies in cases of recurrent congestion, incidents, and major events.

Strategy 10

Port of Oakland advises arriving and departing trucks about port delay and estimated travel times

The Oakland Port is currently implementing an electronic identification system to reduce truck waiting time. The Port of Oakland sees that there are more problems for trucks going into the port than leaving the port. It will be very helpful to provide port delay information to truck drivers before they drive to the port so that they can schedule their trips more efficiently.

Strategy 12

Multi-agency or multi-network incident response teams and service patrols and training exercises.

It is critical not only to identify the type of incident but also what equipment is needed to respond to each incident.

Strategy 14

Guidelines for construction work hours during emergencies.

Earthquakes are a major concern for all in the Bay Area. However, because of the unpredictable nature of earthquakes, it is difficult to develop detailed plans that will deal with all aftermath situations. This strategy however intends to set up an institutional framework and protocols for collaborative responses to the aftermath of major events such as earthquakes.

5.4.2 Institutional and Operational Issues

ICM has been welcomed by stakeholders along the I-880 corridor. However, there have been various institutional issues brought up by the stakeholders during the series of ICM workshops and meetings. The issues, concerns and recommendations from the stakeholders are summarized below by Strategy.

Strategy 1

A corridor-based multimodal advanced traveler information system (ATIS) that supports travelers pre-trip.

Consolidating real-time information from all sources along the I-880 corridor requires significant collaboration among the operating agencies (511, Caltrans, Alameda CMA, AC Transit, BART and local jurisdictions). Currently, MTC is working with AC Transit and BART to obtain real-time transit information for 511.

The 511 Strategic Plan leaves open the possibility of alternative business models for delivery of traveler information. Multi-agency agreements need to be established for the exchange of information.

Real-time information from buses allows schedule adherence performance to be easily traced. AC Transit representatives are concerned that this may lead to potential resistance from transit agency staff.

Strategy 2

Promote route shifts between roadways via en-route traveler information devices (e.g. DMS, HAR, "511") advising motorists of congestion ahead, directing them to adjacent freeways or arterials and *Strategy #5 Coordinated operation between freeways and arterial traffic signals*

The diversion of traffic from highway to arterials is a sensitive issue. It is necessary to work with Caltrans, the individual cities along the arterials and AC Transit to determine reasonable strategies to balance traffic flows between freeways and arterials. Trailblazing signs on arterials are needed to get the diverted traffic back to the freeway or directed to transit. Some local merchant resistance was experienced when large CMS signs were proposed for major arterials (size and aesthetic concerns); so context sensitivity will be key. Small, simple signs are more likely to be accepted, as with the Silicon Valley Smart Corridor. The I-880 Smart Corridor has plans for trailblazing signs, but funding is not yet available.

For collaboration between freeway and arterial operations, a multi-agency participation agreement needs to be established that defines thresholds of performance on arterials, since cities are likely to require such an agreement to avoid overflow of demand from freeway onto local arterials. For the strategies related to signal timing changes, an agreement on using a single software platform for arterial signal timing may be required. Fortunately, there is a system developed by Caltrans (CTnet) that could be used without additional capital costs.

Strategy 3

Promote modal shifts from roadways to transit via en-route traveler information devices (e.g. DMS, HAR, "511") advising motorists of congestion ahead, directing them to high capacity transit networks and providing real-time information on the number of parking spaces available in the park and ride facility.

Transit agencies may need to consider appropriate access control schemes for available parking to control demand during normal operations, including parking pricing and reservation systems. Neighborhoods near major transit stations may fear parking overflow in local streets (especially during major incidents) and need to be convinced that appropriate arrangements will be in place under such situations.

Strategy 4

Promote shifts between transit facilities via en-route traveler information devices (e.g. station message signs and public announcements) advising riders of outages and directing them to adjacent rail or bus services.

There is a concern about the potential liability induced by providing real-time arrival information for the *other* transit system. For example, when AC Transit connection information becomes available at BART station platforms, there is a strong possibility of BART riders running for the bus, which could cause disruptions of normal passenger flow and potentially injuries. AC Transit has already had NextBus information at WTA ferry station. Additional information from ferry to AC would be helpful.

Strategy 7

Signal priority for AC Transit buses.

Cities have had concerns about the potential for the signal priority deployment to interrupt traffic. Further detailed evaluation of the TSP along International Blvd and East 14th St. can provide evidence to concerned cities that signal priority does not create significant impacts on regular traffic flow.

Strategy 8

AC Transit adjusts operations based on real-time information about highway incidents and special events

AC Transit has the obligation to serve all the bus stops unless a certain street is closed, thus bus routes cannot be changed in real time. Re-routing is much more feasible with express buses that run on the freeway, rather than regular buses running on arterials. The option of re-routing buses running on arterials is therefore excluded from this strategy.

Strategy 9

Transit hub connection protection for special events or major incidents

In general, the transit service planners try to connect bus schedules and BART arrivals and departures. However, AC Transit and BART have different headways, so connection protection is very difficult to do under normal operations. Transit bus operation is measured by on-time performance, but connection protection at one station can adversely affect the arrival time at the downstream stations. In order to maintain the published schedule, transit connection protection requires additional buses. BART transfer riders are a small percentage of AC Transit bus riders. AC normally would not delay services to wait for BART riders and AC has limited ability to do so. Furthermore, the published schedule has built in contractually-required rest periods in cases where there is currently no slack. AC Transit can only provide connection protection for emergencies and pre-planned special events. It may be feasible to select some key transit hubs/connection points such as the Coliseum for a demonstration of transit connection protection on routes that have long headways.

Strategy 10

Signal preemption or "best Route" for emergency vehicles

Instrumenting all police and paramedics' vehicles is very desirable but could be very costly. The ICM team will work with these stakeholders to determine if this is feasible within the ICM scope.

Strategy 11

Multi-agency or multi-network incident response teams and service patrols and training exercises.

Multi-agency or multi network response is urgently needed, however, complicated to implement. MTC, Caltrans, and CHP are taking the lead to deal with this issue and local agencies will soon become involved. Logistics of coordinated response among agencies, especially for incident and emergency management, will require detailed interagency agreements.

The ICM Team plans to work with the stakeholders to address the broad range of issues listed above. At a more general level, the stakeholders indicated that public outreach is greatly needed to explain to the general public, merchants and other local stakeholders the merits of some of the components of ICM strategies that may be controversial (such as dynamic trailblazer signs in their neighborhoods). Also, a regular I-880 corridor forum is needed to keep the stakeholder agencies informed and in communication

with each other. ACCMA currently has an I-880 Corridor Committee that meets on an as-needed, task-oriented basis. Such a forum could be enhanced to meet regularly and include a broader range of relevant stakeholders.

5.5 I-880 ICM Concept Implementation Institutional Framework

The primary purpose of the I-880 ICM Concept Implementation Institutional Framework is to implement, operate, and manage the corridor. The operating agencies along I-880 include multiple jurisdictions and agencies. The management and operations of the corridor and the ICMS will be a joint effort involving all the stakeholders. For the effective operation and management of the I-880 ICM system, an ICM Operations Committee (ICMOC), consisting of representatives from each of the stakeholder agencies, is proposed. The I-880 ICM Operations Committee (ICMOC) will be in charge of the development of policies and to final approval of operation plans and protocols. The ICMOC will be the consensus body to make decisions on coordination among different stakeholders and to help resolve issues encountered across agencies.

Under the guidance of ICMOC, MTC will be the administrative agency for the I-880 ICM, serving as the decision-making body for budget development, project initiation and selection, and overall administrative and operational policy.

The I-880 ICM will be a distributed system. While all stakeholders along the I-880 corridor will be collaborating on the implementation of all of the proposed strategies, based on the roles and responsibilities of the stakeholders in the existing operation for transportation systems along the I-880 corridor, a lead agency will be assigned for the implementation of a particular strategy. The lead agency will be responsible for the daily operation of the strategy it is in charge of and will coordinate with other agencies that are involved in the operation of such strategy. A clear communication protocol will be identified between agencies in order to facilitate the timely implementation of the protocols. When issues occur, the lead agency will be responsible for reporting the issues to the ICMOC and will assist the ICMOC to resolve the issues.

The table below illustrates the responsibilities of the ICMOC and each stakeholder for successful operation and management of the I-880 ICM corridor.

TABLE 5.3
Roles and Responsibilities

STAKEHOLDER/ AGENCY	RESPONSIBILITIES
ICMOC	▪ Monitor all conditions within the I-880 ICM corridor including performance measures ▪ Ensure coordination between different stakeholders to provide accurate traveler information ▪ Suggest adjustments to network operating parameters in the event of significant variations in network demands ▪ Demonstrate I-880 ICM concept
Caltrans District 4	▪ Daily maintenance and operations of freeway and local arterials which are part of state highway system ▪ Coordinate truck and freight activities on freeway and local arterials which are part of state highway system ▪ Monitor traffic operations of freeway and local arterials which are part of state highway system ▪ Coordinate construction and maintenance activities on freeway and local arterials which are part of state highway system ▪ Provide ramp metering information to local jurisdictions ▪ Provide traffic and incident information to traveler information systems ▪ Freeway Surveillance ▪ Monitor/Operate Dynamic Message Signs ▪ Provide Support for the I-880 ICM operational test
MTC	▪ Provide Traveler information through 511 system ▪ Provide overall coordination for the 880 ICM
ACCMA	▪ Monitor arterial traffic operations ▪ Arterial Surveillance on East Bay SMART corridors ▪ Provide East Bay SMART corridors information to local jurisdictions ▪ Provide East Bay SMART corridors information to Caltrans District 4 ▪ Provide East Bay SMART corridors information to MTC's 511 traveler information ▪ Provide East Bay SMART corridors information to Transit agencies AC Transit and BART ▪ Provide support for the I-880 ICM operational test
Local Jurisdictions	▪ Monitor signal operations ▪ Adjust transit signal priority
AC Transit	▪ Daily operation of bus transit service along the I-880 ICM corridor

STAKEHOLDER/ AGENCY	RESPONSIBILITIES
	▪ Monitor bus transit on-time performance ▪ Provide pre-schedule and real time information to traveler information systems ▪ Enact response plans during special events and incidents
BART	▪ Daily operation of rail transit service along the I-880 ICM corridor ▪ Monitor rail transit on-time performance ▪ Provide pre-schedule and real time information to traveler information systems ▪ Enact response plans during special events and incidents
Port of Oakland	▪ Coordinate truck and freight activities with Caltrans District 4
Emergency Responding Agencies (CHP, Police, Fire, and Paramedics)	▪ Daily law enforcement activities along the I-880 ICM corridor ▪ Coordination of law enforcement and incident response activities ▪ Coordination of emergency services and incident response activities ▪ Integration of all the emergency responding agencies' interfaces

I-880 Corridor ICM Operational Description

When the I-880 ICM is implemented, the enhanced information sharing and integrated network operations will allow each individual network to improve its own efficiency and effectiveness, while enabling the corridor as a whole to better adapt to changing conditions by managing its overall transportation supply and demand. To the users, ICM will provide efficient and reliable travel throughout the I-880 Corridor and the constituent networks, resulting in improved and more consistent trip travel times. Below is a conceptual operational description of the I-880 ICM. Note that this conceptual operation description is still under development.

It is envisioned by the I-880 ICM stakeholders that ICM will improve their operational efficiency and the proposed ICM strategies are intended to facilitate information sharing and support existing operations. Based on the existing condition and operation of the transportation systems, the I-880 corridor stakeholders decided that a physically centralized ICM control center would be very costly and not practical within the scope of the current ICM program. Instead, the proposed I-880 ICM 'control center' will be a virtual one. A key element of the virtual ICM control center is a centrally managed data repository allowing real-time data exchange among agencies. Communications, systems, and system networks will be integrated to support the virtual corridor information center. Voice, data, video, information, and control will be provided to all agencies based on the adopted protocols and standards for the sharing of information and the

distribution of responsibilities. MTC's 511 system will support the virtual nature of the integrated information sharing and control functions.

New ICM functions, to be implemented based on the needs of the selected strategies, will be integrated into existing transportation systems. The operation of the ICM operational functions will be led by the operating agencies that have primary responsibility in today's operations. The control and related functions for specific strategies will be shared among the corridor agencies, coordinated by the lead agency. Table 5.4 defines the roles and responsibilities of I-880 stakeholders for each proposed strategy.

TABLE 5.4
Roles and Responsibilities Per Strategy

Strategies	Responsibilities
#1 A corridor-based pre-trip ATIS database	Lead agency: MTC Supporting agencies: Caltrans, Alameda CMA, AC Transit, BART, Port of Oakland, Water Transit Authority
#2 Promote route shifts between roadways via en-route traveler information device	Lead agency: Caltrans Supporting agencies: AC Transit for buses; BART for rail
#3 Promote modal shifts from roadways to transit via en-route traveler information devices	Lead agency: Caltrans Supporting agencies: AC Transit for buses; BART for rail
#4 Promote shifts between transit facilities via en-route traveler information devices	Lead agency: AC Transit Supporting agencies: BART
#5 Coordinated operation between freeway and arterial traffic signals	Lead agency: Caltrans (for state routes) Alameda CMA (for local streets) Supporting agencies: Cities
#6 Enhance arterial signal timing with advance information about special events at Coliseum	Lead agency: Caltrans (for state routes) Alameda CMA (for local streets) Supporting agencies: Cities and Oakland Coliseum
#7 Transit signal priority	Lead agency: Caltrans (for state routes) Alameda CMA (for local streets) Supporting agencies: AC Transit and Cities
#8 AC Transit adjusts operations based on real-time about incidents and special events	Lead agency: AC Transit Supporting agencies: MTC
#9 Transit hub connection protection for special events or	Lead agency: AC Transit Supporting agencies: BART,

Strategies	Responsibilities
major incidents	MTC
#10 Port of Oakland advise trucks travel time based on real-time traffic information	Lead agency: Port of Oakland Supporting agencies: Caltrans, MTC
#11 Signal pre-emption or "best route" for emergency vehicles	Lead agency: Caltrans (for state routes) Alameda CMA (for local streets) Supporting agencies: CHP, cities, paramedics
#12 Multi-agency or multi-network incident response teams and service patrols and training exercises	Lead agency: CHP for freeways Local Policy Agencies Supporting agencies: Caltrans, MTC, AC Transit, BART and Cities
#13 Coordinate scheduled maintenance and construction activities among corridor networks	Lead agency: Caltrans (for state routes) Alameda CMA (for local streets) Supporting agencies: All stakeholders
#14 Guidelines for construction work hours during emergencies or special events	Lead agency: Caltrans (for state routes) Alameda CMA (for local streets) Supporting agencies: All stakeholders

Performance measurement and monitoring will be performed using PeMs for freeways and arterials and by AC Transit and BART for their services. The lead operation officer identified by each agency will make reports to and be accountable to the ICMOC.

Traveler information (on 511, websites, CMS, and through the media and ISPs) will be corridor-based, providing information on corridor trip alternatives complete with current and predicted conditions. Travelers will access or be given real-time corridor information so they can plan or alter their trips in response to current or predicted conditions on any of the networks in the corridor.

Each traveler will be able to make route and modal shifts between networks easily due to integrated and real-time corridor information and coordinated operations between networks. Using one network or another will be dependent on the preferences of the traveler, and not the nuances of each network. Travelers will be able to educate themselves about the corridor so they can identify their optimal travel alternatives and obtain the necessary tools (e.g., smart card, available parking) to facilitate their use of corridor alternatives when conditions warrant.

5.7 Availability of Detailed Real-Time Data for Evaluation

Since 2004, the Robert E. Parsons Traffic and Transit Laboratory (PT^2L) has started collecting detailed, high resolution, real-time traffic and transit data from a number of arterials, urban areas and transit systems for the Arterial and Highway Performance Measurement System (APeMS). Within the boundaries of the I-880 ICM corridor, the PT^2L will soon start to collect second by second traffic and transit data from the East 14th Street corridor, covering 16 intersections in Oakland, 27 intersections in San Leandro, and 10 intersections in Hayward. These traffic data are signal status and loop detector data through frame relay communication, while the transit data are continuous vehicle location data from selected in-service buses through GPRS wireless communication. Caltrans has agreed to instrument additional intersections along International and Mission Blvd. in the next a few months. The completed data collection corridor will cover one entire major arterial in parallel to I-880. With PeMs data collected every 30 seconds, PT^2L will be able collect high resolution freeway, major arterial and transit data, which establishes the foundation for detailed quantitative before-and –after evaluation of the I-880 ICM.

In addition to the detailed data, data management and analysis tools have been and are being developed for easy access to the data, data preprocessing and analysis. As shown in FIGURE 5.0-1, field data are managed and stored in a MySQL based traffic system database. The database structure design is shown in

FIGURE 5.0-2. Around the central database, the data pre-processing tools, data mining tools, administration tools, and simulation interface tools are being developed.

FIGURE 5.0-1 Data Management and Analysis Tools

(Source: PT²L APeMS)

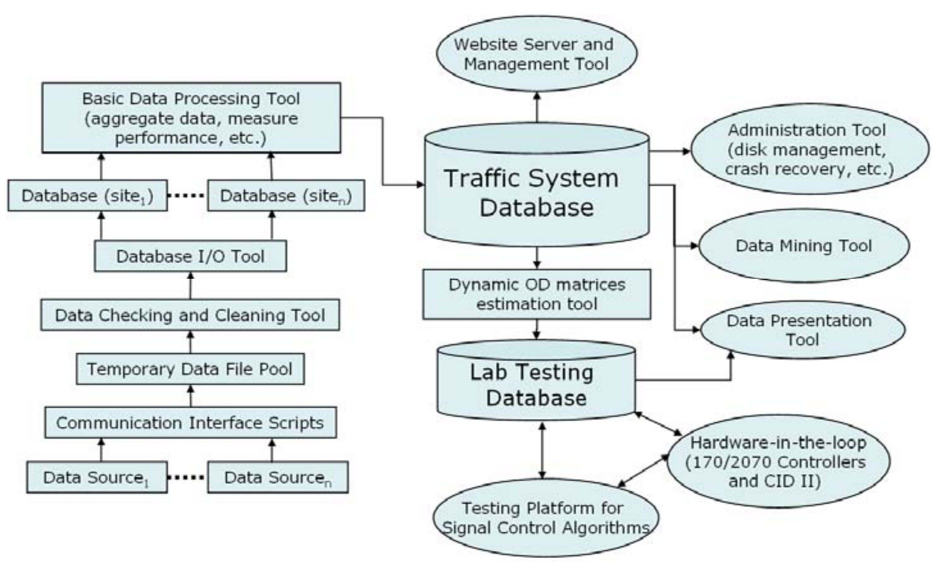
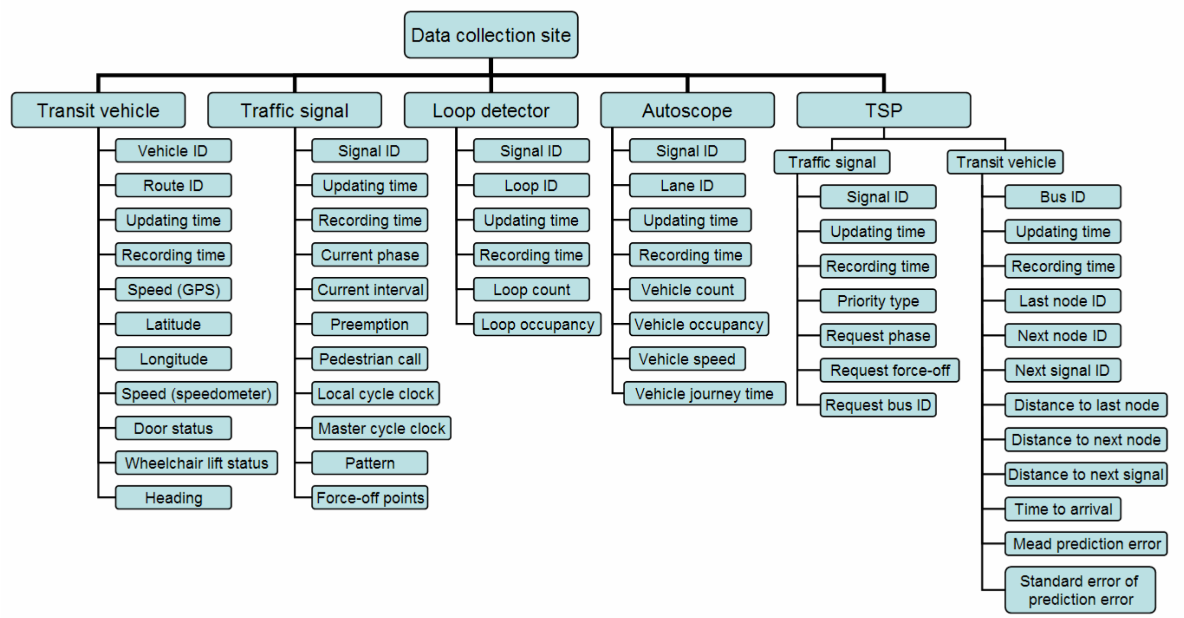


FIGURE 5.0-2 Database Structure

Transit Data Collection

(Source: PT²L APeMS)



PT^{2}L is collaborating with AC Transit to collect its transit system data. PT^{2}L has installed its self-designed Automatic Vehicle Location (AVL) systems on the whole fleet of buses on AC Transit's Rapid bus line. The second-by-second Global Positioning System (GPS) coordinates, vehicle speeds, and Coordinated Universal Time (UTC) for each bus are now continuously transmitted to the central database at PT^{2}L.

Applying the Data for I-880 ICM System Evaluation

In order to quantify the improvements associated with the ICM implementation, before-and-after scenario comparisons for all the sub-systems, including the arterial and highway system, the freeway system, and the transit system, need to

be performed. PT^{2}L, with the detailed and ever-growing data source and the data processing and analysis tools, can support the comprehensive system evaluation.

For a fair and objective evaluation, a set of well defined Measures of Effectiveness (MOEs) has been developed for each network, as discussed in Section 3.3.1. MOEs should be independent of the impact of local characteristics, should be quantifiable in the before-and-after condition, and should accommodate monitoring of the subject system. The MOEs that have been developed for APeMS arterial applications are shown in Table 5.5, and the transit MOEs are shown in Table 5.6. Methods have been developed for calculating these MOEs from the available raw data.

TABLE 5.5 MOEs for APeMS

Category / Stakeholders	Transit Vehicles	Transit Passengers
Reliability	(1) Percentage of on-time runs at timepoint; (2) average arrival deviation at timepoint; (3) variance of arrival deviation at timepoint; (4) largest arrival deviation at timepoint; (5) variance of segment travel time; (6) number of missed connections at transfer point; (7) Variance of total route travel time (results in reduced layover schedule)	(1) Number of missed connections (transfers); (2) average waiting time at bus stop
Travel Time/Speed	(1) Average travel time on segment and breakdown (dwelling time, intersection delay and running time etc); (2) Average travel speed on segment; (3) average delay at prioritized intersection (signal delay and other delay) (4) number of stops at red	(1)Average person delay at intersections
Operating Cost	(1) Average fuel consumption; (2) fleet size requirement; (3) number of operators	N.A.
Pollutant Emission	(1) Average vehicle emission (CO and NOx)	N.A.
Ridership	(1) Average passenger occupancy per bus; (2)number of passenger per mile	N.A.
Safety	(1) Number of accidents (involving transit vehicles)	
TSP System Performance and Signal System	(1) Frequency of TSP calls (cycle-based); 2) Frequency of TSP executions (cycle-based,early green, green extension and other operations respectively); 3) TSP successful rate (early green, green extension and other operations respectively); 4) Missed coordination steps; 5) Effects on bandwith	

TABLE 5.6 MOEs for Transit System

Category / Stakeholders	Transit Vehicles	Transit Passengers
Reliability	(1) Percentage of on-time runs at timepoint; (2) average arrival deviation at timepoint; (3) variance of arrival deviation at timepoint; (4) largest arrival deviation at timepoint; (5) variance of segment travel time; (6) number of missed connections at transfer point; (7) Variance of total route travel time (results in reduced layover schedule)	(1) Number of missed connections (transfers); (2) average waiting time at bus stop
Travel Time/Speed	(1) Average travel time on segment and breakdown (dwelling time, intersection delay and running time etc); (2) average travel speed on segment; (3) average delay at prioritized intersection (signal delay and other delay) (4) number of stops at red	(1)Average person delay at intersections
Operating Cost	(1) Average fuel consumption; (2)fleet size requirement; (3) number of operators	N.A.
Pollutant Emission	(1) Average vehicle emission (CO and NOx)	N.A.
Ridership	(1) Average passenger occupancy per bus; (2) number of passenger per mile (3) occupancy vs. capacity	N.A.
Safety	(1) Number of accidents (involving transit vehicles)	

5.8 Transferability of Lessons Learned from 880 ICM Implementation to Other Metropolitan Regions

The eight Pioneer Sites are not intended to be the only locations in the country to explore the opportunities for multimodal corridor integration, but are rather intended to lead the way for many other regions. In order to be useful as examples for others to follow, the Pioneer corridors should share best practices with other transportation professionals, so that the others can learn how to solve their own comparable problems.

In some ways, the I-880 corridor is already a national leader and could be considered to be so far ahead that it would be difficult for others to follow it effectively. One could look at its 5-1-1 traveler information service and its diversity of existing transportation services and conclude that very few other locations are comparable. However, this would be overlooking the serious challenges that confront the I-880 corridor and that make it an effective Pioneer from which others can learn.

The dominant challenge to corridor integration along I-880 is the fragmented institutional structure, which is probably one of the most difficult in the country, combined with a very politically active and engaged electorate. The rail and bus transit services are operated by independent agencies, each with its own elected Board of Directors. AC Transit serves two counties, while BART serves four counties, and their Boards therefore represent these different portions of the Bay Area. Caltrans is responsible for the operation of the I-880 freeway and a few parallel arterials, while the other arterials are under the responsibility of the Alameda County Congestion Management Agency and the cities in the corridor, which are very diverse in size, economic strength and political character. The regional MPO, the Metropolitan Transportation Commission provides capital funding for major projects and also has operational responsibility for the 5-1-1 system, bridge toll collection, the Freeway Service Patrol, and TransLink. If these highly diverse agencies can collaborate on integrated corridor management here, it should be possible to achieve such collaboration almost anywhere in the country, and even the regions with the most complicated institutional structures should be able to learn lessons from the experience along I-880.

The operational complexity of the I-880 corridor also means that it should be possible for many other regions to learn useful lessons from our experience. The range of operational challenges is so broad that most regions will have to address at least some of them, even if few will have to address all of them:

local bus transit, regional express bus, commuter rail and intercity rail services all operating in parallel and feeding passengers to each other;

large special-events venues (Oakland Coliseum and Arena) located adjacent to a major freeway and rail transit station;

regional airport (Oakland International) with a high volume of freight as well as passenger traffic, adjacent to the freeway and special-events venues;

major seaport (Port of Oakland), with very high volume of container traffic, adjacent to freeway and central business district;

location vulnerable to major natural disaster (earthquake on Hayward Fault) and therefore requiring serious emergency operations planning;

high level of traffic congestion, with essentially no excess capacity available on any modes in the corridor during peak periods;

major employment centers located just beyond both ends of the corridor (downtown Oakland to the north and San Jose/Silicon Valley to the south), attracting very high volumes of commuter traffic;

major transportation infrastructure development and refurbishment projects likely to introduce serious traffic disruptions in the near future;

electronic toll collection used on bridges adjoining the corridor;

geographic barriers (San Francisco Bay and East Bay Hills) seriously restricting transportation access across the corridor, to destinations to both the east and west sides.

The experiences of the I-880 corridor in integrating its multitude of transportation operations should be useful to regions that even have only one or two of the listed operational complexities.

APPENDIXES

Appendix A: Meeting Minutes

A1. Kick-off meeting minutes

ICM: 880 Pioneer Site Team Kick-Off Meeting
11/29/06
MTC

Attendees were representatives from (sign-in sheet available from MTC):

Public Agencies: MTC, Caltrans D4 Operations (CT), Alameda CMA (ACCMA), BART, AC Transit

Consultants: PATH/CCIT, Kimley-Horn Associates (KHA), DKS Associates, System Metrics Group (SMG), Cambridge Systematics (CS)

1. Albert Intro Remarks

- Not here to do a project for the sake of doing a project. Purpose is to solve some of the major problems in the corridor and address how to find the ways to get systems to work together.
- The I-880 corridor was selected from among a variety of strong candidates in the Bay Area because it is one of the most congested, is served by multiple modes, has strong freight flows, has a strong modeling heritage and a lot of existing data collection infrastructure, and has some impending construction work that will introduce further disturbances.
- We need to take what we're already doing on 880 and integrate those activities better (highway, transit, arterials); in other words, the ICM is to take what you have and make existing assets as efficient as possible.

General Comments

DKS: since this is a federal competition for funds, through this process we identify the competitive advantages of the 880 corridor for utilizing ICM (both in terms of effectiveness and as a template for other regions).

ACCMA: ICM effort and associated funding is seed money; it needs to be built on to truly succeed. Stakeholders/Decision makers need to be educated on benefits of integrated corridor management (what's in it for them, benefits to overall corridor).

AC: ICM is an opportunity to promote the need and the benefits of information sharing among agencies.

2. Radiah gave an overview of the I880 ICM program scope

3. Scenario Discussion Comments

Consultants presented the existing conditions of the 880 corridors and potential solutions. The stakeholders discussed the areas where ICM may provide benefits, potential issues and some of the potential strategies:

Normal operation strategies

511 provides pre-trip and cell phone access to traffic conditions, but real-time in-route guidance around bottlenecks and parking availability (for mode shift) is not available. In the near future, My 511 will provide customized alerts to users about incidents on their preferred routes.

There is a need for models to predict the capacity that is available on non-freeway alternatives.

There isn't information to advise travelers to get off freeways and get onto arterials, nor is there a means to familiarize travelers with arterial routes in unfamiliar neighborhoods.

AC Transit expressed concern about shifting traffic from highway to arterials that slows down bus operations. Institutional arrangements/agreements for this type of congestion management are needed.

Information at BART stations about delay on surface roads would be helpful

A key BART bottleneck is parking (where demand exceeds supply), more than track capacity on the Fremont line parallel to 880.

Changeable message signs on arterials (to inform drivers about conditions on freeways or transit) have not been politically acceptable because of aesthetic concerns.

Freeway/Arterial Incidents

Regarding incident detection on arterials, ACCMA has placed detectors on major arterials along the 880 corridor (Hesperian, International) and information is available during the hours that they are staffed.

The incident information becomes available on 511 in about 2 minutes (including time for verifying incidents through CHP)

Currently, not being able to respond to all incidents, particularly off work hours. Shortening response time to recover from incident is at least as important as quickly notifying travelers about the incident.

Multimodal trip planner from 511 does not include real-time updates of transit schedules to account for service delays or disruptions.

Dynamic dispatching of buses involves new ways of operation and currently the capacity and infrastructure for dynamic dispatching is not available.

Data shows that ramp metering can reduce accidents. Ways of preventing accidents should be investigated

We need a toolbox instead of only one strategy for accident recovery

MTC: My511 service (expected launch in February) will begin to address desire for pushing personal notification of transit service status and route-specific incident notification

Transit Incidents

Current traffic information does not provide proactive alert/guidance on what to do when congestion occurs.

Current incident responses are reactive rather than pro-active.

It would be useful for AC Transit to provide riders with real-time schedule adherence information.

BART real-time operational status should be made available BEFORE you enter system (via 511, on-street signs before entering station, or station agent booths).

Operational considerations are very different for hourly express buses that use the freeways than for the local buses that operate at shorter headways. The express buses do not need to make intermediate stops, so they have a lot more flexibility to re-route to avoid incidents.

The operations people from AC Transit and BART need to get more involved in these ICM discussions to determine what is realistically achievable.

Scheduled Events

Need to minimize the impact on the whole transportation system, rather than a particular system.

Real-time information about travel alternatives is not available for all systems, particularly to help transfer from one mode to another.

Freeway drivers need information about parking availability before they exit the freeway.

There is a need for making the business case for all agencies. Specifically, transit agencies need to translate ICM into their bottom line value/benefits

Anush noted that KHA developed the Oakland Airport ITS Implementation Plan

Major Events

ICM can potentially become a vehicle to tackle homeland security funding possibilities.

One strategy for earthquake scenario is to provide temporary parking.

For emergency management, functional redundancy of systems is an important potential benefit of ICM (especially data collection and communications)

4. General discussion by stakeholders

AC Transit

Need to let AC know what are the things that require agency to change, e.g., how to dispatch for different scenarios? what can be done to make things better?

Infrastructure needs to be established in order to encourage mode shift.

Moving traffic to arterials has a negative impact on buses – productivity goes down as traffic speed declines, so we need to evaluate the tradeoff between benefit to highways vs. impact on transit

ICM may contribute to better inputs to route planning

Need to separate technical integration issues from institutional issues (such as agency coordination and political will). For instance, holding buses to meet late arriving BART trains has both technical issues (pushing correct info to CAD AVL system) and institutional issues (how supervisors monitor on-time performance, bus driver contracts, etc,)

It is important to address not only the capital funding but also the O&M needs to keep the systems going, as part of the case for supporting capital improvements. For example, they have CAD AVL data that is not utilized because they have no expertise or resources to “mine” it, and no desire or perceived need to share info.

Important to recognize what signals travelers respond to (cost, convenience, etc.), don't just focus on traveler information needs.

BART

Still not sure what can be done for ICM.

Is it about ways to help other operators or it helps BART? Need to be clear what are the benefits to the agency. For BART, the economic side weighs heavily on the cost/benefits.

BART: For transit agencies, cost/benefit of transit operations is more important than increasing ridership, and the benefit is counted as bottom-line revenue, not any broader societal benefit.

Caltrans

The ICM is not only about the current project. It can help to address congestion management in general.

Emphasis needs to be placed on the motorist. Traveler convenience is important. Travel time is a very attractive measure for travelers and needs to be a key part of ICM. Improved travel time capabilities, allowing it to be delivered to travelers at their point of origin (home, work, en-route). Provide traffic information to the major employers and work sites.

Getting the transit service into the neighborhoods is essential for getting people use transit (but AC Transit noted the challenges this poses to their productivity).

We should deal with the most typical incidents and address major catastrophic events.

We need to start thinking about what the final product is in the context of combined and different systems in order to get internal support from stakeholder agencies.

Scenario development should focus on the most common incidents and responses.

ACCMA

For BART, signs for riders at the street level about the delays would be very helpful for potential riders to make smarter decisions.

Funding is a major issue, especially who pays for operation costs, additional staff, M&O.

Have to address operation issues in order to gain full usage of the infrastructure, most effective way to address congestion issue.

Operations get no respect from the decision makers, who are much more comfortable with capital construction projects.

Need to elevate ICM to the board members, need to explain how ICM would benefit the operators, show benefits which will bring in funding, e.g., San Pablo seed funding $6 M and grew into $20 M, (Albert added: to demonstrate what can be done with ICM).

AC and BART agreed that management presentations will be helpful.

Partnership is the key.

Group

We need to be sensitive to institutional and cultural differences of different agencies.

What would be the best strategy to use ICM to compete for future funding?

The operation scenarios need to be transparent to the management of the agencies.

We need to address how to help agencies to make culture changes. ICM could be a catalyst to help promote those changes.

It is important to reassess what has worked and not worked from past experience.

How to balance short term benefits vs. long term benefits? Specifically, short term benefits to the region (such as shifting traffic from highway to arterials) may not benefit all the agencies (e.g. transit agencies). For Transit agencies, carrying more people may not be their final objective. The ultimate objective is the economic bottom line.

It is important to address overlapping interests and solutions, which can help to overcome the institutional differences.

Related to Funding

Sean: If we come up with strategies that look effective, are there any other sources of FUNDING to augment the ICM program?

Albert: MTC is open to possibilities raised from the ICM process; FTA indicated that there is a new program to be announced.

Cyrus: Packaging of different grants, to form partnerships. Example, funding for BRT on International Blvd combines funding from measure B, Regional Measure 2, 3 TFCA, etc.

BART: FTA will have a transit operations grant program available soon. Federal Small Starts program also a possibility for funding related to transit operations & systems integration.

5. Stakeholder representation on the ICM TAC

In addition to the list summarized by Radiah, stakeholders suggested to add the following agencies:

- Invite the cities (public works directors), but if they are not attending they will be represented by Cyrus
- World trade center for Bay Area, working with MTC on freight
- AAA
- Association of fire chiefs

6. Action Items/Next Steps

- 880 ICM Stakeholder Meeting 12/14 at Caltrans D4 Offices. (9 am -3 pm). The purpose of this meeting is outreach to educate them about the ICM opportunity, obtain their buy-in to participate in the program, and elicit their needs and priorities for systems integration in the corridor to improve corridor mobility. To prepare for the meeting, consultants will:
    - develop draft agenda by XX/XX
    - synthesize 11/29 discussion to identify the right questions to ask stakeholders on 12/14.
    - put together a couple of concrete integration examples to illustrate objectives of ICM program
- Stakeholders (AC, BART, ACCMA, Caltrans) are to provide inputs on the following items by 12/08/06:
    - Review the strategy spreadsheet prepared by Radiah and provide comments
    - Provide additional inputs for issues (last slide for each scenario)
- DKS will meet with BART and AC Transit to get a better sense of their systems and most important issues. Habib will ask Radiah to coordinate the meeting

7. MTC is to work with AC and BART POCs to arrange presentations to BART and AC Boards

- MTC and consultants to schedule conference call for 12/15 to synthesize results of 12/14 stakeholder workshop and determine how to proceed from there.

A2: Stakeholder meeting Jan 11, 2007

1. Intro Remarks (Albert Yee)

- The meeting is expected to be a two-way dialog to help stakeholders identify existing problems and find out what ICM can do to help solve the problems. The goal is to help to make the most efficient use of the I-880 corridor.
- The corridor means not only the freeway, but also arterials and transit (AC transit and BART).
- The I-880 corridor was selected since it is heavily congested, multi-modal (AC transit and BART), and serves as both a commuter corridor and a trade corridor. It has a rich set of parallel arterials and transit services. There are several studies that are carried out on I-880.
- ICM does not focus on funding new projects. But as we go through and find out what we can do to improve operations, MTC and Caltrans may be able to finance projects that are the most cost effective.

2. Radiah gave an overview of the I880 ICM program scope.

General Comments

City of Hayward: Relationship of ICM with previous studies on the I-880 corridor

Tarek: The scope of ICM is narrower, mainly focusing on technical integrations; while the previous studies looked at all possible solutions, including capital investment (which is not the focus of ICM).

City of Oakland: Is funding available for Stage 3?

Radiah: There will be $10M in the demonstration stage (Stage 3) of ICM for up to four sites. But the funding is only for integration (including software development) and not for capital investment.

3. I-880 Corridor Performance Issues: Problems, Needs, and Constraints

Consultants presented the existing conditions of the 880 corridors under five conditions: normal, freeway/arterial incidents, transit incidents, scheduled events, and major events. The stakeholders discussed the areas where ICM may provide benefits, their needs and potential solutions.

Normal operations

The consultant team needs information on parking availability from BART and seat utilization from AC transit.

BART: parking lots are full by 9am (some by 8am) except at Hayward station

Whipple, Jackson, and Mission should be included in the project. I-980 interchange is not included since it is outside the boundary defined for the project.

Peak periods of the I-880 corridor start to spread and mid-day congestion starts to increase.

For travel time reliability, 15% of drivers experience 7 to 30 minutes delay, which needs to be improved.

Freeway/Arterial Incidents

Incident is normal for the I-880 corridor and contributes to 70 – 80 % of the delay.

Port of Oakland: is there info showing how many incidents are truck or port related? Since clearance time will double for such incidents, and incident involving commercial vehicles especially those with hazardous materials contribute more to the delay.

Transit Incidents

The purpose is to improve information sharing.

BART is now testing its system capability to respond to extreme cases (like suicide). Currently manual coordination is used which relies on media to disseminate related information.

BART focuses on peak commuting times and will respond when they are notified.

With major incidents in BART service, AC transit could provide bus bridges. There is no pre-defined strategies, the decision is mostly based on professional judgment.

The number of major incidents is useful to evaluate benefits (e.g., delay saving) and should be available from transit agencies.

BART: The current number of BART-related major incidents per year is less than 100, the exact number should be able to be queried out from a database.

Should VTA be involved?

237 is the boundary of this study, but VTA can be added if there is the need for involvement.

Scheduled Events

City of Oakland: A related study was conducted by city of Oakland in 2003 with other stakeholders. Need more infrastructure (CCTV, inter-connecting w/ service yard, radar, CMS).

Police: use sign board to direct traffic out.

A big concern from the police department is the need of real time information to help people leave the Oakland Coliseum. Currently, there are 10 portable signs that are manually operated to display fastest route information.

We need “good” real time information for freeway and alternative routes (e.g. travel times) so that people can make informed decisions.

BART currently receives events schedule on a monthly basis and responds accordingly based on estimated attendance. Extra services will be provided if the attendance is huge.

For major events, AC transit will add extra services. But the purpose is mainly to ensure the bus system runs smoothly rather than to service the extra demand.

BART and AC transit get the scheduled events information from phone calls, emails, calendars, and mails, from event sponsors or organizers.

Local agencies may also be involved during the course of special event. For example, the City of San Leandro once helped AC transit to create extra bus loading zones for scheduled events.

BART gets real time ridership information from gate counts. But this information is not currently provided to the public.

Major Events:

BART usually does not provide extra services if the major events happen during non-peak commuting times.

AC transit can do re-routing of buses, but to a limited degree.

AC transit and BART respond to major events according to special protocols. Usually MTC calls for a major event and the emergency center coordinates by cell-phones.

A back-up system is necessary in case of power or communication is down due to the major events.

CamSys: is there a spike in BART/AC Transit usage due to 880 closure on Dec 9th?

BART: it is not during peak period, thus no additional service was provided.

AC Transit: minor bus rerouting to accommodate emergency vehicles.

4. Identification of Potential Solutions

Strategies that influence travelers' decisions & choices
Strategy #1, #2

BART has a trip planning tool on its website, but it is only schedule-based and does not have real time travel times or delays of BART.

BART will have real time train info on 511 later this year.

AC Transit's Nextbus displays real-time bus arrival info. Orbital system needs software upgrades to be able to push data to other agencies.

AC Transit users can use 511 transit planner.

511 is planning a "my 511" enhancement that will provide both transit and traffic travel times for a given route. However, there is no plan for a multi-modal planner.

Currently travelers need to go through multiple websites to use pre-trip planning services provided by different agencies (511, BART, AC transit).

Real-time parking availability information is now available for a few BART stations (Rockridge, etc), but BART is not sure whether this can be expanded to other stations.

AC transit: a cost-benefit analysis is needed to evaluate the strategies.

Vassili: This will be the focus of the second phase.

Wei-Bin: BC analysis should be reflected to some extend in the first phase.

There is static data (location and number of spaces) for Caltrans Park and Ride lots on 511, but no real time parking space availability info.

Real time parking information is valuable and exchanging this information is very useful. This will require developing new system and integrating existing systems.

On arterial, there is some radar detection for occupancy by direction. ACCMA website has current arterial condition.

#14 Route Shifts

Caltrans currently only provides route switching recommendation from freeway to freeway (not from freeway to arterial because they do not want to send traffic to local streets where there may not be enough capacity to accommodate the traffic).

Freeway to arterial switching will be considered if there is a pre-planned, pre-approved protocol between Caltrans and cities to divert the traffic.

The key is how to re-route traffic from arterial back to freeway.

#15 Modal shift

City of Hayward: This strategy will yield different results under different situations (for instance, traveler may be willing to switch from driving to public transit for their trips to the office, but probably will not do so for trips back home).

This strategy is difficult to implement since the information needs to be tailored to meet needs of different travelers.

#16 Shifts among transit

AC transit: Info can be displayed on Nextbus, but there is only limited number of Nextbus signs and people already on buses cannot see that info.

Strategies that facilitate collaboration among agencies for operational improvement

Enhance coordination between highways (freeways and arterials)
#8, #12, #13: Coordination between ramp metering and traffic signal timing

Caltrans has desire but not capability for coordination between ramp meter and arterial signals

City of San Leandro: Need trailblazer and/or CMS signs to redirect traffic back to the freeway

City of Hayward: Ramp meters make traffic back up onto local streets; cities want to have information of how ramp metering is implemented and the impact to local streets.

City of Alameda: SR 260 Tube & Jackson on-ramp is congested because ramp metering is not active

Substandard design may prohibit improvements from ramp metering

Implementation of ramp meters should be dynamic and fair

Caltrans: current ramp metering is based on local traffic responsive, no coordination with upstream or downstream. Dynamic ramp metering is needed to do the coordination.

Cities like the idea of coordinating ramp metering and arterial signal timing as long as traffic does not back up to local streets when freeway traffic is free-flowing.

Enhance coordination between highways and transit
#3 Signal priority for transit

This strategy is already in place in certain locations

#11 Adjustment of AC transit bus routes (11a) and schedules (11b)

AC transit has the ability to put more buses on routes that run behind, but currently has no funding to deploy additional buses.

AC has the obligation to serve all the bus stops unless certain street is closed, thus bus route cannot be changed real-time.

11b is more feasible than 11a.

Enhance coordination between transit systems
#5 Multi-modal payment

Albert: Multi-modal payment is desirable. ICM can help to expand the multi-modal payment to other systems (e.g., parking).

AC Transit: there is plan to use Translink to pay for Park&Ride lots.

#6 Transit hub connection protection:

BART riders are a small percent for AC transit. AC normally would not delay services to wait for BART riders. And AC has limited ability to do so.

AC does get BART schedule when setting up their schedules.

AC transit and BART have different headways, thus it is connection protection could be provided for some connections.

Enhance coordination between highways and Oakland Coliseum
#9

City of Oakland previously conducted a study on using adaptive signal timing on 98th and Hegenberger. This also includes the coordination with on- and off-ramps signals at 66th. But there is no funding available.

Enhance coordination between highways and Port of Oakland
#10 Coordination of Highway and Port of Oakland

Container traffic is expected to triple by year 2020.

The distribution center is located in central valley. So most trucks take 880 and 238.

Port is currently implementing an electronic identification system to reduce truck waiting time.

There are more problems when trucks are going into the port than out of the port.

It will be helpful to provide port delay info to truck drivers before they drive to the port.

Enhance coordination with emergency services
#4 Coordination with Emergency Services

There exists mobile data terminal, which does not provide “best route” information.

In City of San Leandro, the police department already has a GPS/GIS tool to track police cars.

Enhance coordination among all for incident response
#7 Multi-agency Incident Response Team

MTC, Caltrans, and CHP are working together for a workshop and training session to develop a better working relationship and to get better response plans. The first phase only involves first responders, but later phases will involve local agencies.

ICM can potentially help first responders to identify types of incidents and types of trucks that are needed to clean the incidents.

Facilitate collaboration among agencies

Collaborative planning for maintenance
#25 Coordinate Scheduled Maintenance and Construction Activities

Caltrans: all lane closures must be reviewed by district traffic managers. This information can be obtained from Caltrans website. However, this information may not be 100% accurate.

511 currently does not have this information.

Collaborative planning for emergency or special events
#29 Work Hours during Emergency or Special Events

Different procedures for emergency vs. special events – separate this into 29a (emergency) and 29b (special events)

#29b Special Events: Caltrans will change construction schedule based on special events.

5. Discussion on prioritization of the strategies

The team will summarize stakeholder comments and recommend feasible strategies that will be discussed and finalized during the next stakeholder meeting.

A3: TAC meeting Jan 18, 2007

Minutes of I-880 ICM TAC Meeting
MTC MetroCenter
101 8th Street, Oakland
Fishbowl Conference Room
January 18, 2007
9 am – 11 am

Attendees:

Caltrans D4	AC Transit
MTC	City of San Leandro
PATH	Kimley-Horn Associates
CCIT	

Item 1 - Review and Finalize 880 Candidate Strategies:
Diagram of ICM concept on whiteboard (Steve Shladover)

Data Collection	→	ICM	→	Data Distribution
Operating Agencies		Communication		Operating Agencies
		Data Processing		Media (to travelers)
		More Communication		Internet (to travelers)

The strategies presented at last week's stakeholder workshop were evaluated by each of the consultant organizations, and two strategies were eliminated from further consideration. The rest of the strategies were included on the table circulated to all meeting participants. The overall strategy ratings were summarized on a numerical scale that ranged from -60 to +60, and the 17 strategies under consideration received ratings from -1 to +20 (in a relatively narrow range compared to the entire scale). Topics that came up in the review of the strategies were:

- Include ferry system in the consideration of transit system coordination strategies, a unique aspect of the 880 corridor.
- If ferries are included, do we include toll systems and SFOBB access as part of the corridor's "sphere of influence?" Similar to comment last week about including VTA. [This comment was not resolved.]
- For each strategy, responsible agencies should identify any capital needs to implement the strategy when engaged in interviews with consultant contacts.
- Parking capacity of transit stations and Park & Ride facilities – there are multiple ways of monitoring and tracking parking availability, but implementation may require some

capital investment. There is also a challenge in getting the information out to the public in a useful way.

- Transit re-routing – it is much more feasible to do this with express buses that run on the freeway, rather than regular buses running on arterials (which should be deleted from strategy 11).
- Typical AC Transit response to major freeway incident is to make or receive a call from Caltrans TMC and check the 880 SMART Corridor website, then use that information to do manual route guidance for express bus drivers.
- Reword Strategy #11 to focus on re-routing of buses that operate on freeway.
- Strategy #12 – Trailblazing signs on arterials are needed to get shifted traffic back to freeway or directed to transit. Some local merchant resistance was experienced when large CMS signs were proposed for major arterials (size and aesthetic concerns); context sensitivity will be key. Small, simple signs are more likely to be accepted, as with Silicon Valley SMART Corridor. 880 SMART Corridor has plans for trailblazing signs, but funding is not yet available.
- Strategy #9 – Move to freeway/arterial category and include advisories to drivers approaching Coliseum on freeway (if congestion is less using exit on far side of Coliseum). When this is moved, “Special Events” can be deleted from the category heading with Emergency Response.
- Strategy #6 – Transit connection protection requires additional buses to be available in order to maintain published schedule, headways and contractually-required rest periods in cases where there is currently no slack. AC Transit currently provides connection protection only for emergencies and pre-planned special events. It may be feasible to select some key transit hubs/connection points such as the Coliseum for a demonstration of transit connection protection on routes that have long headways.
- Strategy #16 – Coordination at Oakland Airport is a big issue, especially when OAK terminals have to be evacuated for security reasons.
- MTC is conducting a Transit Connectivity Study that could help inform these issues.
- Rename Freight Operations category to include Airport and Seaport operations and add a strategy to explicitly include coordination with airport operations.
- Strategy #4 – Currently only fire departments in the corridor have signal pre-emption, but not the police. We need to understand whether the police don’t feel they need it, or whether they would like it but can’t afford it.
- Any other major “special event” venues along the 880 corridor other than the Oakland Coliseum? None were mentioned.
- Strategy #25 – Standardize a repository for reporting on routine maintenance closures of freeways and local arterials, make accessible to other agencies. Each city currently

has its own method of reporting this info. Include EBMUD as well as cities and Caltrans.

- Strategy #29 – Clarify that this refers to construction and maintenance work hours.
- A regular 880 corridor forum is needed to keep stakeholder agencies informed and in communication with each other. ACCMA currently has an 880 Corridor Committee that meets on an as-needed, task-oriented basis. Such a forum could be enhanced to meet regularly and include broader range of relevant stakeholders.
- Public outreach is needed to convince the general public, merchants and other local stakeholders of the merits of some of these alternatives that may be controversial (such as new dynamic trailblazer signs in their neighborhoods).
- In order to strengthen our competitiveness on the national scene, we should be careful to take credit for corridor integration activities that are already very strong in the 880 corridor, including Translink fare collection, BATA monitoring of Fastrak transponders for travel times, and 511 website. The Federal ICM program can gain the benefit of these without having to pay for them.

Item 2 - ICM Milestones

- Draft ConOps due March 20, 2007.
- Sample Data Requests: MTC/PATH will develop a process for contacting stakeholders to collect sample data needed as part of ICM Phase 1. Vassili with CS will inform stakeholders of data needed, Jeff with CCIT will be repository of data. Idea to form an 880 ICM TAC subcommittee to address data needs and collection issues.

Item 3 - Next Steps

- Steve was concerned about the number of strategies to be carried forward. Are all worth pursuing to the same level of detail? Should they be prioritized? There was agreement that additional clustering/collapsing of strategies is needed, but that we first need to establish what the specific cost or institutional impediments to implementation would be, based on detailed interactions with the stakeholder agencies.
- Following the meeting, MTC revised the strategy table to include a refined list of strategies to be explored by the consultants for consideration and inclusion in the ConOps. The 17 strategies have been clustered into 7 major categories. Within these categories, it was determined by the TAC that some strategies should be consolidated into one strategy. For example, the "Freeway/Arterial Operations Integration" strategies can be combined into a single strategy that addresses several ramp metering elements.
- Consultants will contact agencies to develop strategies further before the next TAC meeting (scheduled for Feb 16th 9 am – 11 am). The consultants need to start

writing the Concept of Operations to have something ready to present for that meeting.

- Consultants are encouraged to schedule meetings with their assigned stakeholder agencies within the next week, to acquire the additional knowledge and information needed to determine the actual feasibility of each strategy. As additional functional information is collected, some strategies may be eliminated due to identified implementation issues while others may rise to the top of the priority list. It is suggested that these meetings be coordinated to occur during the week of Jan. 29-Feb. 2nd. (Note - AC Transit expressed their availability to meet Jan. 29-31.)

Summary of TAC recommendations for modifications to Strategies & Categories:

a) Addition of trailblazer signs as component of the "Traveler Information Strategies". Stakeholders felt the trailblazers signs were an enabler for disseminating information to the public for traffic diversion and en-route traveler information. Nextbus signs were also identified as a mechanism for disseminating info to the public. (Vassili, maybe you can share with the group your findings on the trailblazer demonstration conducted in the South Bay).

b) "Roadway/Transit Coordinated Operations" strategies, #11, AC Transit indicated there was opportunity to re-route buses that operate along the corridor (Transbay buses) as opposed to the buses that operate along the arterials. The recommendation was to omit "arterials" from the strategy description.

c) "Freeway/Arterial Operations" strategies #8, #12, #13 & #9 recommended to be consolidated into a single strategy with several elements, including ramp metering, arterial signal adjustment, trailblazer signs and special events information.

d) "Transit to Transit Ops" category. It was proposed that consultants gather additional information from the MTC, "Transit Connectivity Study" currently underway. AC Transit indicated that Strategy #6 Transit Hub may be difficult to implement due to associated collective bargaining issues however, they did express that there is potential to demonstrate at a single transit hub where parking capacity and other strategies can potentially be deployed in coordination.

e) Add "Airport" to the "Freight Integration" category. AC Transit described examples of opportunities for enhanced integration of transit information at the airport.

f) "Emergency Response" category. Assigned consultant to gather additional info from the ACCMA and local jurisdictions with regards to strategy #4 Signal pre-emption.

g) "Planning and Integrated Operations", assigned consultant to coordinate meeting with Barry Loo, Caltrans Traffic Management Chief, to discuss feasibility of strategies.

h) In addition, comments on the strategies were also submitted (emailed to all) by the City of Hayward (R. Carmichael) and the City of Alameda (V. Patel) for consideration.

Item 4 – Next 880 ICM TAC Meeting

- Friday, February 16, 9am – 11am at MTC, Fishbowl Conference Room

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Appendix B: Strategies

Note color codes for classifying strategies:

Not considered further, either because it's an enabler of multiple other strategies or it does not apply to this corridor

Only considered relevant in its real-time aspects

New strategy for I-880 corridor, not included in FHWA listing

APPROACH	Information Sharing/Distribution	Reasons to delete or add	Stakeholder Involved
ICM Enablers	Manual information sharing.	Not a complete strategy, but an enabler	
	Automated information sharing (real-time data).	Not a complete strategy, but an enabler	
	Automated information sharing (real-time video).	Not a complete strategy, but an enabler	
	Information clearing-house/Information Exchange Network between corridor networks or agencies (e.g., information is displayed on a single graphical representation of the corridor, showing real-time status of all the corridor networks and connections).	Not a complete strategy, but an enabler	
	A common incident reporting system and asset management (GIS) system.	Not complete strategies, but enablers	
	Shared control of "passive" ITS devices, such as CCTV.	Not a complete strategy, but an enabler	

	Access to corridor information (e.g., ATIS Database) by Information Service Providers (ISPs) and other value-added entities.	Not a complete strategy, but an enabler	
APPROACH	Improve Operational Efficiency of Network Junctions and Physical Interfaces		
Strategies	A corridor-based advanced traveler information system (ATIS) database that provides information to travelers pre-trip.		MTC and all stakeholders
	En-route traveler information devices owned and operated by network agencies (e.g., DMS, 511, transit public announcement systems) being used to describe current operational conditions on another network(s) within the corridor.	Addition from 12/11 meeting	Caltrans, AC Transit, BART
APPROACH	Improve Operational Efficiency of Network Junctions and Physical Interfaces		
STRATEGIES			
	Signal priority for transit (e.g. extended green times to buses that are operating behind schedule).		AC Transit, Caltrans, ACCMA, Cities
	Signal pre-emption or "best route" for emergency vehicles.		ACCMA, Cities, Caltrans
	Multi-modal electronic payment.		MTC, AC Transit, BART
	Transit hub connection protection (holding one service while waiting for another service to arrive).		AC Transit, BART
	Multi-agency or multi-network incident response teams and service patrols and training exercises.		Caltrans, BART, AC Transit
	Coordinated operation between ramp meters and arterial traffic signals.	Mentioned in 12/11 meeting (overlap with 12 and 13)	Caltrans

	Coordinated operation between arterial traffic signals and rail transit at-grade crossings.	Not in this corridor, since BART is grade-separated	
	Enhance arterial signal timing with advance information about special events at Coliseum	Mentioned in 12/11 meeting	Caltrans, ACCMA, cities, Coliseum
	Port of Oakland advise trucks travel time based on real-time traffic information	from 12/11 meeting	Caltrans, Port of Oakland
	AC Transit adjusts bus routes, schedules and operations based on real-time information about highway and arterial traffic and special events	From 12/11 meeting	AC Transit, Caltrans
APPROACH	Accommodate and Promote Cross-Network Route and Modal Shifts		
STRATEGIES	Modify arterial signal timing to accommodate traffic shifting from freeway.		Caltrans, cities, ACCMA
	Modify ramp metering rates to accommodate traffic shifting from arterial.		Caltrans, cities, ACCMA
	Modify transit priority parameters to accommodate more timely bus and light rail service on arterial.	Already covered under signal priority	
	Promote route shifts between roadways via en-route traveler information devices (e.g. DMS, HAR, "511") advising motorists of congestion ahead, directing them to adjacent freeways or arterials.		Caltrans
	Promote modal shifts from roadways to transit via en-route traveler information devices (e.g. DMS, HAR, "511") advising motorists of congestion ahead, directing them to high-capacity transit networks and providing real-time information on the number of parking spaces available in the park and ride facility.		Caltrans, BART, AC Transit

APPROACH	Accommodate and Promote Cross-Network Route and Modal Shifts (Cont.)		
STRATEGIES	Promote shifts between transit facilities via en-route traveler information devices (e.g. station message signs and public announcements) advising riders of outages and directing them to adjacent rail or bus services.		BART, AC Transit
	Re-route buses around major incidents.		
APPROACH	Manage Capacity — Demand Relationship Within Corridor (Real-time/Short-term)		
STRATEGIES	Lane use control (reversible lanes or contra-flow).	Only counts toward ICM if it involves real-time integration across networks (freeway, arterial, transit)	
	Convert regular lanes to transit-only or emergency-only.	Real-time conversion based on operating conditions would be ICM	
	Add transit capacity by adjusting headways and number of vehicles.	Only counts toward ICM if it involves real-time integration across transit operators	
	Add transit capacity by adding temporary new service (e.g., express bus service, "bus bridge" around rail outage or incident).	Only counts toward ICM if it involves real-time integration across transit operators	

	Add capacity at parking lots (temporary lots).	Only counts toward ICM if it involves real-time integration across network operators (freeway, arterial, bus, rail)	
	Increase roadway capacity by opening HOV/HOT lanes and shoulders.	Not ICM - no cross-modal integration	
	Modify HOV restrictions (increase minimum number, make bus only).	Only counts toward ICM if it involves real-time integration across network operators (freeway, arterial, bus)	
	Restrict ramp access (metering rates, closures).	Not ICM - no cross-modal integration	
	Convert regular lanes to truck-only.	Only counts toward ICM if it involves real-time integration between Caltrans and Port	
	Coordinate scheduled maintenance and construction activities among corridor networks	Add real-time changes to plans to accommodate incidents	Caltrans, AC Transit, BART
	Variable speed limits (based on TOD, construction, weather conditions).	Not ICM - no cross-modal integration	
	Modify toll and HOT pricing.	Only counts toward ICM if it involves real-time integration across network operators (freeway, arterial, bus)	
	Modify transit fares to encourage ridership.	Not ICM - no cross-modal integration	
	Modify parking fees.	Not ICM - no cross-modal integration	

	Variable truck restrictions (lane, speed, network, time of day).	Only counts toward ICM if it involves real-time integration across network operators (freeway, arterial, bus)	
	Restrict or reroute commercial traffic.	Looks redundant with preceding item	
APPROACH	Manage Capacity — Demand Relationship Within Corridor (Long-term)		
STRATEGIES	Low cost infrastructure improvements to cross-network linkages and junctions.	ICM is not supposed to include infrastructure improvements	
	Re-routing rail transit to alternative rail networks.	Real-time rerouting based on operating conditions would be ICM	
	Guidelines for work hours during emergencies or special events.		MTC, ACCMA, Caltrans, AC Transit, BART
	Peak spreading.	This is a goal, not a strategy	
	Ride-sharing programs.	Not ICM - no cross-modal integration	

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Appendix C: Candidate Strategies

(A) Traveler Information Strategies (4)

No.	Description **Narrative Rating Scale** (++) Strongly Agree (+) Agree (0) Neutral (-) Disagree (--) Strongly Disagree ( ) No Rating	Consultant Team	Significant Transportation Impact	High Benefit/Cost Ratio	Minimal Institutional or Political Challenge	Will Improve Competitiveness	Little Technical Complexity	Composite	Overall Strategy Ranking
1	A corridor-based advanced traveler information system (ATIS) database that provides information to travelers pre-trip.	PATH CCIT CSI KHA SMG DKS	+ 0 0 - 0	+ + + - +	0 - - + 0	+ 0 0 0 0	+ - - 0 0	++++ - - - +	2+
2	En-route traveler information devices owned and operated by network agencies (e.g., DMS, 511, transit public announcement systems) being used to describe current operational conditions on another network(s) within the corridor.	PATH CCIT CSI KHA SMG DKS	+ + + - 0	+ + + - +	0 - - + 0	+ + + 0 0	0 0 0 0 0	++++ ++ ++ - +	8+
14	Promote route shifts between roadways via en-route traveler information devices (e.g. DMS, HAR, "511") advising motorists of congestion ahead, directing them to adjacent freeways or arterials.	PATH CCIT CSI KHA SMG DKS	++ + + - -	++ ++ ++ - +	- 0 0 - -	+ + + - -	0 - - - -	++++ +++ +++ 5- ---	2+

(A) Traveler Information Strategies (4)

No.	Description **Narrative Rating Scale** (++) Strongly Agree (+) Agree (0) Neutral (-) Disagree (--) Strongly Disagree ( ) No Rating	Consultant Team	Significant Transportation Impact	High Benefit/Cost Ratio	Minimal Institutional or Political Challenge	Will Improve Competitiveness	Little Technical Complexity	Composite	Overall Strategy Ranking
15	Promote modal shifts from roadways to transit via en-route traveler information devices (e.g. DMS, HAR, "511") advising motorists of congestion ahead, directing them to high capacity transit networks and providing real-time information on the number of parking spaces available in the park and ride facility.	PATH	0	+	+	++	-	+++	8+
		CCIT	0	+	0	++	--	+	
		CSI	+	+	0	+	0	+++	
		KHA	0	+	0	++	--	+	
		SMG	0	0	0	0	0	0	
		DKS							

(B) Roadway/Transit Coordinated Operations Strategies (2)									
No.	Description **Narrative Rating Scale** (++) Strongly Agree (+) Agree (0) Neutral (-) Disagree (--) Strongly Disagree ( ) No Rating	Consultant Team	Significant Transportation Impact	High Benefit/Cost Ratio	Minimal Institutional or Political Challenge	Will Improve Competitiveness	Little Technical Complexity	Composite	Overall Strategy Ranking
		CCIT	-	+	0	+	+	++	
		CSI							
		KHA	-	+	0	+	+	++	
		SMG	0	0	+	-	-	-	
		DKS	+	+	+	+	+	5+	
		CCIT	0	-	--	+	0	--	
		CSI							
		KHA	0	-	--	+	0	--	
		SMG	0	0	0	0	0	0	
		DKS	+	+	+	+	-	++ +	

(C) Freeway/Arterial Operations Integration Strategies (4)									
No.	Description **Narrative Rating Scale** (++) Strongly Agree (+) Agree (0) Neutral (-) Disagree (--) Strongly Disagree ( ) No Rating	Consultant Team	Significant Transportation Impact	High Benefit/Cost Ratio	Minimal Institutional or Political Challenge	Will Improve Competitiveness	Little Technical Complexity	Composite	Overall Strategy Ranking
8	Coordinated operation between ramp meters and arterial traffic signals.	PATH	++	+	-	++	-	+++	14+
		CCIT	++	+	-	+	-	++	
		CSI	++	++	-	+	+	5+	
		KHA	++	+	-	+	-	++	
		SMG	+	+	+	-	-	+	
		DKS	+	+	+	-	-	+	
12	Modify arterial signal timing to accommodate traffic shifting from freeway.	PATH	+	+	-	+	-	+	12+
		CCIT	+	+	-	+	-	+	
		CSI	++	++	-	+	+	5+	
		KHA	+	+	-	+	-	+	
		SMG	+	+	-	+	-	+	
		DKS	+	+	+	+	-	+++	
13	Modify ramp metering rates to accommodate traffic shifting from arterial.	PATH	+	+	0	+	-	++	17+
		CCIT	+	+	+	+	-	+++	
		CSI	++	++	-	+	+	5+	
		KHA	+	+	+	+	-	+++	
		SMG	+	+	-	+	-	+	
		DKS	+	+	+	+	-	+++	

(D) Transit-Transit Operations Integration Strategies (2)									
No.	Description **Narrative Rating Scale** (++) Strongly Agree (+) Agree (0) Neutral (-) Disagree (--) Strongly Disagree ( ) No Rating	Consultant Team	Significant Transportation Impact	High Benefit/Cost Ratio	Minimal Institutional or Political Challenge	Will Improve Competitiveness	Little Technical Complexity	Composite	Overall Strategy Ranking
6	Transit hub connection protection (holding one service while waiting for another service to arrive).	PATH	0	+	-	++	+	+++	
		CCIT	0	+	--	++	+	++	
		CSI							
		KHA	0	+	--	++	+	++	
		SMG	0	0	+	-	+	+	13+
		DKS	+	+	+	+	+	5+	
16	Promote shifts between transit facilities via en-route traveler information devices (e.g. station message signs and public announcements) advising riders of outages and directing them to adjacent rail or bus services.	PATH	-	+	0	++	0	++	
		CCIT	0	+	0	++	-	++	
		CSI							
		KHA	0	+	0	++	-	++	
		SMG	-	0	+	-	-	--	
		DKS	+	+	+	+	+	5+	9+

(E) Freight Operations Strategy (1)									
No.	Description **Narrative Rating Scale** (++) Strongly Agree (+) Agree (0) Neutral (-) Disagree (--) Strongly Disagree ( ) No Rating	Consultant Team	Significant Transportation Impact	High Benefit/Cost Ratio	Minimal Institutional or Political Challenge	Will Improve Competitiveness	Little Technical Complexity	Composite	Overall Strategy Ranking
10	Port of Oakland advise trucks travel time based on real-time traffic information.	PATH	+	+	+	++	+	6+	
		CCIT	0	+	+	++	+	5+	
		CSI							
		KHA	+	+	+	++	+	6+	
		SMG	0	0	0	0	0	0	
		DKS	+	+	+	0	0	+++	20+

(F) Emergency Response and Special Events Integration Strategies (3)									
No.	Description **Narrative Rating Scale** (++) Strongly Agree (+) Agree (0) Neutral (-) Disagree (--) Strongly Disagree ( ) No Rating	Consultant Team	Significant Transportation Impact	High Benefit/Cost Ratio	Minimal Institutional or Political Challenge	Will Improve Competitiveness	Little Technical Complexity	Composite	Overall Strategy Ranking
4	Signal pre-emption or "best route" for emergency vehicles.	PATH	-	++	0	0	++	+++	
		CCIT	-	+	0	+	+	++	
		CSI							
		KHA	-	+	0	+	-	0	
		SMG	-	-	+	-	-	---	
		DKS	+	+	+	+	+	5+	7+
7	Multi-agency or multi-network incident response teams and service patrols and training exercises.	PATH	0	++	-	0	0	+	
		CCIT	+	++	0	0	+	+++ +	
		CSI	++	++	+	+	+	7+	
		KHA	+	++	0	0	+	+++ +	
		SMG	-	0	+	-	-	--	
		DKS	+	+	+	+	+	5+	19+

No.	(G) Planning Integrated Operations Strategies (2) Description **Narrative Rating Scale** (++) Strongly Agree (+) Agree (0) Neutral (-) Disagree (--) Strongly Disagree ( ) No Rating	Consultant Team	Significant Transportation Impact	High Benefit/Cost Ratio	Minimal Institutional or Political Challenge	Will Improve Competitiveness	Little Technical Complexity	Composite	Overall Strategy Ranking
25	Coordinate scheduled maintenance and construction activities among corridor networks.	PATH	0	+	0	0	++	+++	
		CCIT	0	+	+	+	+	++++	
		CSI							
		KHA	0	+	+	+	+	++++	
		SMG							
		DKS	+	+	+	+	+	5+	16+
29	Guidelines for **construction** work hours during emergencies or special events.	PATH	0	+	0	+	++	++++	
		CCIT	+	+	0	0	++	++++	
		CSI							
		KHA	+	+	0	0	++	++++	
		SMG							
		DKS	0	0	0	0	0	0	12+

Note: Please rate each strategy for each of the five criteria, please use -- (strongly disagree), - (disagree) to 0 (neutral) to + (agree) to ++ (strongly agree).

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APPENDIX D: ITS FUTURE PROJECT DESCRIPTION2

Project #	Project Description	Participating Agencies	Market Package
Regional/Cross-Cutting			
REG 1	Integrate the Caltrans Transportation Management System with other traffic management systems around the Bay Area region, as appropriate, to allow for coordinated operations and information sharing; including the following: the various SMART Corridors throughout the Bay Area region, Local City/County traffic management systems, TravInfo, etc.	Caltrans Sub regional Local Cities-Counties SMART Corridor partner agencies CHP MTC Others as appropriate	ATMS 1 ATIS 1
REG 2	Integrate the SMART Corridors throughout the Bay Area with other local traffic and transit management systems around the Bay Area region, as appropriate, to allow for coordinated operations and information sharing.	Sub regional Local Cities-Counties SMART Corridor partner agencies Transit agencies as appropriate Others as appropriate	ATMS 1 APTS 7
REG 3	Conduct a project to evaluate and recommend a consistent region-wide methodology for deployment of transit signal priority and emergency vehicle pre-emption.	MTC Transit operators as appropriate Sub regional Local Cities-Counties Caltrans	APTS 7

2 http://www.mtc.ca.gov/planning/ITS/downloads.htm

Project #	Project Description	Participating Agencies	Market Package
REG 4	Integrate transit operations/management system(s) of the various transit operators in the Bay Area region with other transit (bus and rail) and traffic management systems and centers, as appropriate, throughout the Bay Area region, to allow for coordinated operations and information sharing.	Transit operators as appropriate Sub regional Local Cities-Counties Caltrans SMART Corridor Agencies Others as appropriate	APTS 7
Traffic Management			
TM 1	Expand the Caltrans Traffic Operations Systems (TOS) throughout the Bay Area region from a geographic perspective in high priority corridors.	Caltrans Others as appropriate	ATMS 1
TM 2	Expand and modify the functionality of the Caltrans Traffic Operations Systems (TOS) to include: highway speed monitoring, field device monitoring and control, reversible lane monitoring, weather monitoring (environmental) monitoring, en-route traveler information dissemination, emissions monitoring, and vehicle probe data acquisition.	Caltrans Others as appropriate	ATMS 1 ATMS 2 ATMS 4 ATMS 6 ATMS 8 ATMS 11 ATMS 18 ATMS 19 MCO 3
TM 3	Implement Freeway Ramp Metering in corridors where congestion and ramp volumes warrant. The Caltrans/CHP TMC should have the capability to monitor and/or control the ramp metering functions from the TMS.	Caltrans CHP Other local agencies as appropriate	ATMS 7
TM 4	Deploy high priority traffic signal system interconnections across jurisdictional boundaries, as appropriate.	Sub regional Local Cities-Counties SMART Corridor agencies Others as	ATMS 7

Project #	Project Description	Participating Agencies	Market Package
		appropriate	
TM 5	Develop and implement local TOCs/TMCs, either individually or jointly with other neighboring agencies. These projects would develop local agency (city and county level) TOCs/TMCs with varying levels of capability depending on the needs of the deploying local agency, or agencies. Joint centers would likely follow the SMART Corridor Paradigm. These projects would allow for command and control of the field assets of each individual agency as well as the ability to share data and/or information with other agencies on an as needed basis. Shared control of field assets would be voluntary on an agency by agency basis.	Local cities and county agencies as appropriate Others as appropriate	ATMS 1 ATMS 3 ATMS 6 AD 1
TM 6	Conduct projects to update signal timing, coordination, and synchronization on a periodic basis to account for changes in population, traffic volumes, and traffic patterns.	Local cities and county agencies as appropriate Caltrans Others as appropriate	ATMS 1 ATMS 3 ATMS 7
TM 7	Deploy projects for interoperation and coordination at agency boundaries, from not only a signal timing perspective, but also from an emergency vehicle pre-emption and transit signal priority perspective.	MTC Caltrans Local cities and county agencies as appropriate Transit agencies as appropriate Local police and fire agencies as appropriate Others as appropriate	APTS 7 EM 2
Traveler Information			
TI 1	Conduct projects to incorporate and integrate real-time transit information, roadway construction information, road	MTC Others as	ATIS 1 ATIS 2

Project #	Project Description	Participating Agencies	Market Package
	weather information, arterial data, and other new data sources into the regional 511 system.	appropriate	MCO 3 MCO 7
Public Transportation			
PT 1	Conduct a project to establish a common methodology to exchange automated vehicle location (AVL) data from transit vehicle systems of the various transit operators throughout the Bay Area region from a center-to-center perspective.	Various Bay Area region transit operators.	APTS 1
PT 2	Implement transit vehicle (bus and rail) emergency notification systems that enable emergency communications between the transit vehicle and the transit operations system and other centers.	Various Bay Area region transit operators Others as appropriate	APTS 5
PT 3	Implement transit signal priority in selected locations and along key transit corridors, as appropriate, throughout the Bay Area region. This project is a placeholder for any agency (local or state) seeking this type of deployment.	Transit operators as appropriate Sub regional Local Cities-Counties Caltrans Others as appropriate	APTS 7
Emergency Management			
EM 1	Deploy a regional system to allow emergency response vehicles and agencies to communicate with each other in the field.	MTC CHP Caltrans Local police and fire agencies Others as appropriate	ATMS 8 EM 1
EM 2	Conduct a project to integrate the CHP 911 Call Center Dispatch with external entities, as appropriate, in order to	CHP FSP	ATIS 1 ATIS 2

Project #	Project Description	Participating Agencies	Market Package
	automatically exchange incident information.	SMART Corridor partner agencies as appropriate Local Police and Fire agencies as appropriate Others as appropriate	ATMS 8 EM 4 EM 1
EM 3	Conduct a project to develop system interconnects from the Bay Area Incident Response System (BAIRS) to the following Bay Area region systems/stakeholders: Caltrans transportation management system, Caltrans maintenance vehicles, the various SMART Corridors, Local City-County Police and Fire systems, Local City-County traffic operations systems, CHP CAD system, Freeway Service Patrol (FSP), 911 call answering centers, 511 and TravInfo traveler information systems and others as appropriate.	Caltrans SMART Corridor partner agencies Local Police and Fire agencies as appropriate CHP MTC Others as appropriate	ATMS 6 ATMS 8 EM 1 ATIS 1 AD 2
EM 4	Implement emergency vehicle preemption in selected locations and along key corridors, as appropriate, throughout the Bay Area Region. To be used for standardized deployment throughout the region.	Sub regional Local Cities-Counties Caltrans SMART Corridor partner agencies Local City-County Police and Fire agencies as appropriate CHP MTC	EM 2

Project #	Project Description	Participating Agencies	Market Package
		Others as appropriate	
EM 5	Deploy automated vehicle location (AVL)_systems on emergency vehicles throughout the Bay Area region. To be used for standardized deployment throughout the region.	Sub regional Local Cities-Counties Local City-County Police and Fire agencies as appropriate CHP MTC Others as appropriate	EM 1 EM 2 EM 4

Appendix E: Bay Area Regional Architecture Change Approval Process3

METROPOLITAN
TRANSPORTATION
COMMISSION

Joseph P. Bort MetroCenter
101 Eighth Street
Oakland, CA 94607-4700
Tel: 510.464.7700
TDD/TTY: 510.464.7769
Fax: 510.464.7848

Bay Area ITS Architecture Maintenance Committee
Kick-off Meeting

Draft

Appendix A: Continuous Change Approval Procedure

The Bay Area Regional ITS Architecture is a living document with changes made based on recommendations of the Maintenance Committee members. The formal procedure for a change in the ITS Architecture to be submitted, reviewed, discussed, and provisionally approved are defined in this section.

Continuous ITS Architecture changes refer to those changes that happen between two major ITS Architecture updates. The current update is planned for completion in November 2007. The purpose of addressing these changes promptly and recognizing them as an official part of the Regional ITS Architecture is to ensure ITS activities are coordinated to provide the maximum benefit to the region and to comply with Federal requirements. Keeping this purpose in mind, the procedure for a typical change to be adopted in the ITS Architecture is:

Change Identification – Requests for changes can be made by stakeholders. A stakeholder is any agency or private organization identified as a participant in the architecture. Changes may be submitted by stakeholders not included on the list, but the addition of a stakeholder must first be reviewed by the Maintenance Committee before the project change.

Change Definition –the requested change needs to be documented first on a change request form, available on the MTC website. The form will be compiled and managed by Kimley-Horn and Associates, Inc. and collects the following information:

Agency requesting the change

Request date

Proposed change description

The architecture aspects to be added, deleted or revised

Contact information

Initial Assessment –Kimley-Horn and Associates, Inc. will perform the initial assessment to determine whether the requested change is appropriate and in line

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3 http://www.mtc.ca.gov/planning/ITS/3-7-06_Minutes_App_A.doc

with the existing Bay Area Regional ITS Architecture. This initial assessment will provide a basis for the provisional approval of the change by the ITS Architecture Maintenance Committee. In the initial assessment, Kimley-Horn and Associates, Inc. will address such issues as:

Does the requested change form provide all the required information? If not, Kimley-Horn and Associates, Inc. will contact the requesting stakeholder to collect additional information.

Which stakeholders will be affected by the requested change? Are all affected stakeholders in agreement about the change?

Does the requested change overlap with existing infrastructure (based on the current version of the Bay Area Regional ITS Architecture Inventory and knowledge of other current projects in the region)? An overlap would indicate an opportunity to share the resources and costs in order to maximize investment.

Mapping the requested change into the Bay Area Regional ITS Architecture, does the change serve one or more of the identified needs?

Does the requested change follow the ITS standards requirement in the Bay Area Regional ITS Architecture?

Using the project sequencing list in the Bay Area Regional ITS Architecture, does the change overlap with existing or planned projects?

Change Approval –The initial assessment analysis should be distributed to every ITS Architecture Maintenance Committee member two weeks prior to the quarterly Committee meeting so that each member can have sufficient time to review the change proposals and assessment analysis before the meeting. While reviewing the initial assessment analysis, the ITS Architecture Maintenance Committee member will consider all the questions listed above and confirm that Kimley-Horn and Associates, Inc.'s analysis is accurate and comprehensive. During the Committee meeting, members need to reach consensus on disposition of each change request in the meeting. A checklist of questions that can guide Committee members to review the changes are:

What can the proposed change/project do to satisfy one or more of the regional transportation needs?

Which stakeholders will be affected by the requested change? Are all affected stakeholders in agreement about the change?

Will the proposed change/project apply data communication standards?

Will the proposed change/project provide infrastructure or service that has already existed or will be implemented by other planned projects? If yes, are these projects coordinated?

Change Disposition — The disposition and comments on every requested change will be documented and distributed to every stakeholder or posted online. Approved changes will be compiled as completed and wait to be incorporated in the architecture document when a major update takes place. Meanwhile, the addendum is considered an official part of the Bay Area Regional ITS Architecture and all projects identified in the addendum comply with Federal Requirements.

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Appendix F. Functional Analysis

In order to evaluate the technical feasibility of the candidate ICM strategies, the I-880 ICM team's systems approach included a functional decomposition and functional analysis to answer the following questions:

6. **What functions are needed for each of the ICM candidate strategies? Are these functions already in existence or new functions that still need to be developed? What are the new functions?**
7. **How should an ICM that implements the proposed strategies for the I-880 corridor be architected? How should the functions be allocated?**

Note that, in addition to contributing to the ConOps development process, the functional analysis also serves a number of important roles in the remaining ICM program:

- The functional analysis establishes the foundation for asset assessment that maps functions to physical components, thereby ensuring that each function has an acknowledged owner and determining what new subsystems, devices or software integration are needed in order to implement the proposed ICM strategies.
- In the requirement definition phase, functional analysis will serve as a basis for mapping functions to system requirements.
- In selecting the strategies, the functional analysis will also help to determine how resources will be allocated for implementing the ICM strategies according to stakeholders' priorities and budget constraints.
- The functional analysis provides the basis for the requirements allocation that guides the system implementation and testing.
- The functional analysis serves as a tool for traceability of the ICM strategies.

The functional analysis provides a breakdown of the existing transportation network functions and new ICM functions into individual functional elements. As part of the functional decomposition, in the context of the ITS systems already deployed along the I-880 corridor, the following functional groups are defined:

Functional decomposition provides a systematic view of how existing ITS systems for the transportation networks along the I-880 corridor are configured functionally. Through functional decomposition, large system functions are decomposed into elemental functions at the basic operation levels and are represented using blocks in a diagram. The interactions among different transportation networks are represented using dashed blocks that are repeated

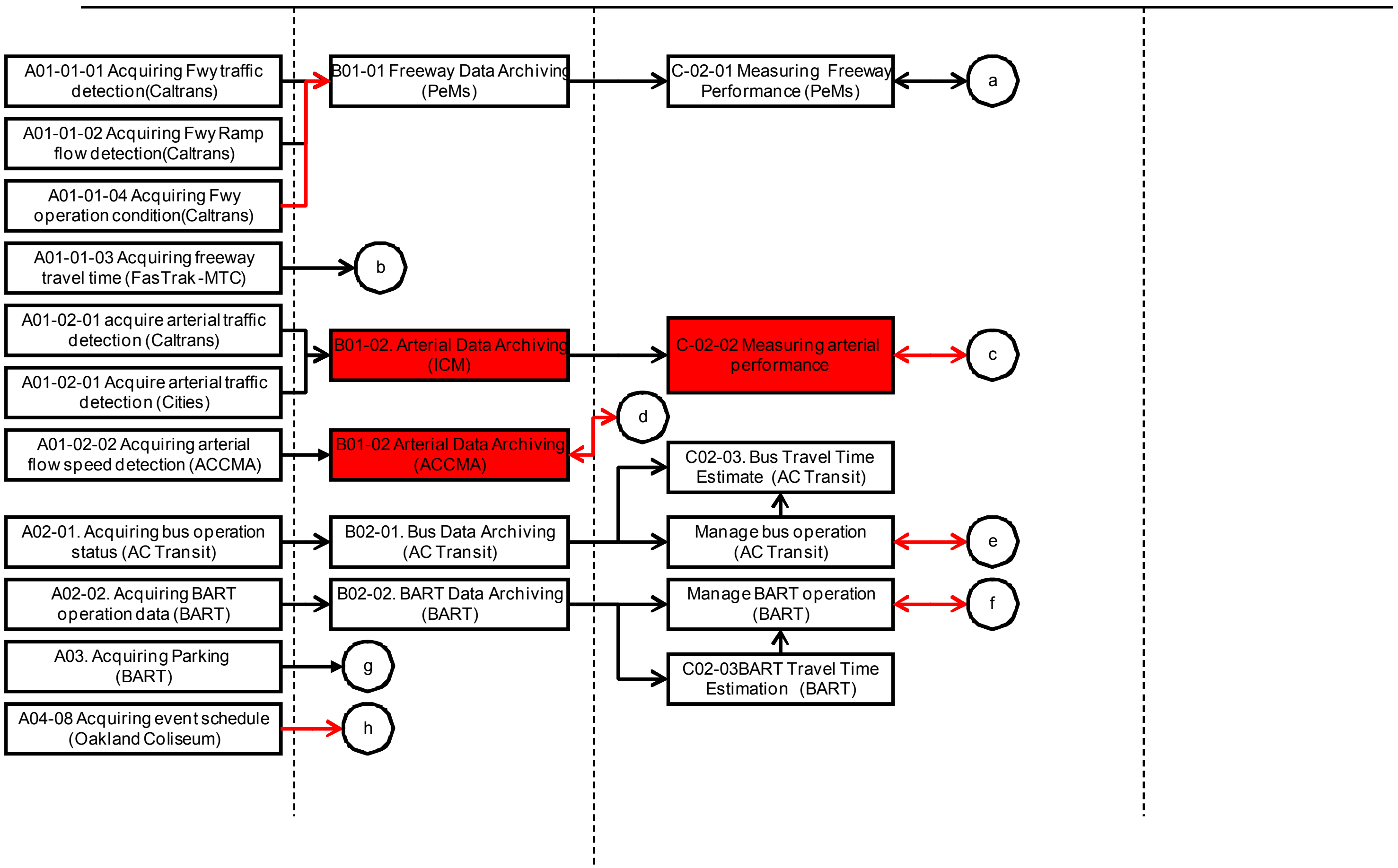
from the other network. Communication links between functional blocks are also represented in the block diagram, indicated using a line with arrows indicating the direction of information flow. The following are examples of the functions and how they are numbered:

Figures below show the functional decompositions for various subsystems, each implement a candidate ICM strategy, to reveal what new functions are needed. New functions that are required for all candidate ICM strategies under consideration are then mapped into the functional block diagrams, represented using red blocks. New communications links that are not in existence but will be needed for implementing one or more ICM strategies are also represented in the functional block diagram, as shown using red lines. A complete map of functions and strategies is given in Table 1, where the new ICM functions are marked in red,

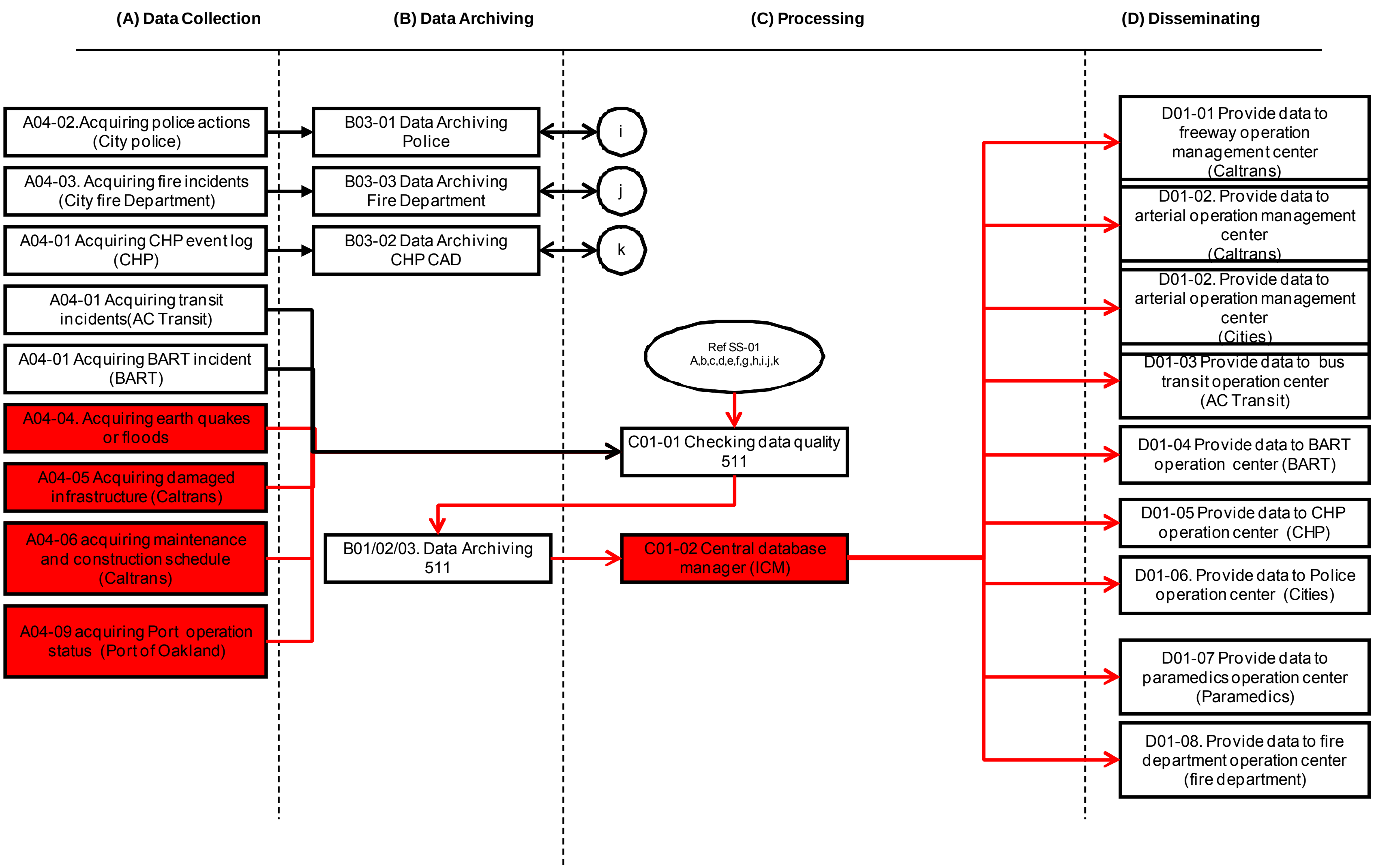
The functional decomposition and functional analysis presented in Figure 1-4 and Table 1 provide a clear and comprehensive view of the existing ITS systems already deployed in the I-880 corridor, how readily ICM can be implemented in the context of the existing ITS systems, and the relationship between the existing functions and the new ICM functions.

Notation: Solid black – existing functions
Red – New functions
Dashed – Referenced from other system chart

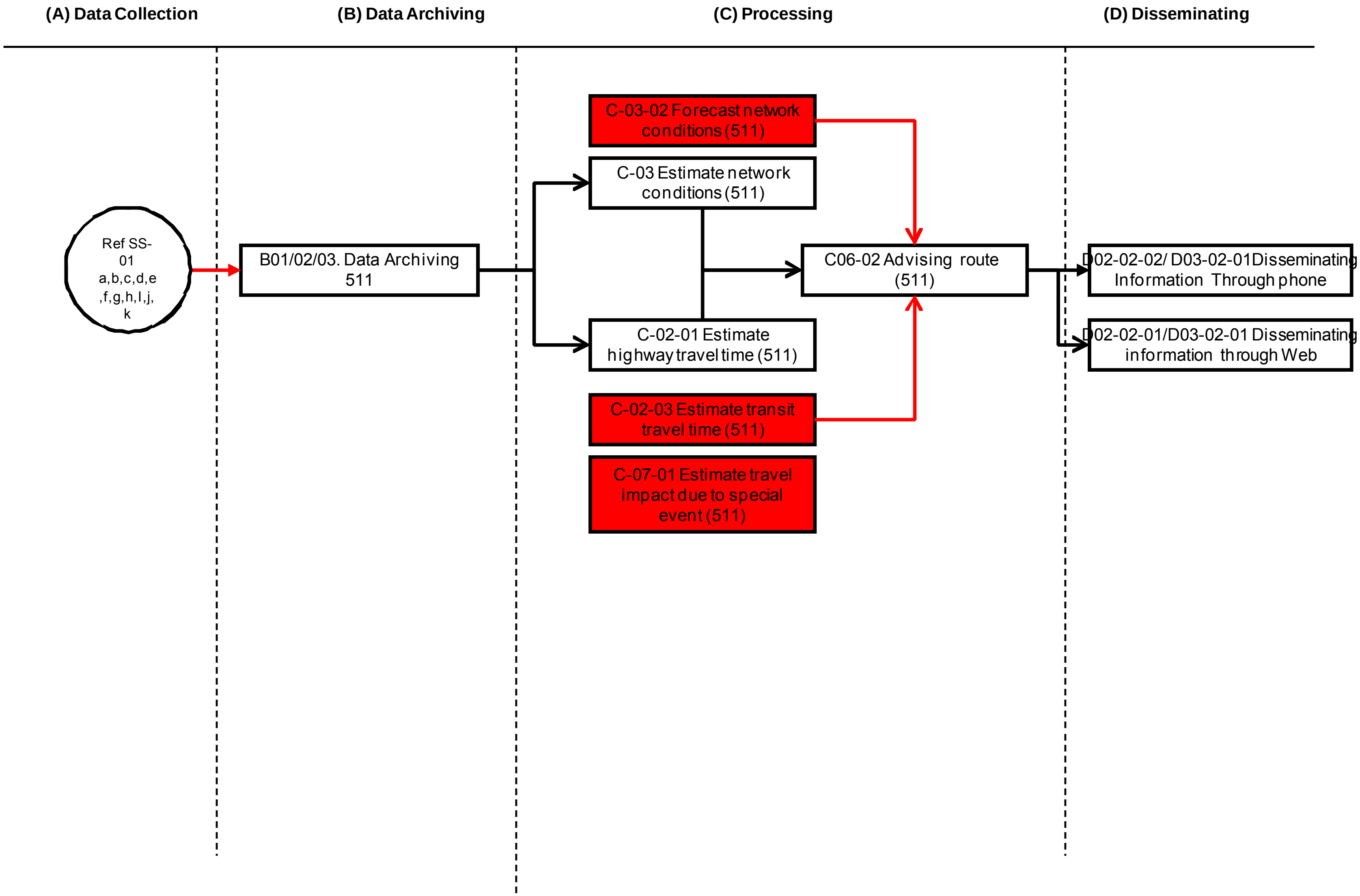
SS-01Information Sharing



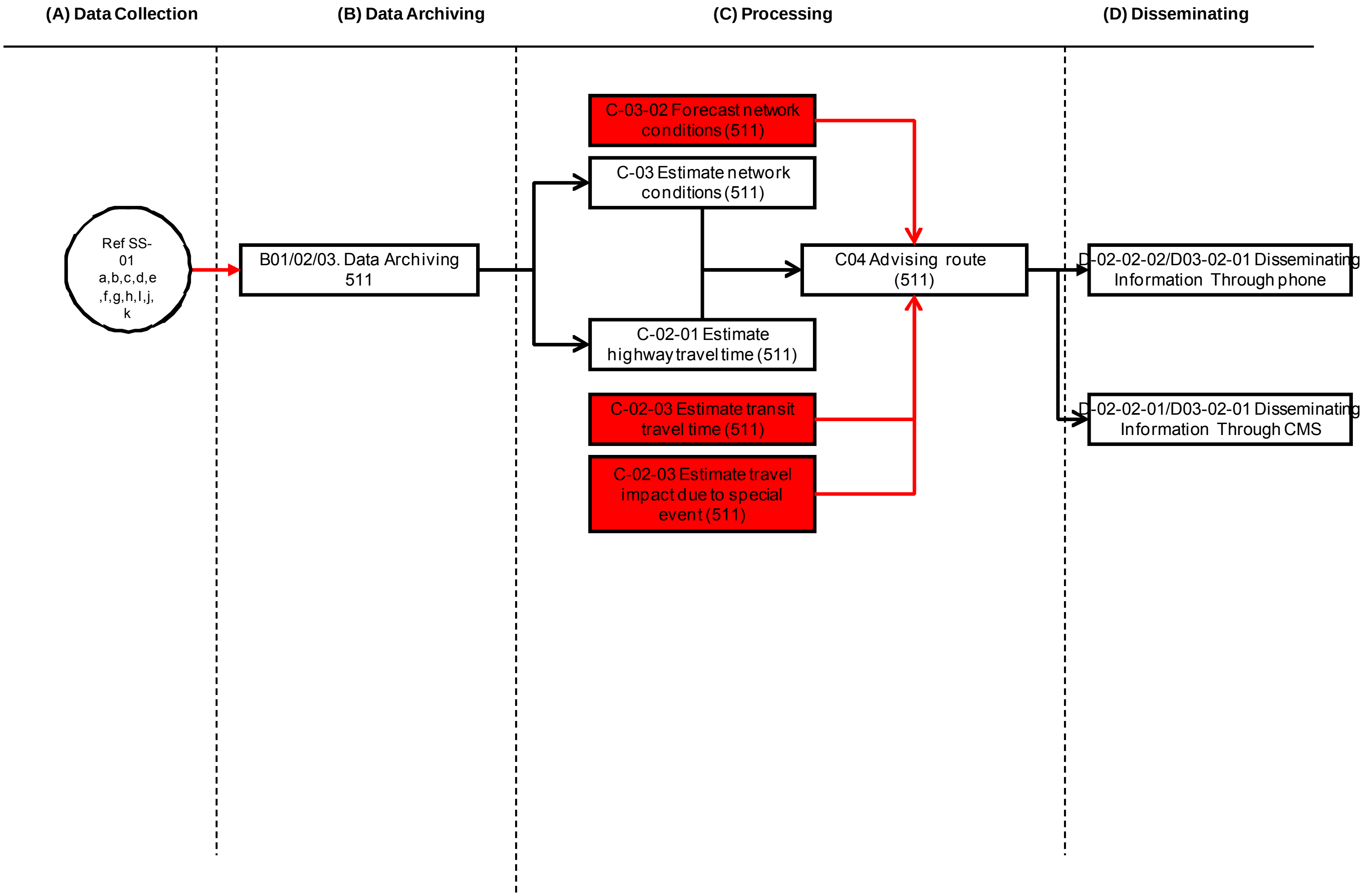
SS-01Information Sharing (Cont'd)



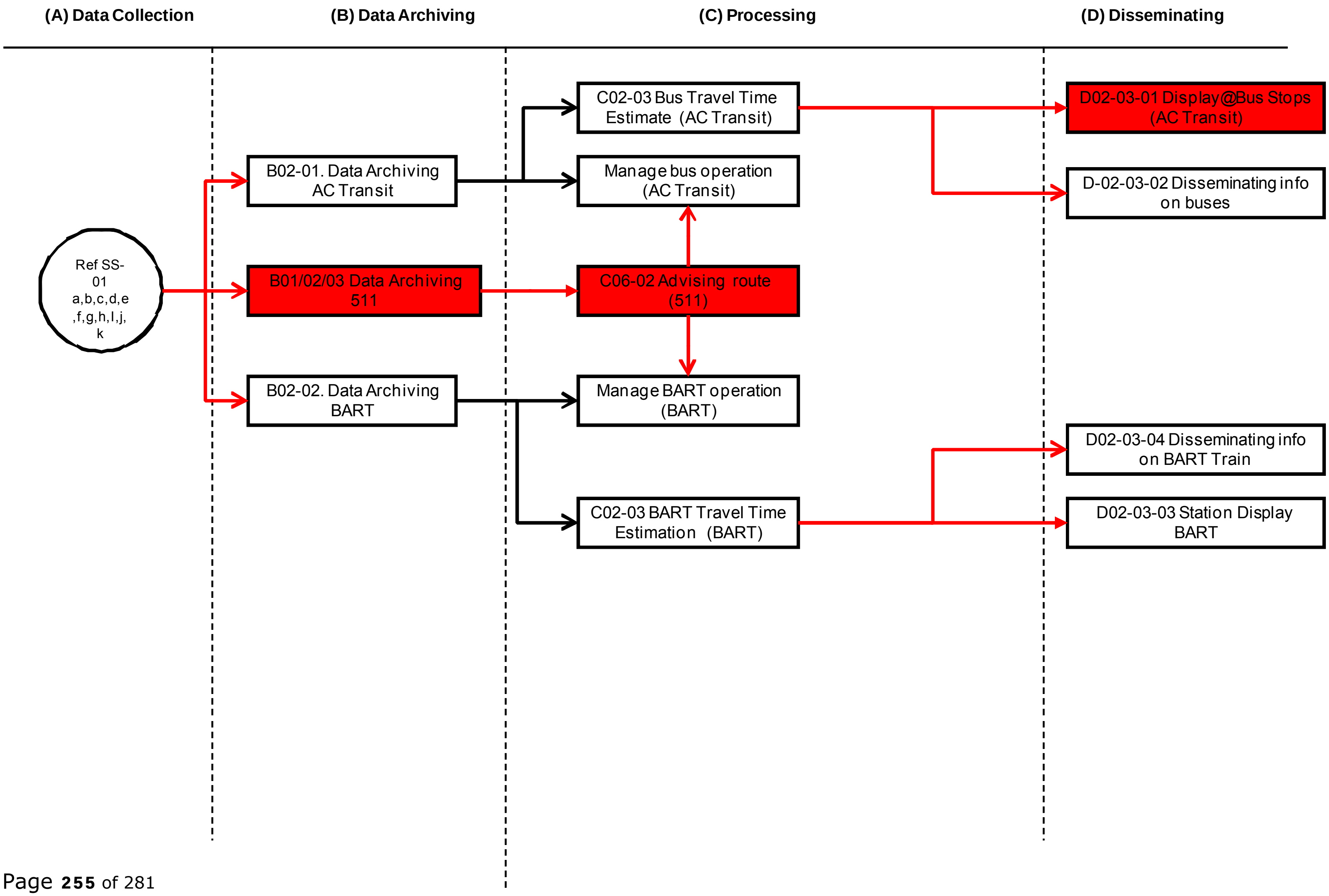
SS-02 Providing Traveler Information Through 511



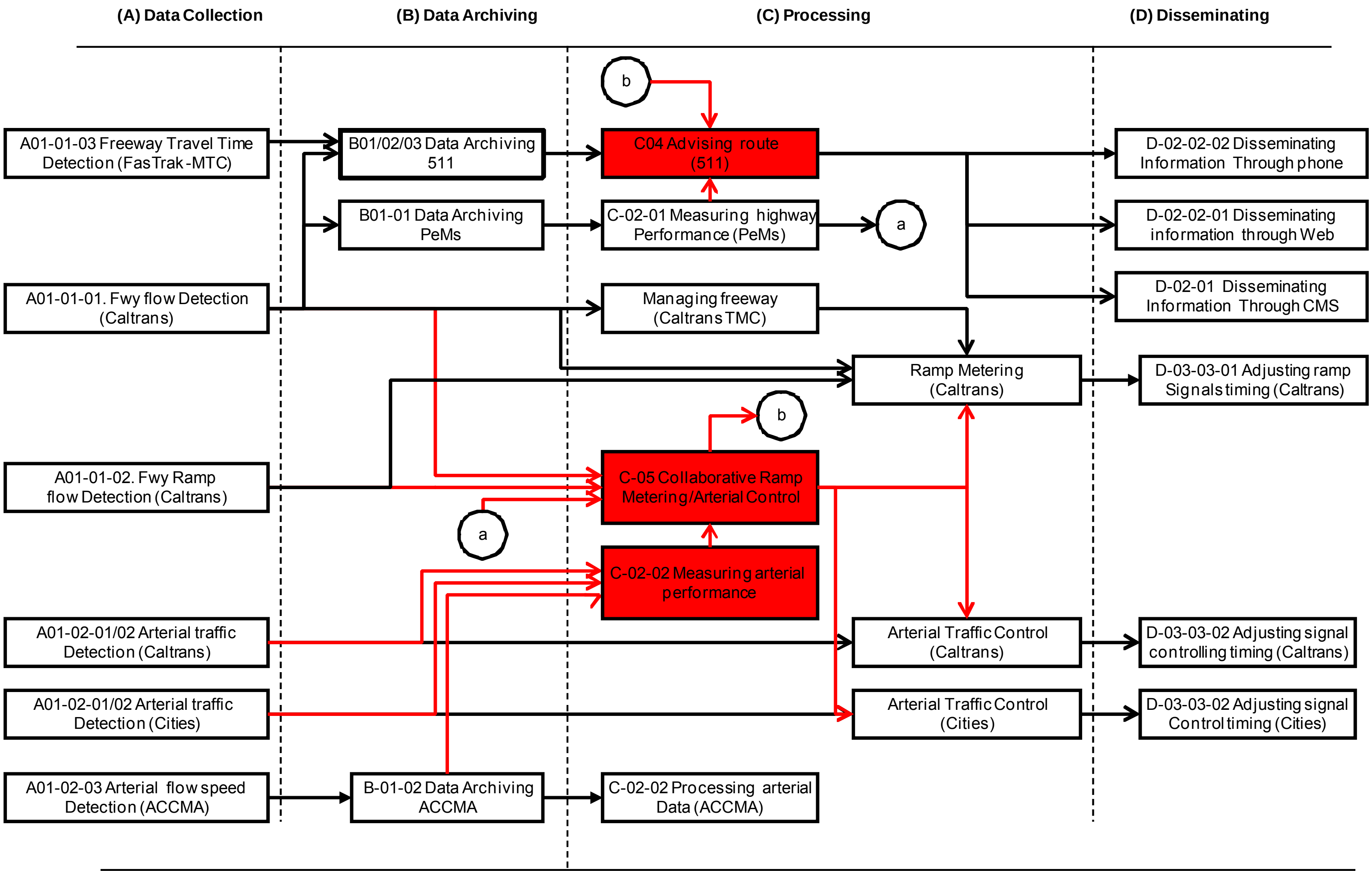
F-03 Providing Information In Real-time to Travelers for En-route Decision Making



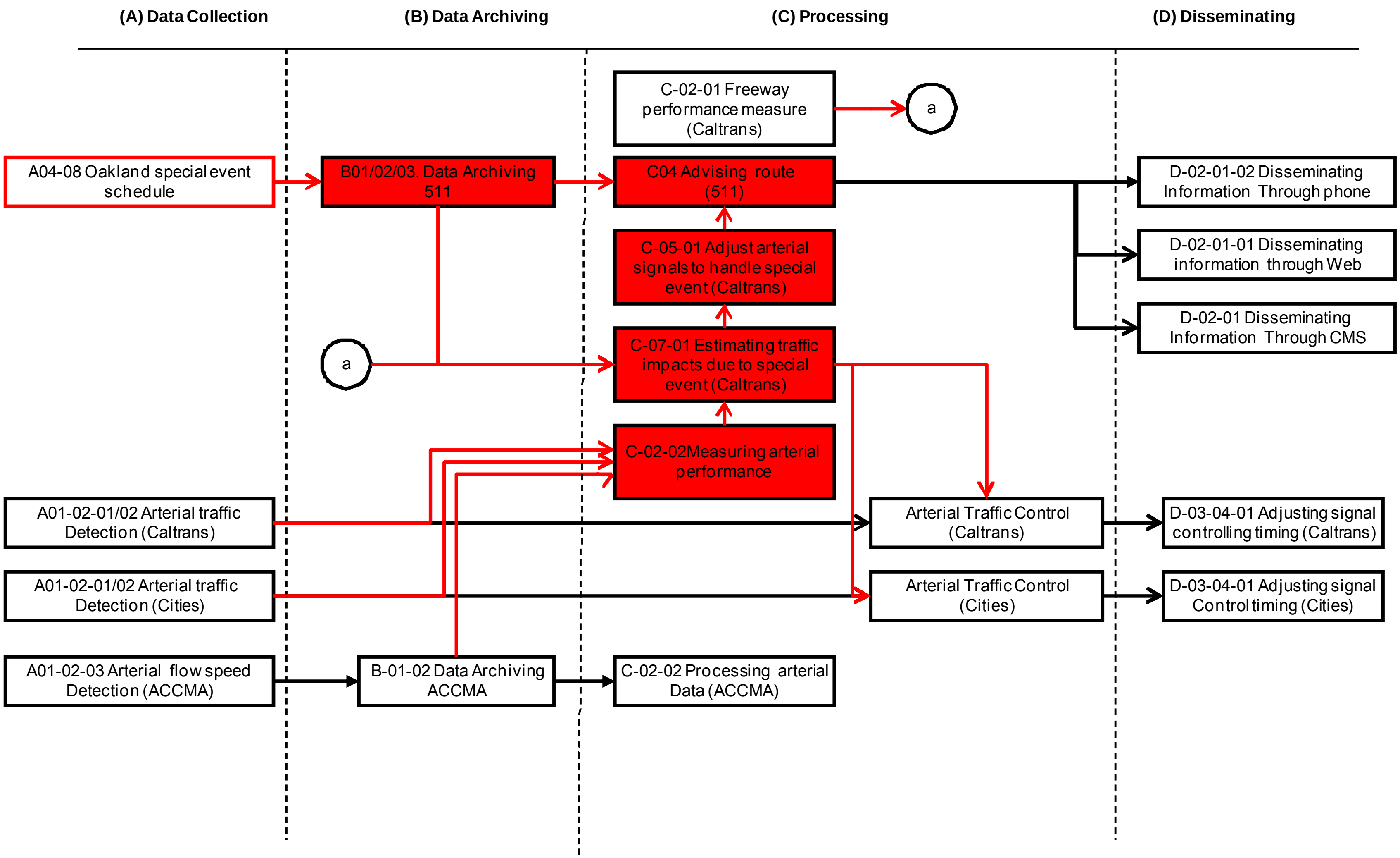
F-04 Presenting Travel Advisory Information in Real-time at Transit Stations and on Transit Vehicles



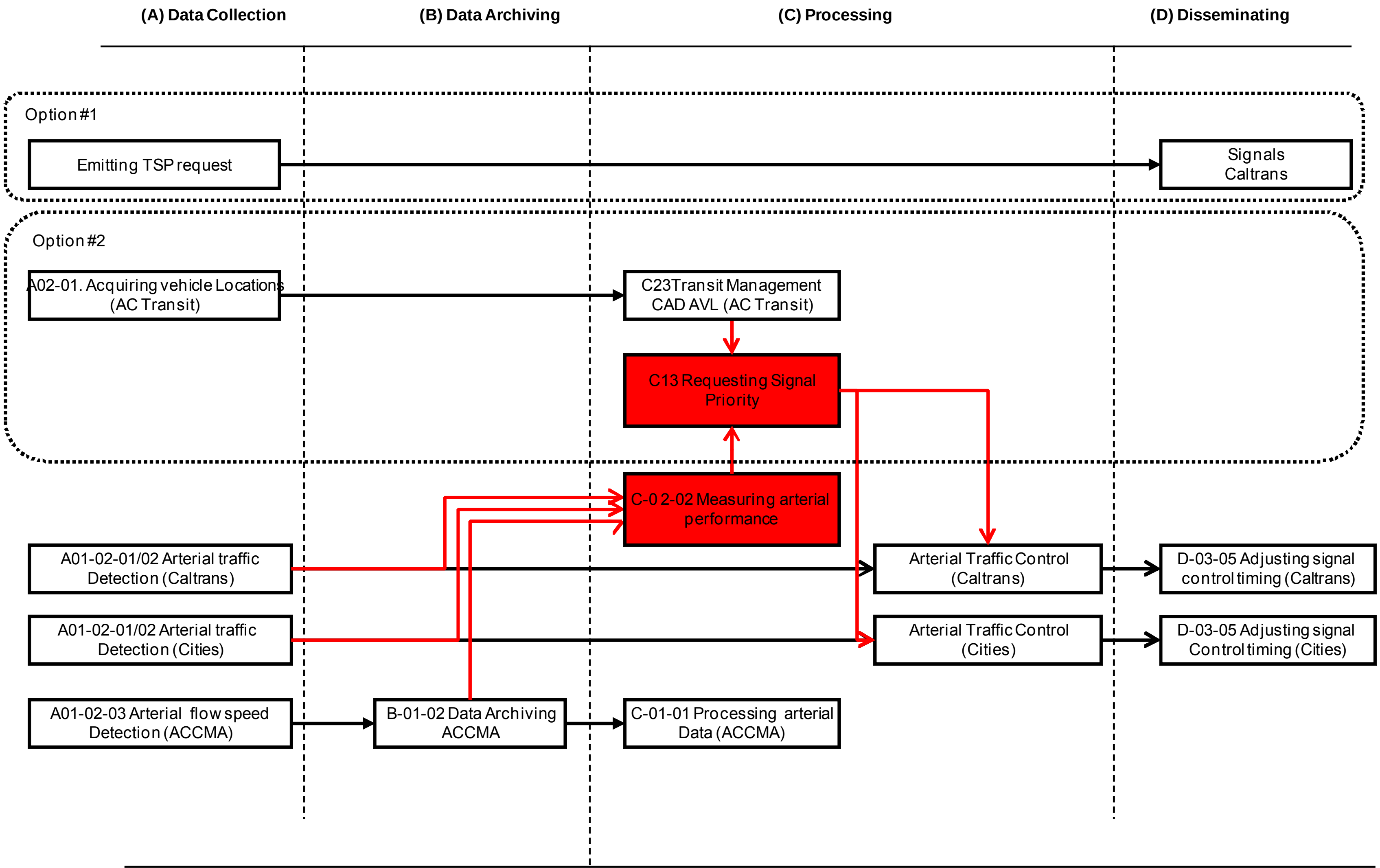
SS-05 Arterial/Ramp Metering



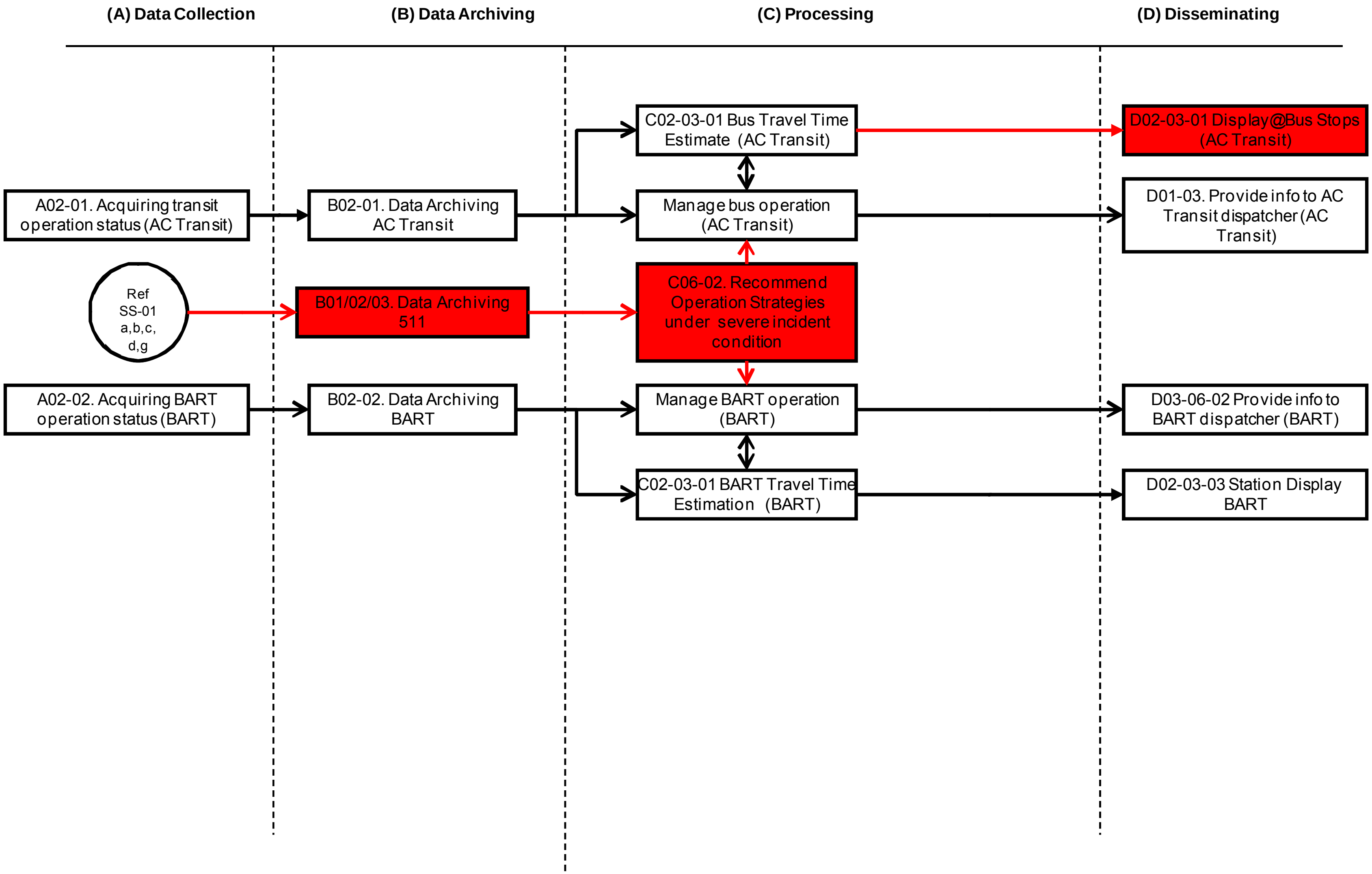
SS-06 Facilitating Arterial Signal Control Systems to Handle Special Events



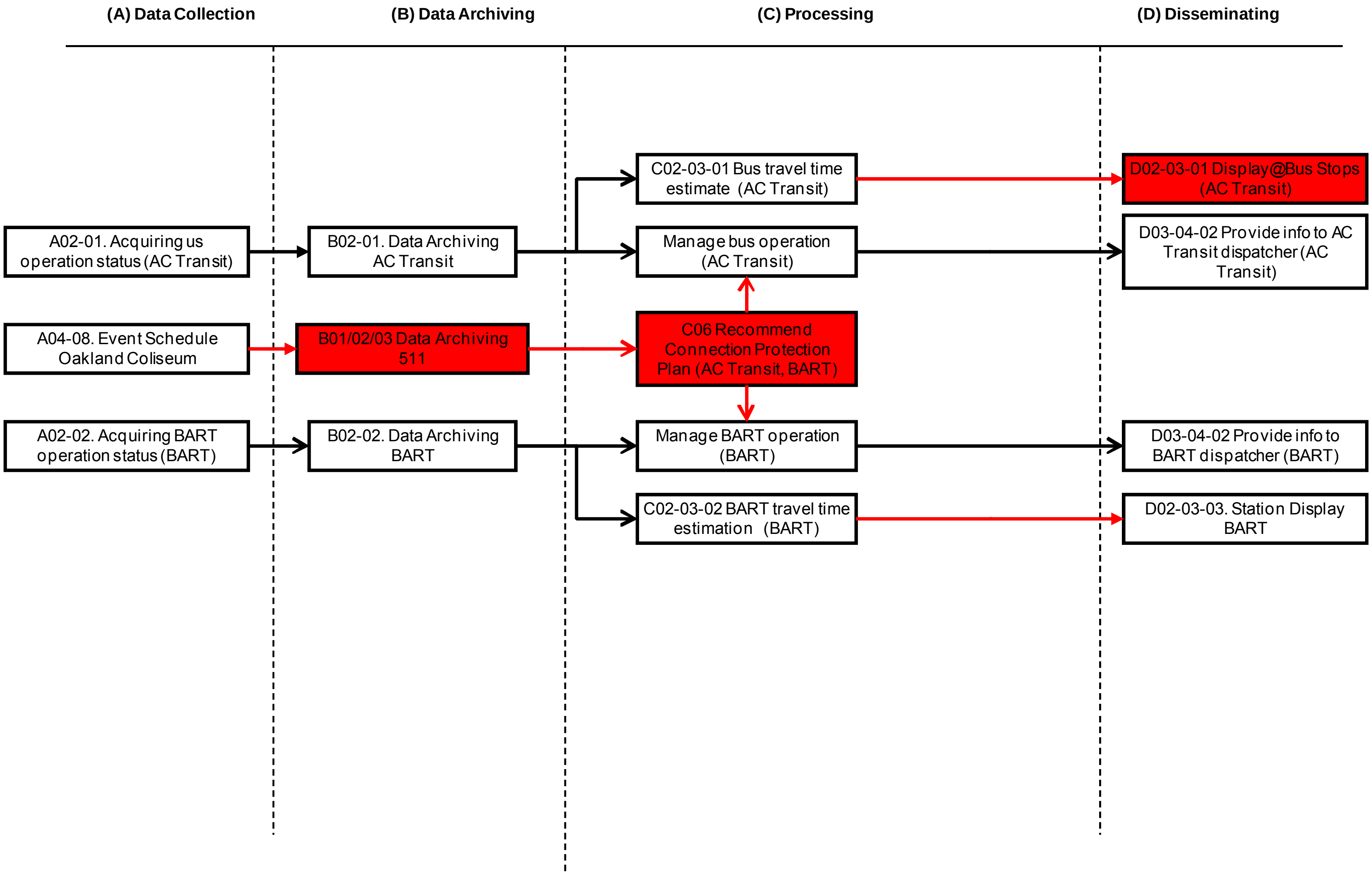
SS-07 Managing Arterial Signal to Provide Transit Signal Priority



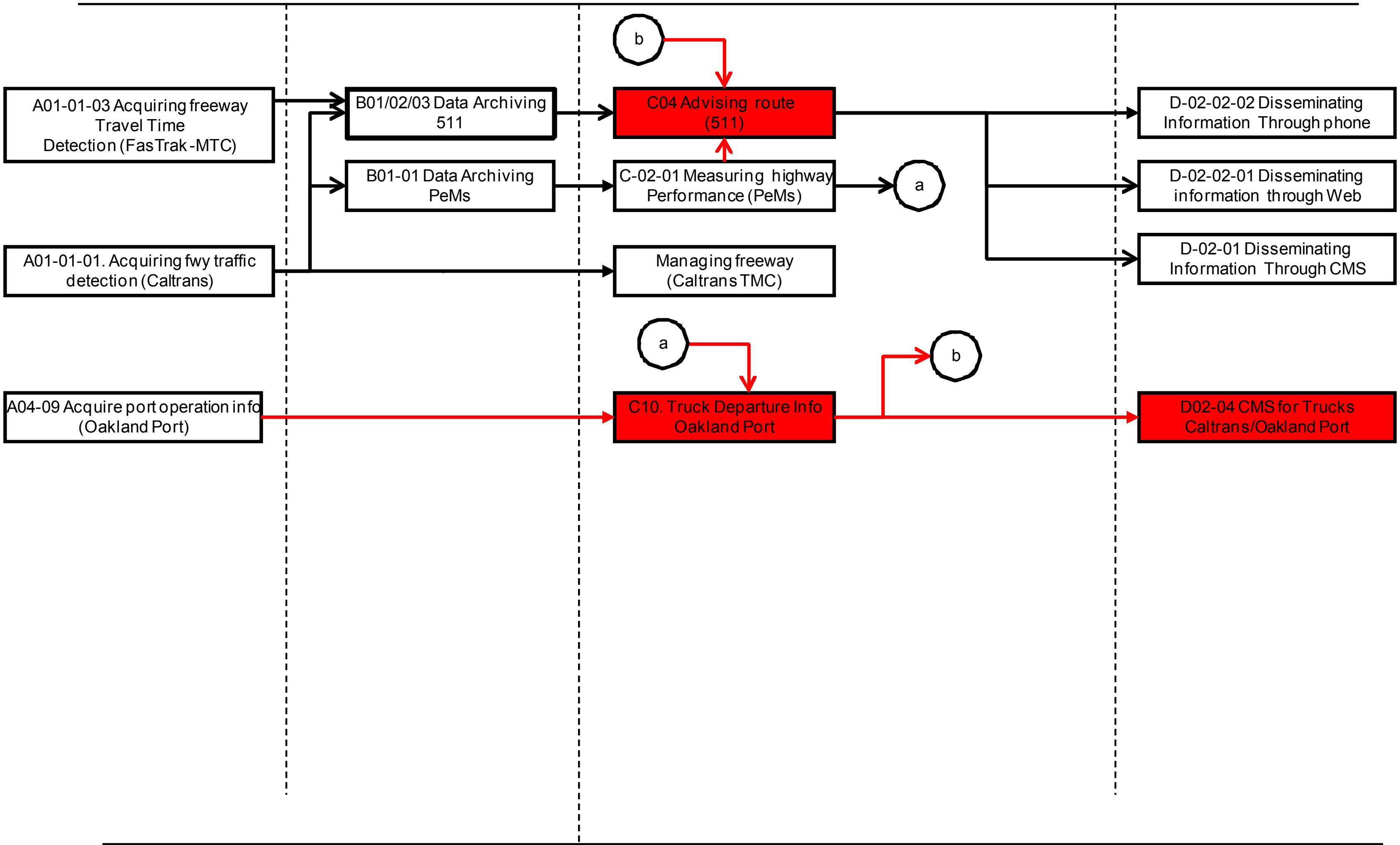
SS-08 Managing Transit Operation under Severe Incident Conditions



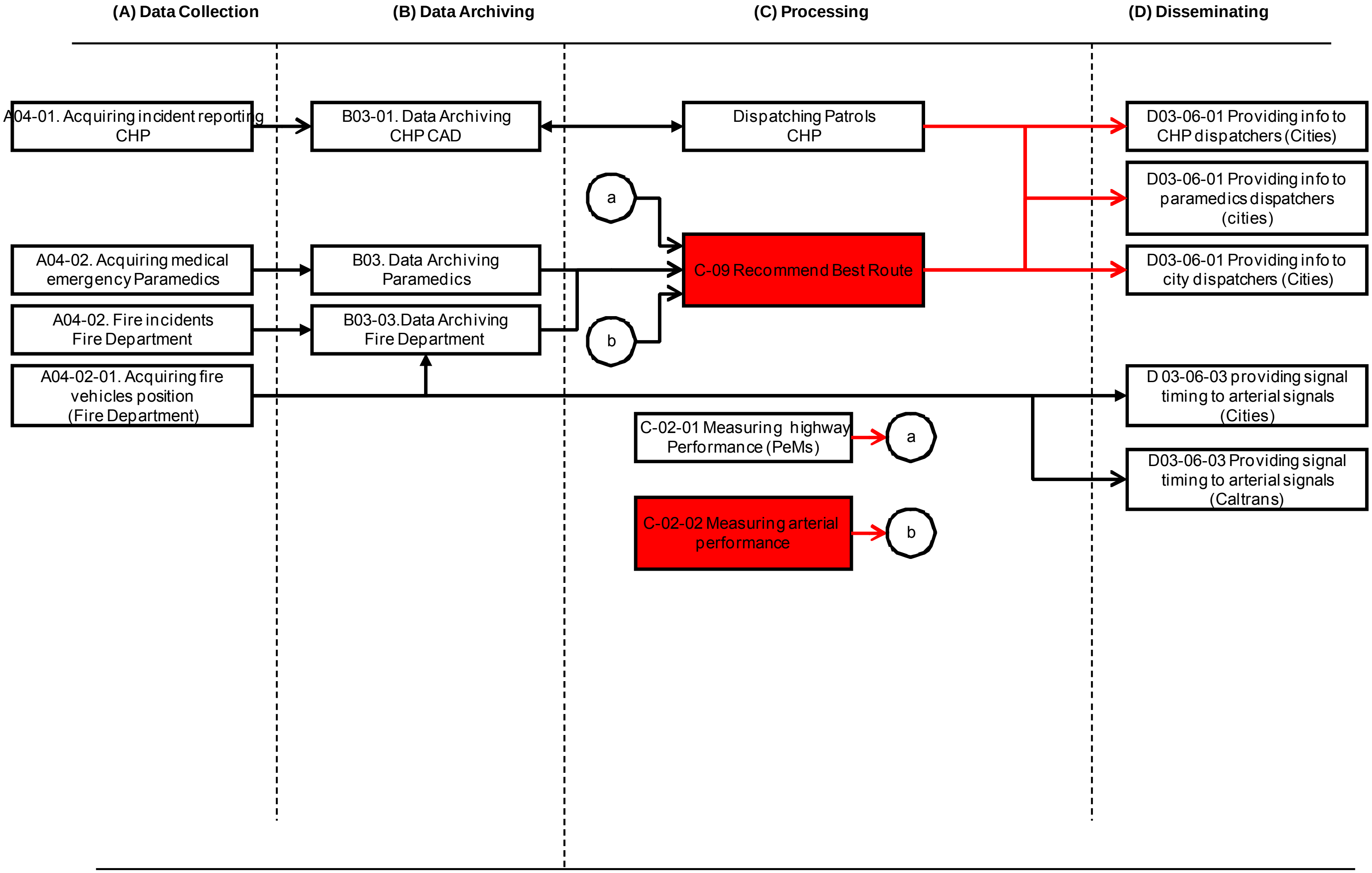
SS-09 Managing Transit Hub Connection Protection for Special Events



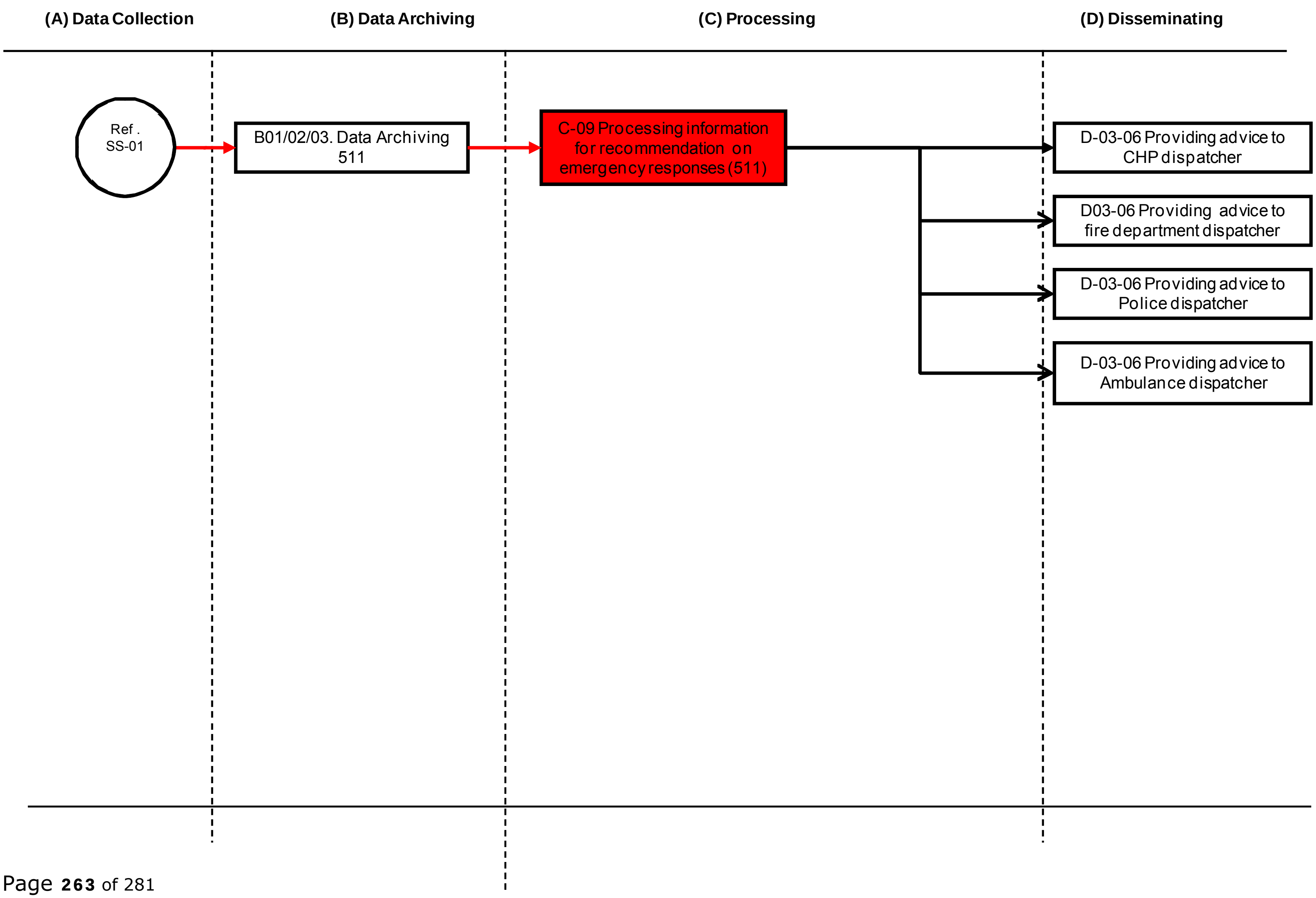
SS-10 Advising Truck Operators and Drivers About Port Delay and Estimated Travel Time



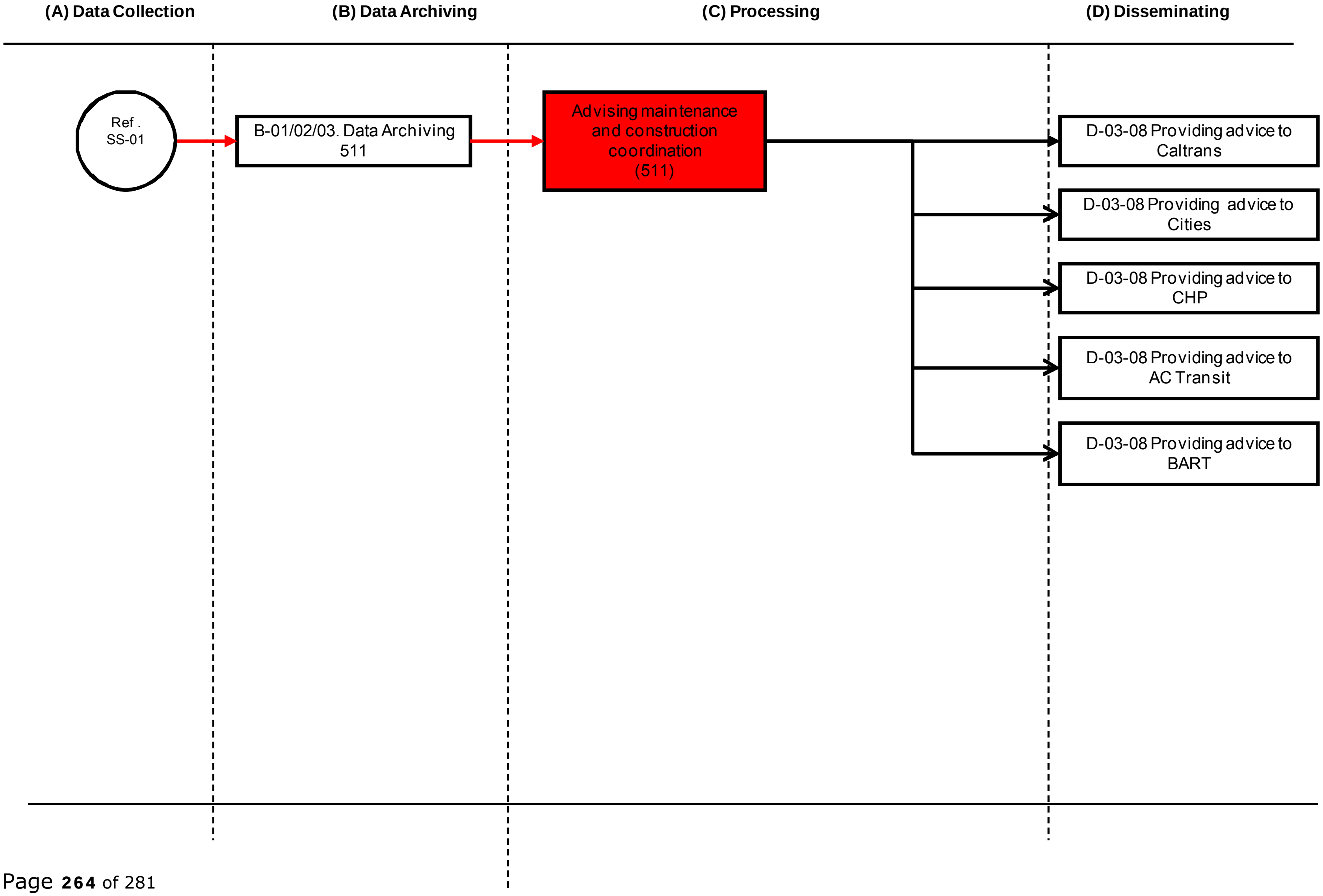
SS-11 Providing Emergency Vehicle with Signal Pre-emption and Best Routing Recommendations



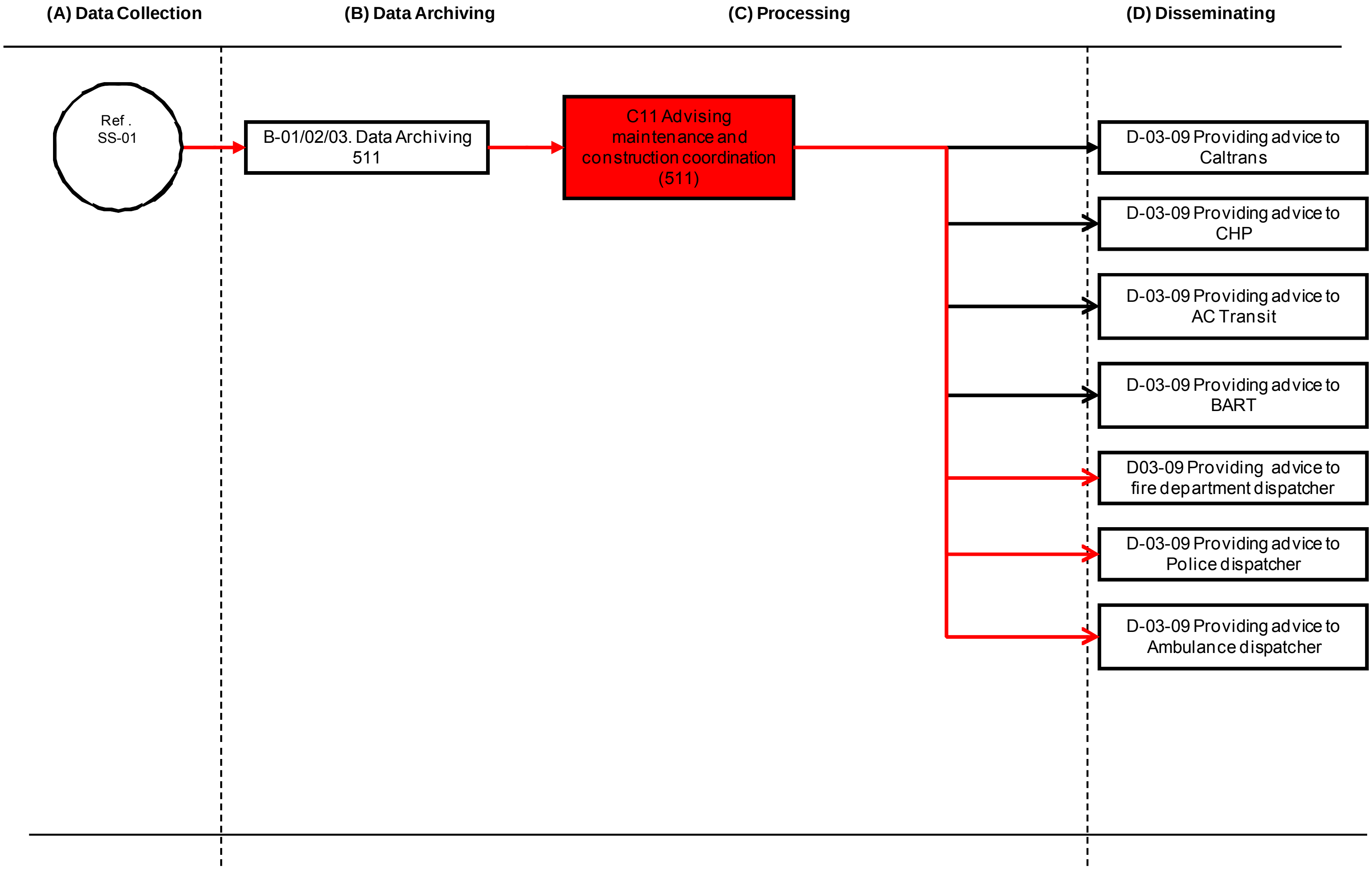
SS-12 Facilitate Rapid Incident Response



SS-13 Supporting Maintenance and Construction Coordination



SS-14 Supporting Coordination of Construction Work During Emergencies



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Function\ Strategies	1. Corridor-based ATIS that provides	14 Promote route shifts between	15 Promote modal shifts from roadways to transit via en-route	3 Signal priority for transit	11 AC Transit adjusts bus routes, schedules and operation based on real-time hwy	8,12,13 Coordinated operation between ramp meters and	9 Enhance arterial signal timing with advance info about	6 Transit hub connection protection	16 Promote shifts between transit facilities via en-route	10 Port of Oakland advise trucks travel time based on real-	4 Signal pre-emption or "best route" for emergency vehicles	7 Multi-agency or multi-network incident response teams and service	25 Coordinate scheduled maintenance and construction activities	29 Guidelines for construction work hours during
Highway Detection (Caltrans)					X					X		X		
FasTrak (MTC)					X					X		X		
Highway detection (SpeedInfo)					X					X		X		
Phone calls												X		
Field Reporting (CHP)												X		
Receiving data (SpeedInfo)					X					X		X		
Receiving data (CHP)												X		
Data Archiving (Caltrans TMC)														

Function\ Strategies	1. Corridor-based ATIS that provides	14 Promote route shifts between	15 Promote modal shifts from roadways to transit via en-route	3 Signal priority for transit	11 AC Transit adjusts bus routes, schedules and operation based on real-time hwy	8,12,13 Coordinated operation between ramp meters and	9 Enhance arterial signal timing with advance info about	6 Transit hub connection protection	16 Promote shifts between transit facilities via en-route	10 Port of Oakland advise trucks travel time based on real-	4 Signal pre-emption or "best route" for emergency vehicles	7 Multi-agency or multi-network incident response teams and service	25 Coordinate scheduled maintenance and construction activities	29 Guidelines for construction work hours during
Data Archiving (PeMs)														
Data Archiving (511)														
Data Archiving (CHP CAD)												X		
Ramp Metering Algorithms (Caltrans)														
TMC (Caltrans)												X	X	X
Measuring Performance (PEMS)														
Slow Down Detection (511)										X				
Travel Time														

Function\ Strategies	1. Corridor-based ATIS that provides	14 Promote route shifts between	15 Promote modal shifts from roadways to transit via en-route	3 Signal priority for transit	11 AC Transit adjusts bus routes, schedules and operation based on real-time hwy	8,12,13 Coordinated operation between ramp meters and	9 Enhance arterial signal timing with advance info about	6 Transit hub connection protection	16 Promote shifts between transit facilities via en-route	10 Port of Oakland advise trucks travel time based on real-	4 Signal pre-emption or "best route" for emergency vehicles	7 Multi-agency or multi-network incident response teams and service	25 Coordinate scheduled maintenance and construction activities	29 Guidelines for construction work hours during
Estimation (511)														
Dispatching Patrols (CHP)												X		
Incident detection					X					X		X		X
Collaborative Ramp Metering/Arterial Control (Caltrans)														
Ramp signals (Caltrans)														
Practitioners (Caltrans)														
CMS (Caltrans)														
Webs (511)														

Function\ Strategies		1. Corridor-based ATIS that provides	14 Promote route shifts between	15 Promote modal shifts from roadways to transit via en-route	3 Signal priority for transit	11 AC Transit adjusts bus routes, schedules and operation based on real-time hwy	8,12,13 Coordinated operation between ramp meters and	9 Enhance arterial signal timing with advance info about	6 Transit hub connection protection	16 Promote shifts between transit facilities via en-route	10 Port of Oakland advise trucks travel time based on real-	4 Signal pre-emption or "best route" for emergency vehicles	7 Multi-agency or multi-network incident response teams and service	25 Coordinate scheduled maintenance and construction activities	29 Guidelines for construction work hours during
	Phone calls (511)														
	Loops (Caltrans)														
	Loops (cities)??														
	Vision sensors (ACCMTA)														
	Midblock radars (ACCMA)														
	Data Archiving (Caltrans)														
	Data Archiving (ACCMA)														
	Signal Control (Caltrans)														

Function\ Strategies	1. Corridor-based ATIS that provides	14 Promote route shifts between	15 Promote modal shifts from roadways to transit via en-route	3 Signal priority for transit	11 AC Transit adjusts bus routes, schedules and operation based on real-time hwy	8,12,13 Coordinated operation between ramp meters and	9 Enhance arterial signal timing with advance info about	6 Transit hub connection protection	16 Promote shifts between transit facilities via en-route	10 Port of Oakland advise trucks travel time based on real-	4 Signal pre-emption or "best route" for emergency vehicles	7 Multi-agency or multi-network incident response teams and service	25 Coordinate scheduled maintenance and construction activities	29 Guidelines for construction work hours during
Data processing (ACCMA)														
Arterial PeMs (Caltrans)					X									
Travel Time Estimation (511)										X				
Incident Detection (511)					X							X		X
Signals (Caltrans)														
Signal (Cities)														
Web (ACCMA)														

Function\ Strategies		1. Corridor-based ATIS that provides	14 Promote route shifts between	15 Promote modal shifts from roadways to transit via en-route	3 Signal priority for transit	11 AC Transit adjusts bus routes, schedules and operation based on real-time hwy	8,12,13 Coordinated operation between ramp meters and	9 Enhance arterial signal timing with advance info about	6 Transit hub connection protection	16 Promote shifts between transit facilities via en-route	10 Port of Oakland advise trucks travel time based on real-	4 Signal pre-emption or "best route" for emergency vehicles	7 Multi-agency or multi-network incident response teams and service	25 Coordinate scheduled maintenance and construction activities	29 Guidelines for construction work hours during
	Arterial CMS (Caltrans/511)														
	Schedules (AC Transit)														
	Incident (AC Transit)					X							X		
	Incidents (BART)														
	Schedule (BART)														
	TSP Emitter														
	Bus AVL (AC Transit)					X									

Function\ Strategies		1. Corridor-based ATIS that provides	14 Promote route shifts between	15 Promote modal shifts from roadways to transit via en-route	3 Signal priority for transit	11 AC Transit adjusts bus routes, schedules and operation based on real-time hwy	8,12,13 Coordinated operation between ramp meters and	9 Enhance arterial signal timing with advance info about	6 Transit hub connection protection	16 Promote shifts between transit facilities via en-route	10 Port of Oakland advise trucks travel time based on real-	4 Signal pre-emption or "best route" for emergency vehicles	7 Multi-agency or multi-network incident response teams and service	25 Coordinate scheduled maintenance and construction activities	29 Guidelines for construction work hours during
	Passenger # (AC Transit)														
	Passenger O/D (BART)														
	Track Data (BART)														
	Data Archiving (AC Transit)														
	Data Archiving (BART)														
	Transit Management (AC Transit)					X									
	Bus Travel Time Estimate (AC Transit/NextBus)														

Function\ Strategies	1. Corridor-based ATIS that provides	14 Promote route shifts between	15 Promote modal shifts from roadways to transit via en-route	3 Signal priority for transit	11 AC Transit adjusts bus routes, schedules and operation based on real-time hwy	8,12,13 Coordinated operation between ramp meters and	9 Enhance arterial signal timing with advance info about	6 Transit hub connection protection	16 Promote shifts between transit facilities via en-route	10 Port of Oakland advise trucks travel time based on real-	4 Signal pre-emption or "best route" for emergency vehicles	7 Multi-agency or multi-network incident response teams and service	25 Coordinate scheduled maintenance and construction activities	29 Guidelines for construction work hours during
BART Travel Time Estimation (BART)														
Central Traffic Control (BART)														
Bus Travel Time Estimation (511)														
Connection Protection (AC Transit)														
Display @ Bus Stops (AC Transit)					X									
Posted Schedule (AC Transit)														
Station Display (BART)														
Event Schedule Oakland Coliseum													X	X

Function\ Strategies	1. Corridor-based ATIS that provides	14 Promote route shifts between	15 Promote modal shifts from roadways to transit via en-route	3 Signal priority for transit	11 AC Transit adjusts bus routes, schedules and operation based on real-time hwy	8,12,13 Coordinated operation between ramp meters and	9 Enhance arterial signal timing with advance info about	6 Transit hub connection protection	16 Promote shifts between transit facilities via en-route	10 Port of Oakland advise trucks travel time based on real-	4 Signal pre-emption or "best route" for emergency vehicles	7 Multi-agency or multi-network incident response teams and service	25 Coordinate scheduled maintenance and construction activities	29 Guidelines for construction work hours during
Police actions (Police)												X		X
Fire incidents (Fire Department)												X		X
Medical emergency (Paramedics)												X		X
AVL Paramedics												X		X
Truck dispatching info (Oakland Port)										X				
Data Receiving (Police)												X		X
Data Receiving (Police)												X		X

Function\ Strategies	1. Corridor-based ATIS that provides	14 Promote route shifts between	15 Promote modal shifts from roadways to transit via en-route	3 Signal priority for transit	11 AC Transit adjusts bus routes, schedules and operation based on real-time hwy	8,12,13 Coordinated operation between ramp meters and	9 Enhance arterial signal timing with advance info about	6 Transit hub connection protection	16 Promote shifts between transit facilities via en-route	10 Port of Oakland advise trucks travel time based on real-	4 Signal pre-emption or "best route" for emergency vehicles	7 Multi-agency or multi-network incident response teams and service	25 Coordinate scheduled maintenance and construction activities	29 Guidelines for construction work hours during
Data Receiving (Police)												X		X
Data Archiving (Police)												X		X
Data Archiving (fire Department)												X		X
Data Archiving (Paramedics)												X		X
Truck Departure Info (Oakland Port)										X				
Radio													X	X
CMS (Oakland Port)										X				

Appendix G AC Transit Bus Service in the Neighborhood of 880 Corridor

AC Transit Local Service

1Lx - Berkeley BART to Bay Fair BART via Telegraph Ave., International Blvd., and E. 14th St.

1R - International Rapid -- U.C. Berkeley campus to Bay Fair BART via Berkeley BART, Telegraph Ave., International Blvd., and E. 14th St.

45 - Coliseum BART to Foothill Square, Oakland, via Edes Ave., Sobrante Park, 105th Ave. and 104th Ave.

46 - Coliseum BART to Mountain Blvd. & Keller Ave. via 81st Ave., 82nd Ave. and Fontaine St.

47 - Fruitvale BART to MacArthur Blvd. & 55th Ave. via Maxwell Park: Monticello Ave. and Madera St.

50 - Fruitvale BART to Bay Fair BART via Park St., Bay Farm Island, Oakland Airport, Coliseum BART, Eastmont Transit Center, MacArthur Blvd., and 159th Ave.

51S - Supplementary service

53 - Fruitvale BART to Lyman Rd. and Tiffin Rd. via Fruitvale Ave.

54 - Fruitvale BART to Merritt College via 35th Ave. and Redwood Rd.

55 - San Leandro Main Library to Bay Fair BART via Davis St., Mulford Gardens, San Leandro Marina, Fairway Dr. and Halcyon Dr.

56 - Two-way loop: Coliseum BART, Seminary Ave., Millsmont, Mountain Blvd., 90th Ave., 85th Ave. and San Leandro Blvd.

63 - Weekdays: Downtown Oakland to Fruitvale BART via Coll. of Alameda, Ferry Terminal, Alameda Point, Otis Dr., Alameda Towne Center, Encinal Ave. and High St. Weekends: shortened route through Alameda Point to Ferry Terminal.

77 - Hayward BART to Tampa Ave. and Tennyson Rd. via Soto Rd., Gading Rd., Huntwood Ave., West Industrial Pkwy., Ruus Rd. and Folsom Ave.

79 - Berkeley BART to El Cerrito Plaza BART via The Alameda and Colusa Ave.

80 - San Leandro BART to Hayward BART via Estudillo Ave., Foothill Blvd., Castro Valley Blvd., Castro Valley BART, Center St. and B St.

81 - San Leandro BART to Hayward BART via Williams St., Wicks Blvd., Lewelling Blvd., Hesperian Blvd., Hacienda Ave. and Meekland Ave.

83 - Hayward BART to South Hayward BART via A St., Hesperian Blvd., Clawiter Blvd., Investment Blvd., Arden Rd. and Tennyson Rd.

84 - San Leandro BART to Kaiser Hospital Hayward via Marina Blvd., Farnsworth St., Washington Ave., Bay Fair BART, Elgin St., Somerset Ave., Castro Valley BART, Grove Way, Centennial Hall, Hayward BART, Amador St., Underwood Ave. and Tennyson Rd.

85 - San Leandro BART to Hayward BART via Washington Ave., Paseo Grande, Hesperian Blvd. and A St.

86 - Hayward BART to South Hayward BART via Winton Ave., Mack St. (AC Transit Hayward Division), Cabot Blvd., Industrial Blvd. and Tennyson Rd.

87 - One-way loop: Castro Valley BART, Castro Valley Blvd., Eden Hospital, Seven Hills Rd., Center St., Castro Valley Blvd.

91 - Castro Valley Senior Center to San Antonio St. and San Luis Obispo St., Hayward, via Redwood Rd., Castro Valley BART, A St., Hayward BART, Whitman St., South Hayward BART and Huntwood Ave.

92 - Cal State East Bay to Chabot College via 2nd St., Winton Ave. and Hesperian Blvd. Continues weekends to South Hayward BART via Hesperian Blvd. and Tennyson Rd.

93 - Bay Fair BART to Hayward BART via Ashland Ave., Paseo Grande, Grant Ave., Bockman Rd., Hacienda Ave., Blossom Way and Western Blvd.

94 - Hayward BART to Hayward Highlands via East St. and Hayward High School

95 - Hayward BART to Fairview District via D St. and Maud Ave. Weekends serves Don Castro Regional Recreation Area.

97 - Bay Fair BART to Union City BART via Hesperian Blvd., Southland Shopping Center, Chabot College, Union Landing Shopping Center and Alvarado-Niles Blvd.

98 - Coliseum BART to Grass Valley via Edgewater Dr., 98th Ave., Oakland Zoo and Golf Links Rd.

99 - Bay Fair BART to Fremont BART via Mission Blvd., Hayward BART, South Hayward BART, and Union City BART.

210 - Ohlone College to South Hayward BART via Washington Blvd., Fremont Blvd., Union Landing Shopping Center and Huntwood Ave.

211 - Union City BART to Fremont BART via Decoto Rd., Fremont Blvd. and

Walnut Ave.
212 - Fremont BART to Lakeview Industrial Park via Fremont Blvd.

213 - Fremont BART to Lido Faire Shopping Center via Mowry Ave., New Park Mall, Cherry St. and Newark Blvd.

214 - Fremont BART to Union City BART via Stevenson Blvd., Cedar Blvd., New Park Mall, Central Ave., Sycamore St., Haley St., Lido Faire Shopping Center, Hwy. 84 and Decoto Rd.

215 - Wkdys, Fremont BART to Gateway Blvd. & Lakeside Pkwy. via Mission Blvd., Driscoll Rd., Osgood Rd., Warm Springs Blvd., and Kato Rd. Wknds, Fremont BART to Pacific Commons via Mission Blvd., Driscoll Rd., Osgood Rd., and Auto Mall Pkw

216 - Fremont BART to Union City BART via Mowry Ave. and Niles Blvd.

217 - Fremont BART to Great Mall Transit Center, Milpitas, via Walnut Ave., Mission Blvd., Warm Springs Blvd., Milpitas Blvd. and India Community Center.

218 - Lido Faire Shopping Center to Ohlone College via Gateway Blvd., Thornton Ave., Peralta Blvd., Paseo Padre Pkwy., Fremont BART, Grimmer Blvd. and Mission Blvd.

232 - Union City BART to New Park Mall via Paseo Padre Pkwy., Ardenwood Blvd., Lido Faire Shopping Center and Cedar Blvd.

235 - Fremont BART to Pacific Commons via Stevenson Blvd., Boyce Rd., and Christy St. Returns via Albrae St. and Stevenson Blvd.

305 - Montclair District, Oakland to Glencourt Dr. & Saroni Dr. via Snake Rd. and Colton Blvd.

314 - From 11th St. & Market St., Oakland, to South Shore Shopping Center via Downtown Oakland, Webster St., and Central Ave.

328 - Central Fremont loop: Fremont BART; Main Lib.; Fremont Senior Ctr; Chapel Wy; Paseo Padre Pkwy; Driscoll Rd; Las Palmas Ave; Schools for the Blind, Deaf, and Multihandicapped; Fremont BART; Country Dr; Fremont Hub; return to Fremont BART

329 - From Chapel Way and Bay St. to Lido Faire via Chapel Way, Paseo Padre Pkwy., Fremont BART, Mowry Ave., NewPark Mall, Silliman Rec. Center, Smith Ave., Central Ave., Newark Senior Ctr., Newark City Hall, Musick Ave., Edgewater Dr., and Lake Blvd.

332 - Fremont BART to New Park Mall via Mowry Ave., Niles Blvd., Union City BART, Paseo Padre Pkwy., Ardenwood Blvd., Lido Faire Shopping Center and Cedar Blvd.

333 - Newark flexible service: departs Union City BART, Lido Faire, and New Park Mall. Passengers can request service to any bus stop in the City of Newark.

386 - Hayward BART to Sabre St. & Mack St. (AC Transit Hayward Division) via Winton Ave. and Southland Mall.

391 - Hayward Villa to Southland Shopping Center via Spanish Ranch, New England Village, Georgian Manor, Industrial Parkway, Josephine Lum Lodge and Hesperian Blvd. Returns via I-880.

610 - Edgewater Dr. & Hegenberger Rd., Oakland, to Castlemont High School via 98th Ave. and Bancroft Ave.

612 - Coliseum BART to Castlemont High School via 73rd Ave. and MacArthur Blvd.

613 - Coliseum BART to Madison Middle School, Oakland (Sobrante Park) via Hegenberger Rd., Empire Rd., 98th Ave., International Blvd. and 105th Ave.

614 - Edes Ave. & 85th Ave. to Castlemont High School via Edes Ave., Sobrante Park, 105th Ave., International Blvd., and 90th Ave.

618 - 1st Ave. & International Blvd., Oakland, to Montera Middle School via Park Blvd., Liemert Blvd., Monterey Blvd. and Mountain Blvd.

620 - Cedar Blvd. & Stevenson Blvd., Newark, to Newark Jr. High via Cedar Blvd. and Newark Blvd.

621 - Ardenwood Blvd. & Commerce Dr., Fremont to American High School via Paseo Padre Pkwy., Decoto Rd. and Fremont Blvd.

622 - Dixon Landing Rd. & Milpitas Blvd., Milpitas to Irvington High School via Warm Springs Blvd. and I-880.

623 - Dixon Landing Rd. & Milpitas Blvd., Milpitas to Irvington High School or Horner Jr. High School via Warm Springs Blvd., Mission Blvd., Paseo Padre Pkwy., Auto Mall Pkwy. and Grimmer Blvd.

624 - Paseo Padre Pkwy. and Mission Blvd., Fremont to Mission San Jose High School via Paseo Padre Pkwy., Driscoll Rd. and Mission Blvd.

625 - Niles Blvd. & El Portal Ave., Fremont, to Washington High School and Centerville Jr. High School via Niles Blvd., Mowry Ave. and Fremont Blvd.

626 - Lido Faire Shopping Center to Newark Memorial High School via Newark Blvd. and Cedar Blvd.

627 - Cedar Blvd. & Central Ave., Newark to Newark Jr. High via Cedar Blvd.,

Jarvis Ave., Haley St. and Thornton Ave.

628 - Lido Faire Shopping Center to Newark Memorial High School via Cedar Blvd.

629 - Lido Faire Shopping Center to Newark Memorial High School via Jarivs Ave., Haley St., Sycamore St. and Cherry St.

631 - Bay Farm Island to Encinal High School via Lincoln Middle School, Encinal Ave., Alameda High School and Central Ave.

642 - Skyline Blvd. & Tunnel Rd., Oakland via Broadway Terrace and Mountain Blvd. or Snake Rd. & Colton Blvd., Oakland via Colton Blvd., Saroni Dr., Snake Rd. and Mountain Blvd. to Montara Middle School.

645 - 105th Ave. & Edes Ave. to King Estates Middle School via Sobrante park, 105th Ave., International Blvd., 98th Ave. and Mountain Blvd.

646 - Coliseum BART to Skyline High School via 81st Ave., 82nd Ave., Fontaine St., Keller Ave., Hansom Dr. and Skyline Blvd.

647 - Ardenwood Blvd. & Commerce Dr., Fremont to Thornton Jr. High School via Paseo Padre Pkwy., Decoto Rd. and Cabrillo Dr.

648 - Fruitvale BART to Skyline High School via High St., Tomkins Ave. Mountain Blvd. and Redwood Rd.

649 - Golf Links Rd. & Dunkirk Ave., Oakland, to Skyline High School via Golf Links Rd., Sequoyah Rd. and Skyline Blvd.

650 - Seminary Ave. & International Blvd., Oakland, to Skyline High School via Seminary Ave., Greenly Dr., Keller Ave., Hansom Dr. and Skyline Blvd.

652 - 90th Ave. & International Blvd., Oakland, to Skyline High School via 90th Ave., 98th Ave., Sequoyah Rd., Hansom Dr. and Skyline Blvd.

654 - Frutivale BART to Skyline High School via 35th Ave. and Redwood Rd.

655 - Frutivale BART to Montera Middle School via 35th Ave., Redwood Rd., Skyline Blvd., Joaquin Miller Rd. and Mountain Blvd.

657 - Coliseum BART to Oakland Technical High School via 73rd Ave. and MacArthur Blvd.

801 - All Nighter. Downtown Oakland to Fremont BART via International Blvd., E. 14th St. and Mission Blvd.

840 - All Nighter. Downtown Oakland to Eastmont Transit Center via Foothill Blvd.

Transbay Service

M - Castro Valley Park & Ride to Hillsdale Shopping Center, San Mateo via Castro Valley BART, Hayward BART, Chabot College, Foster City and Hillsdale Blvd.
MA - Union City BART to Hillsdale Shopping Center, San Mateo via Union Landing Shopping Center, Hesperian Blvd., Chabot College, Hillsdale Blvd. and Oracle campus, Redwood City.

NC - NX2 & NX3 & NX4 combination. Does all of NX2 before continuing on to NX3 and in some cases NX4.

NX4 - Castro Valley Park & Ride to Transbay Terminal, San Francisco via Center St., Seven Hills Rd., Lake Chabot Rd. and Foothill Blvd.

O - Park Ave. & Encinal Ave. to Transbay Terminal via Santa Clara Ave. and Webster St. (Some trips: Fernside Blvd. & Versailles Ave. to San Francisco via High St., Encinal Ave., Santa Clara Ave. and Webster St.)

OX - Bay Farm Island to Transbay Terminal, San Francisco via Island Dr. Park & Ride, Encinal Ave. and Park St.

S - Eden Shores, Hayward, to Transbay Terminal, San Francisco via Hesperian Blvd. and Paseo Grande.

SA - Paseo Grande and Paseo Largavista, San Lorenzo, to San Francisco via Lewelling Blvd., Farnsworth St. and Merced St.

SB - Cedar Blvd. & Stevenson Blvd., Newark, to San Francisco via Cedar Blvd., Newark Blvd, Union City Blvd. and Hesperian Blvd.

U - Fremont BART to Stanford University via Centerville Amtrak and Ardenwood Park & Ride.