San Mateo Smart Corridor System
Concept of Operations (ConOps)
Document #21000.007

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1.0 Purpose of Document

The Concept of Operations (ConOps) document provides the foundation for the development of the San Mateo Smart Corridor System. It details what the project is expected to achieve, what systems will be used and under what conditions the systems will operate. Error! Reference source not found. depicts the process through the full lifecycle of the project. The overall objective of the Systems Engineering process is to prepare a well thought-out plan approved by stakeholders in an effort to reduce project risk by considering the full lifecycle of the project throughout each step and to define the "big picture" first before defining the details.

The ConOps was developed in September, 2009. As part of the System Integrator support project, the System Integrator is tasked to update the ConOps in accordance with FHWA guidelines that accurately describes the stakeholders' vision of how the Smart Corridor System will operate. This document is the first of the two updates to be developed on the project.

This report represents the Concept of Operations for the Smart Corridor Program. The Concept of Operations defines the roles and responsibilities of stakeholders in the Smart Corridors, their relationships to each other and overall how the system is envisioned to operate. The Concept of Operations is technology-independent. It does not describe how the technology operates, but instead describes the roles and responsibilities of the agencies. Subsequent and supplemental reports will define the system requirements, high-level design, and technologies. These subsequent reports will have details on communications, field devices, and costs.

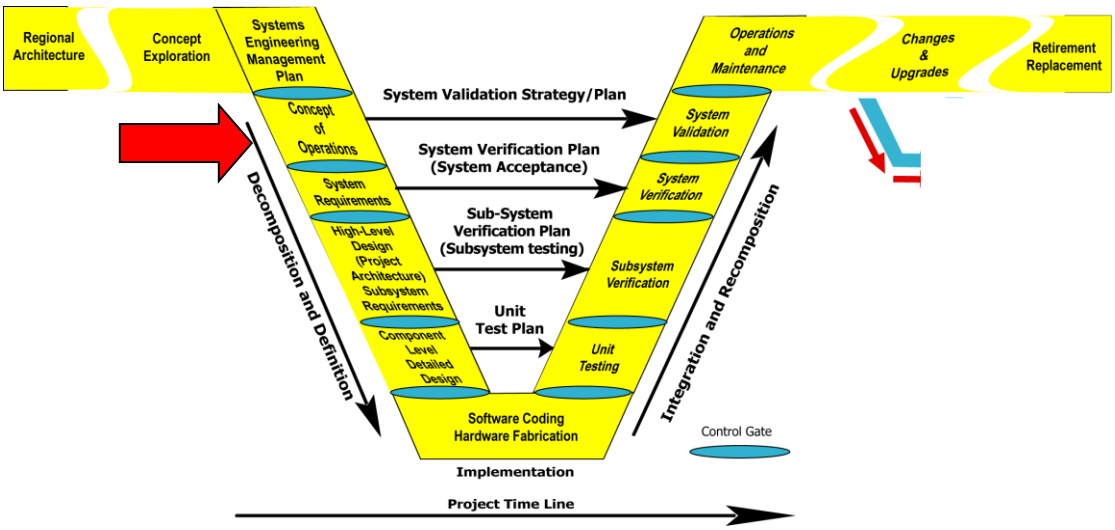

Figure 1 – Systems Engineering "V" Diagram

2.0 Scope of Project

The mitigation of impacts of non-recurring traffic congestion on local streets in San Mateo County due to major freeway incidents on US-101 was identified as a high-priority project in the Smart Corridor Program. Accordingly, the City/County Association of Governments (C/CAG), in cooperation with the San Mateo County Transportation Authority (SMCTA), the Metropolitan Transportation Commission (MTC), the California Department of Transportation (Caltrans) District 4 and the cities of San Carlos, Millbrae, East Palo Alto, San Bruno, San Mateo, Redwood City, Belmont, Burlingame, Atherton and Menlo Park, initiated an effort to develop a countywide traffic management system, the San Mateo Smart Corridor Program. The overall Smart Corridor Program (Program) includes the installation of the following ITS elements:

- Directional signs (trailblazer and turn prohibition) to direct traffic;
- Fixed and pan-tilt-zoom closed-circuit television (CCTV) cameras at intersections and midblock locations to monitor traffic congestion and evaluate length of traffic queues;
- Communications to provide interconnect between local agency traffic signals on local streets and State operated traffic signals on State routes;
- Upgraded traffic signal controllers and/or cabinets and traffic signal operation software systems to provide increased traffic flow during incident and non-incident conditions;
- Arterial dynamic message signs (ADMS) to inform motorists of traffic conditions;
- Center-to-center communications between all local agencies and the Caltrans District 4 Transportation Management Center (D4TMC) to increase sharing of data and video during incident conditions; and
- Vehicle detector stations (VDS) on non-freeway state routes (El Camino Real) and local streets at mid-block locations for better monitoring of traffic during incident conditions.

The Program is comprised of ITS field elements managed and shared by the local agency stakeholders and Caltrans operations staff for improved traffic management capabilities between the freeway and arterial corridors. A critical component of this system is the communication infrastructure which consists of fiber optic cable, Ethernet hardware and ITS device controllers. All ITS field devices are connected and controlled at both the local Traffic Management Center (TMC) and the Caltrans TMC through the communication infrastructure. Each local agency in the program has a “virtual TMC”, meaning there is no centralized location where operations management occurs. Rather, local agency staff manages their systems from their own workspaces (offices, cubicles, etc.). By contrast, Caltrans District 4 has a large TMC facility dedicated to managing the freeways within the entire nine-county Bay Area. During normal working hours, each agency operates its own system with Caltrans assuming operations for the entire system during incidents and off-hours.

Project Background

C/CAG and SMCTA, in conjunction with Caltrans District 4, has initiated an effort to address the operation of the freeway and arterial roadway network in San Mateo County. The San Mateo County Smart Corridor Program is intended to benefit a variety of users including commuters, local traffic, and commercial vehicle and transit operators.

A Traffic Incident Management Committee (TIMC) was formed to identify and evaluate projects under the Smart Corridor Program. The TIMC is comprised of representatives of local agencies, Caltrans, California Highway Patrol (CHP), MTC, San Mateo County Office of Emergency Services (OES), and San Francisco International Airport (SFO) as well as C/CAG and SMCTA. The TIMC focus is to increase coordination between Caltrans, CHP, local agency public safety, and local agency public works staff during freeway incidents when a significant amount of traffic is expected to exit the freeway and use local streets as an alternate.

In addition, a Steering Committee was established as the decision-making body of the Smart Corridors Program. Members include the Caltrans District 4 Chief of Operations, the MTC Director of Highway Operations, the SMCTA Program Director, the San Mateo City Public Works Director, and the C/CAG Executive Director.

The TIMC also facilitated the development of the Alternate Routes for Traffic Incident (ARTI) Guide (April 2008) to identify arterial streets that would best serve as alternative routes for moving traffic during incidents on US-101 and minimizing the impacts of diverted traffic on the local street network across multi-jurisdictional boundaries. During normal operations, each local agency will control its respective signalized intersections and have access to the CCTV cameras. During a major freeway incident on US-101, operators at the D4 TMC will implement previously developed special-event signal timing plans and activate Informational Message Signs (IMS), trailblazer signs (TBS) and arterial dynamic message signs (ADMS) along the appropriate ARTI route(s) and notify the local agencies that the management of the alternate route(s) is in effect. The ARTI Guide has subsequently been revised (June 2009) with the assistance of Caltrans staff.

The project is estimated to cost $30.71 million, with $22.37 million in construction costs, with a phased approach proposed. A Project Study Report (PSR) for this project was approved on March 28, 2008.

A Concept of Operations (ConOps) was prepared in October 2008 and updated in September 2009, with input from local agencies and Caltrans, and direction from the Federal Highway Administration (FHWA). This is an initial step in the Systems Engineering process defined by the FHWA. This document identifies the stakeholders, their roles and responsibilities, their coordination with each other, and how the system will be developed.

Goals of the Project

The goals of the project identified in the Concept of Operations have been modified as shown in **Table 1**.

Table 1 – Project Goals

Goal Area	Smart Corridors Program Goals
Traffic Incident Management	• Proactively manage traffic already diverted from the freeway to minimize impacts on local arterials, and return regional traffic back to the freeway as soon as possible by: o Actively managing traffic signal operations on selected routes to maximize traffic flow around a major incident and minimize delays caused by diverted freeway traffic. o Improving collection of current travel condition information along local arterials on the alternate routes. (Future) o Providing accurate and timely route guidance information about the corridors to agency transportation managers. (Future) o Minimizing the intrusion of freeway traffic on local streets due to major freeway incidents.
Interagency Coordination	• Provide the capability for shared control and operation of the Smart Corridors components by the agencies. • Improve sharing of resources between agencies for more unified transportation management operations across jurisdictions. • Improve communications between the agencies during major freeway incidents
Traffic Operations and Management	• Improve traffic flow within the corridor during normal operation • Share traffic information between the agencies to improve coordination and management of traffic during normal operations

Project Phasing

The complete deployment of the Smart Corridor program includes the freeway network and parallel arterials of regional significance in San Mateo County. The deployment will be completed in phases, with each subsequent phase building upon the elements of previous phases.

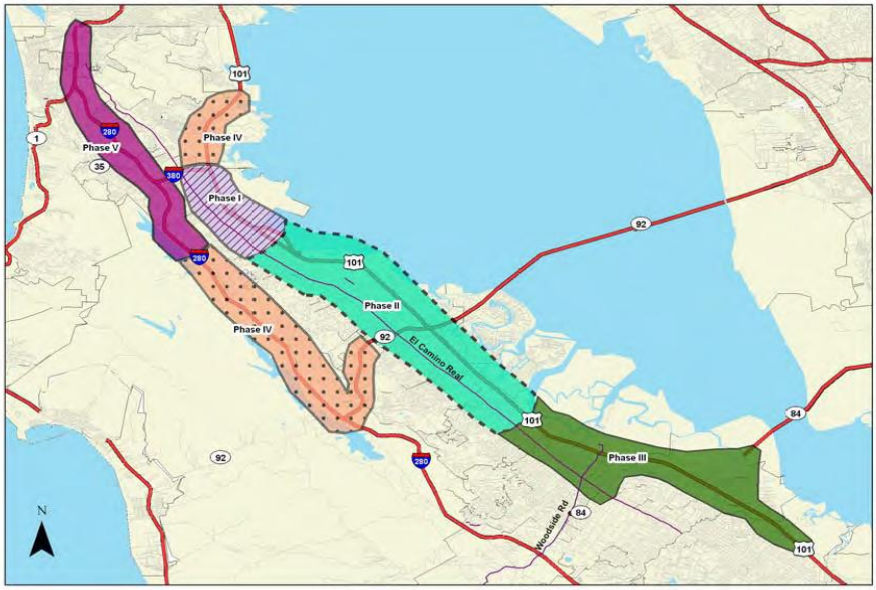

Figure 1 – Smart Corridor Project Phasing

As shown in **Figure 1**, there are three primary phases currently planned for the Smart Corridor Program. These phases include:

- Phase I – US-101 and adjacent local streets between I-380 and 3rd Avenue;
- Phase II – US-101 and adjacent local streets between 3rd Avenue and Whipple Avenue; and
- Phase III – US-101 and adjacent local streets between Holly Street and the Santa Clara County Line.

In order to implement these phases, the Smart Corridor Program was divided into the five projects noted below:

- Project #1: the San Mateo Demonstration project was a proof of concept deployment in the City of San Mateo and was completed in early 2013.
- Project #2: this project was designed as part of three separate projects, the North, South and South Extension projects and includes all elements in local agency Right-of-Way. This project is currently in construction.
- Project #3: this project was designed by Caltrans, in parallel with Project #2, to install ITS improvements on Caltrans Right-of-Way, including El Camino Real, from Whipple Avenue to I-380. This project is currently in construction.
- Project #4: this project will complete the operations planning and integrate the ITS devices that were designed and now being constructed in the other projects.

- Project #5: this project was designed by Caltrans, in parallel with Project #2, to install ITS improvements on Caltrans Right-of-Way from Whipple Avenue to the Santa Clara County line.

Stakeholder Roles

The stakeholders and their roles in this project are listed in **Table 2**.

Table 2 – Project Stakeholders and Current and Proposed Roles

Stakeholder	Current Role(s)
C/CAG	Organize stakeholders in San Mateo County and build consensus; project champion/sponsor; administrative lead.
Caltrans	Operate and maintains the freeways (US-101) and state routes (El Camino Real, SR-84, etc.). Lead the technical side of the project. Will operate the system in the event of a major incident.
SMCTA	Administers the proceeds of a county-wide half-cent sales tax (Measure A) for transportation projects; participates in project steering committee; administers consultant contracts.
CHP	Enforcement, security, and accident investigation on the freeways and state highways. Typically the incident commander.
MTC	Metropolitan Planning Organization (MPO) of the Bay Area, maintains the Regional ITS Architecture, distributes transportation funds; operates and maintains 511, the regional ATIS, and the regional center-to-center data sharing network (currently in development)
San Mateo County	Operate and maintain arterials within its jurisdiction.
San Mateo County Transit (SamTrans)	Operate bus service on the arterials and freeways.
Caltrain	Operate heavy rail commuter service and support private shuttle service
Bay Area Rapid Transit (BART)	Operate commuter rail service.
Dumbarton Express	Operate bus service on the arterials and freeways.
Local Emergency Response and Public Safety Agencies	Respond to incidents on local routes, coordinate with traffic management personnel on local and state routes, and coordinate with CHP during major incidents.
Town of Atherton	Operate and maintain arterials within its jurisdiction.
City of Belmont	Operate and maintain arterials within its jurisdiction.

City of Burlingame	Operate and maintain arterials within its jurisdiction.
City of East Palo Alto	Operate and maintain arterials within its jurisdiction.
City of Menlo Park	Operate and maintain arterials within its jurisdiction.
City of Millbrae	Operate and maintain arterials within its jurisdiction.
City of Redwood City	Operate and maintain arterials within its jurisdiction.
City of San Bruno	Operate and maintain arterials within its jurisdiction.
City of San Carlos	Operate and maintain arterials within its jurisdiction.
City of San Mateo	Operate and maintain arterials within its jurisdiction.
Contractors	Construct ITS field elements and conduct testing.
Consultants – Kimley-Horn	Prepare environmental documentation.
Consultants – Iteris and URS	Develop plans, specifications and estimates.
System Integrator – Iteris	Develop and implement system engineering process. Develop System Integration process and support the System Integration activities.
Signal System Vendor	Implement Smart Corridor signal system.
Signal Timing Consultant	Develop signal timing for all traffic signals in the Smart Corridor area.

The ARTI provides the stakeholders a guideline/process for implementing route guidance and operational strategies to manage diverted traffic on local streets, minimizing the impacts on the residents of County of San Mateo. The primary objectives of the project identified in the ARTI are:

- Proactively manage traffic on local streets that has diverted off the freeway due to a major incident on US-101 or other freeway;
- Minimize the delay that traffic experiences on local streets during major freeway incidents;
- Instrument local streets and provide the TMC operators with the tools to proactively manage traffic detoured due to an incident;
- Enhance the communications and coordination between “local agency public safety, Caltrans, CHP, and local agency public works” to create a regional approach to managing incident traffic; and
- Enable local agencies to share information and control strategies to enhance traffic management.
- Through installation of ITS equipment along the alternate routes, the stakeholders will have tools and strategies that will enable them to do the following:

- Change route guidance signs to guide incident traffic along a specific alternate route to avoid a situation where drivers seek unknown routes;
- Increase the green time along an alternate route during an incident to reduce the travel time.
- Monitor traffic on local streets;
- Share data and video between agencies to create a regional partnership to manage traffic; and
- Coordinate operations between Caltrans and local agencies during major incidents.

Caltrans has agreed to commit to active operation and control of the Smart Corridor tools by the D4 TMC operators with support from local agencies. Active operation during major freeway incidents will include implementing alternate route signage and monitoring CCTV camera images to optimize the flow of traffic along alternate routes. If necessary, it will also require modifying device parameters in response to changing conditions. The system will also require communication and coordination between agencies, adjustment of signal timing, notifications to travelers, and other operational strategies implementation along the affected portion of the corridor in an event of major freeway incident.

The segment of US-101 within the County of San Mateo is part of the National Highway System, classified as a strategic highway network route to provide defense access, continuity, and emergency capability for transporting personnel, materials, and equipment during both peace and war times.

Technical Challenges

Technical challenges to be faced on this project include:

- Coordination of signals across jurisdictional boundaries
- Sharing of control on a hierarchical basis
- Providing a communications network on already crowded local roadways
- Providing aesthetically pleasing equipment in an urban setting
- Use of a hybrid communications system
- Integration of local ITS equipment and systems into a regional traffic management center
- Future integration of the local systems into the Caltrans ATMS

3.0 Referenced Documents

The following documents were referenced in developing the Concept of Operations includes:

- FHWA/Caltrans Systems Engineering Guidebook for ITS, version 3.0, November 2009.
- San Mateo County Smart Corridors Program, Concept of Operations, September 2009.
- San Mateo County Smart Corridor Project Report 4A9200, February, 2010.
- San Mateo County Smart Corridor Project Report 4A9250, 2012.

4.0 Background

4.1 Project Background

The City/County Association of Governments of San Mateo County (C/CAG) and the San Mateo County Transportation Authority (SMCTA) in conjunction with the California Department of Transportation (Caltrans) has initiated an effort to address the operation of the freeway and arterial roadway network in San Mateo County. The San Mateo County Smart Corridor Program is intended to benefit a variety of users including commuters, local traffic, and commercial vehicle and transit operators.

A Traffic Incident Management Committee (TIMC) was formed to identify and evaluate projects under the Smart Corridor Program. The TIMC is comprised of representatives of local agencies, California Department of Transportation (Caltrans), California Highway Patrol (CHP), Metropolitan Transportation Commission (MTC), San Mateo County Office of Emergency Services (OES) as well as C/CAG and SMCTA. The TIMC focus is to increase coordination between Caltrans, CHP, local agency public safety, and local agency public works staff during freeway incidents when a significant amount of traffic is expected to exit the freeway and use local streets as an alternate.

In addition, a Steering Committee was established as the decision-making body of the Smart Corridors Program. Members include the Caltrans District 4 Chief of Operations, the MTC Director of Highway Operations, the San Mateo Public Works Director, the Program Director of the San Mateo County Transportation Authority (SMCTA), and the C/CAG Executive Director.

The Smart Corridor Program will enable stakeholders to implement traffic management strategies through the deployment of Intelligent Transportation System (ITS) elements along state routes and major local streets. These routes will have the tools to manage recurring and non-recurring traffic congestion and improve mobility during normal operating conditions, major freeway incidents, and special events. The development and successful implementation of this project will serve as a roadmap for the long-term direction of ITS deployment in the region.

The mitigation of the impacts of non-recurring traffic congestion on local streets within San Mateo County during major freeway incidents on US-101 was identified as a high-priority project in the Smart Corridor Program. The Smart Corridor project includes the installation of closed-circuit television (CCTV) cameras, Information Message Signs (IMS), Trailblazer Signs (TBS), Arterial Dynamic Message Signs (ADMS), and traffic signal modifications throughout the corridor to monitor and manage traffic flow on local streets.

4.2 Project Needs and Objectives

Cities within San Mateo County experience significant traffic impacts on local streets during major traffic incidents on US 101 and other freeways. When a major incident occurs on the freeway, significant traffic exits the freeway in search of a route to bypass the incident. There are no clearly designated routes that traffic can follow today to bypass a freeway incident, so traffic filters through the local network seeking a viable route around the incident. The local agencies have no tools on the local streets to proactively manage incident traffic that has exited the freeway, so there is no opportunity to improve the poor level of service on the local network during major incidents.

The objectives of the Smart Corridors program are as follows:

- Proactively manage traffic on local streets that has diverted off the freeway due to a major incident on US 101 or other freeway;
- Proactively manage traffic on local streets during normal operating conditions;
- Minimize the delay that traffic experiences on local streets during major freeway incidents;
- Instrument local streets and provide traffic managers and operators with the tools to proactively manage diverted traffic due to an incident;
- Enhance the communications and coordination between local agency public safety, Caltrans, CHP, and local agency public works to create a regional approach to managing incident traffic; and
- Enable local agencies to share information and control strategies to enhance traffic management both during an incident and under normal operating conditions.

The stakeholders of the San Mateo County Smart Corridor Program have identified the following ITS elements that will be deployed along key corridors and routes to achieve the objectives defined above:

- Directional signs (trailblazers and other)
- Fixed or pan-tilt-zoon (PTZ) closed-circuit television cameras (CCTV)
- Communications (conduit, fiber, copper, wireless, software and associated equipment)
- Arterial changeable message signs (Arterial Dynamic Message Signs – ADMS)
- Vehicle detection systems
- Center-to-Center communications between San Mateo County Hub (SMCHub) and District 4 Traffic Management Center (D4TMC)
- Traffic signal controllers, cabinets, signal interconnect equipment and signal operation software systems

Power supply line and equipment

Many of these same elements can also be used to manage traffic along the corridor during recurring congestion. In addition to the ITS elements noted above, the following ITS elements were identified for possible deployment on future projects:

- Transit priority service at intersections;
- Emergency vehicle preemption at intersections;
- Advance warning signs at Caltrain at-grade crossings; and
- Dynamic message signs for arterial travel times.

New equipment installed on this project will take into consideration the potential impacts on aesthetic and environmental issues. All equipment will be installed with minimal impacts.

By equipping local streets with the ITS equipment, the stakeholders will have advanced tools and strategies that will enable them to do the following:

- Activate route guidance signs to guide incident traffic along a specific route rather than drivers seeking unfamiliar routes;
- Monitor traffic on local streets during normal operations and during freeway incidents;
- Share data and video between agencies to create a regional partnership to manage traffic; and
- Coordinate operations between Caltrans and local agencies during major incidents;
- Locally manage traffic during normal operating conditions.

Under normal operations, local agencies and Caltrans will have the ability to coordinate traffic operations.

Caltrans has agreed to commit to active operation and control of the Smart Corridor tools by the District 4 TMC operators with support from local agencies. Active operation during major freeway incidents will include activating trailblazers and monitoring traffic conditions using CCTV camera images and MVDS devices. The system will also require communication and coordination between agencies, adjustment of signal timing, notifications to travelers, and other operational strategies along the affected portion of the corridor in an event of major freeway incidents. During normal operations the respective agencies have control of their respective roadways.

4.3 Rationale for Project Development

San Mateo Smart Corridor Project Report 4A9200 signed March 2010, provides the traffic data on volume, accident and provides commentary on traffic level of service and accident analysis in support of the Smart Corridor. Most of the project intersections operate at LOS F during an

incident in which motorists self-divert off the freeway and onto local streets. The high percentage of rear end accidents on El Camino Real (SR-82) is primarily a result of heavy congestion on the freeway with slow or stopped conditions. There is a need to mitigate the impacts of recurring and non-recurring congestion on local streets in the corridor.

4.4 General Approach to Improving the System

By clearly designating routes that traffic can follow to bypass a freeway incident, and providing local agencies' the tools to proactively manage the traffic on the local streets there is opportunity to improve the level of service on the local network during major incidents on freeway as well as non-incident situations.

5.0 Concept for Proposed System

This chapter describes the concept exploration. The operational concept for that selected approach is described here. This is not intended to be a system design, but a high-level, conceptual, operational description.

5.1 System Concept

Through the efforts of San Mateo Smart Corridor Program, the project stakeholders have agreed with the project concept as a response to the project needs. The Smart Corridor will utilize ITS elements in four major system categories including Incident Management, Arterial Management, Transit Management (future phase) and Traveler Information (future phase). The subsystems that are incorporated within these system groups include:

- Traffic Control Subsystem
- Directional Sign Subsystem
- ADMS Subsystem
- CCTV Camera Subsystem
- Detection System Subsystem
- Communications Subsystem

5.2 Project Alternatives

The northerly portion of the Smart Corridor project from San Bruno Avenue to Whipple Avenue was approved in Project Report 4A9200 dated February 22, 2010. Project 4A9250 is located in the cities of Redwood City, Atherton, Menlo Park, and East Palo Alto and improvements are on US-101, SR 82 (El Camino Real) and SR 84 (Woodside Road), SR-109

(University Avenue), and SR 114. Project EA 4A9260 is on local streets adjacent the state routes in Project 4A9250.

The project reports limit project alternatives to the Build Alternative and No Build Alternative. The No-Build alternative was rejected as the alternative will not meet the project purpose and needs.

The Build alternative provides for County ITS traffic management infrastructure on the US101/El Camino Real corridor including parallel local streets and local streets to and from the freeway on and off ramps within the San Mateo County.

The ITS devices and infrastructure included in the Build alternative are:

- Trailblazer signs: The proposed trailblazer sign (TBS) is a freeway directional static sign with a full matrix electronic board mounted above the sign. The electronic board may show an arrow that will activate to proceed left, right or straight ahead and ability to show text. The sign can be mounted on dual wood post, single post, or cantilever with bracket arm attached to new post.

- ADMS signs can be mounted on an overhead cantilever sign post.

- CCTV Camera; fixed cameras are proposed to be affixed to existing traffic signal post. Fixed cameras are directed at roadway traffic in each direction where four fixed cameras are needed at a four-leg intersection. The purpose of the cameras is to provide the operator with ability to retrieve all views of the intersection simultaneously.

- PTZ Camera: PTZs provided corridor views and can be also be implemented on street intersections where operator may pan to obtain directional intersection views. At local intersection locations, installing dome cameras are an option over fixed cameras because of versatility and can be a cost savings.

- Vehicle Detection Station: Vehicle detection stations provide traffic data such as speed, occupancy and volume to the traffic signal system. They are a compact device that can be mounted on new or existing poles.

- Communication Lines - The Smart Corridor will utilize fiber optic cabling as the preferred media for local and State traffic signals, CCTV and TBS, and ADMS locations. Fiber optics is merited for the bandwidth required for transmission of camera signals and TBS or ADMS signs. It is proposed to use existing conduit throughout the project limits for fiber optic installation in combination with new installations. Wireless communication options will be used at locations where it is not cost effective to

trench. The system is to be installed as an independent separable system at signal controllers with independent cabinets.

- The San Mateo County Hub is the main communication hub for the San Mateo Smart Corridor and is designed to perform backup operations if the D4TMC connection from the SMC Hub to D4TMC fails. The SMC Hub is located in the City of San Mateo's Police Station and was selected because it is centrally located within the county; the facility is secure; it is accessible by local agencies and Caltrans; and is a suitable office environment to maintain a computer network/workstation. In addition, this location may be strategic to operations in an event of an emergency. All field devices will be connected to the hub, and the hub will be connected to the D4TMC via a leased line until a permanent fiber connection is established on BART fiber via the Millbrae BART station.

6.0 User-Oriented Operational Description

This chapter focuses on how the goals and objectives are currently accomplished.

6.1 Stakeholders

There are numerous stakeholders, including institutions and agencies, which play key roles in the operation and maintenance of the San Mateo County Smart Corridor. San Mateo City/County Association of Governments has taken the lead to organize the stakeholders along the corridor while Caltrans has taken on the lead to manage the technical aspects of the Smart Corridor program. The roles and responsibilities of the main stakeholders are described below. The project stakeholders can be separated into three different groups; workers, oversight agencies, and users. The user group describes those stakeholders that benefit from the system but do not participate in the oversight, operation and maintenance of the system. The stakeholders and their roles in this project are listed in **Error! Reference source not found..**

Table 1 – Project Stakeholders and Current Roles

Stakeholder	Current Role(s)
San Mateo City/County Association of Governments (C/CAG)	Organize stakeholders in San Mateo County and builds consensus; project champion/sponsor
California Department of Transportation (Caltrans)	Operates and maintains the freeways (US 101) and state routes (El Camino Real, Hwy 84, etc.)

Stakeholder	Current Role(s)
San Mateo County Transportation Authority	Administers the proceeds of a county-wide half-cent sales tax (Measure A) for transportation projects
California Highway Patrol	Enforcement, security, and accident investigation on the freeways and state highways
Metropolitan Transportation Commission (MTC)	Metropolitan Planning Organization (MPO) of the Bay Area, maintains the Regional ITS Architecture, distributes transportation funds; operates and maintains 511, the regional ATIS, and the regional center-to-center data sharing network (currently in development)
San Mateo County	Operates and maintains arterials within its jurisdiction
San Mateo County Transit (SamTrans)	Operates bus service on the arterials and freeways
Caltrain	Operates commuter rail service and supports private shuttle
Bay Area Rapid Transit (BART)	Operates heavy rail service
Dumbarton Express	Operates bus service on the arterials and freeways
Local Emergency Response and Public Safety Agencies	Respond to incidents on local routes, coordinate with traffic management personnel on local and state routes, coordinate with CHP during major incidents
City of San Carlos	Operates and maintains arterials within its jurisdiction
City of Millbrae	Operates and maintains arterials within its jurisdiction
City of East Palo Alto	Operates and maintains arterials within its jurisdiction
City of San Bruno	Operates and maintains arterials within its jurisdiction
City of San Mateo	Operates and maintains arterials within its jurisdiction
City of Redwood City	Operates and maintains arterials within its jurisdiction
City of Belmont	Operates and maintains arterials within its jurisdiction
City of Burlingame	Operates and maintains arterials within its jurisdiction
City of Atherton	Operates and maintains arterials within its jurisdiction
City of Menlo Park	Operates and maintains arterials within its jurisdiction

6.2 Stakeholder Needs

The following needs were developed based on stakeholder input. These needs are not prioritized but will serve as a guide for developing the system requirements.

- Enhance the communications and control network of local agency traffic signal systems such that local agencies can monitor and modify traffic signal timing parameters from a remote location on a day-to-day basis.
- Remotely adjust traffic signal timing plans within their own jurisdiction.
- Enable local agencies and Caltrans to use ITS tools on local streets to manage and monitor traffic that exits the freeway during a freeway incident in search of an alternate route.
- Establish a communications link between Caltrans and local agencies according to the Bay Area Center-to-Center Network interface standards to allow sharing and control of field devices along local streets. Caltrans will operate all Smart Corridor devices during a freeway incident.
- Provide all local agencies in San Mateo County the ability to view, operate, and share CCTV camera images from any Smart Corridor field camera on any remote computer.
- Enable all local agencies in San Mateo County to share traffic data with each other to improve the cross-jurisdictional coordination during normal operating conditions.
- Create an opportunity to provide transit signal priority and emergency vehicle pre-emption at key intersections of the Smart Corridor.
- Enable local agencies and Caltrans to activate ITS devices along local routes to accommodate increased traffic demand.
- Mitigate impacts that the Smart Corridors project may have on legacy equipment and systems that are not part of the Smart Corridors.

6.3 Current Method of Accomplishing the Goals and Objectives

The goals and objectives of this project are only partially met by employing current practices and facilities.

6.3.1 Incident Management

The Caltrans District 4 TMC is responsible for coordinating much of the activity that occurs on US-101 in the corridor, as part of its role in managing all freeways located within the district.

Events and incidents are detected through the TMC operator monitoring CCTV camera images or interfacing with CHP or TMC maintenance staff. This is currently a reactive approach to incident detection. In the event of an event or incident, the TMC will coordinate a response with an appropriate group, such as the CHP, maintenance or local agency transportation management staff.

Demand onto the freeway is managed through traveler information and by controlling the traffic signals at the base of freeway on-ramps. This is provided through fixed and portable Changeable Message Signs (CMS) and Highway Advisory Radio (HAR) provide information on upcoming events and freeway incidents. Traffic entering the freeway via onramps could be restricted only to the degree that arterial traffic signals control the traffic flow.

6.3.2 Arterial Management

Local streets within the Smart Corridor have very limited deployment of ITS elements. Some cities have existing traffic signal systems with central software. Caltrans has existing copper traffic signal interconnect along the entire length of El Camino Real. Some local agencies have existing cabling for communicating with traffic signals. There are 141 signalized intersections within the project limits that are operated and maintained by Caltrans. There are 112 signalized intersections within the project limits that are operated and maintained by local agencies.

In the event of an incident along the corridor, each City modifies its own signal timing. There is little interaction between agencies to assist with traffic signal coordination. When incidents do happen that increase the vehicle load on the arterial, there is little each City Engineer can do to quickly direct vehicles onto the freeway downstream of an incident. There is no signage to identify to the drivers where an incident is and how to get back onto the freeway at the first on-ramp downstream of the incident. As a result vehicles may have a tendency to stay on the arterial longer than required, thus unnecessarily increasing the load on the arterials downstream of the incident. Belmont has some existing fixed and PTZ cameras. The fixed cameras are currently only used for video detection and do not capture video for traffic monitoring.

6.3.3 Traveler Information

Traveler information on US-101 corridor is provided via CMS, HAR, telephone and the internet. CMS and HAR systems are used to provide real time information and directions to the driver, plus they are used to advise about upcoming events. These systems are controlled from Caltrans District 4 TMC. The Internet is used to provide more detailed information to the public. The primary method of sharing information on the Internet and the telephone is via the Bay Area 511 system. The 511 system receives real time information from detectors, CCTV cameras and other sources. This information is then analyzed and used to display meaningful, up to the minute information. There are no means to provide traveler information on local streets.

7.0 Operational Needs

This section describes the goals and objectives of the Smart Corridor System. These goals and objectives drive the requirements for the system. The Detailed Design Requirements and Detailed Design of the Smart Corridors deployment will indicate the functions, features, technology options, and costs of the program.

7.1 Operational Goals

The Smart Corridors will require active management by the stakeholders to be effective in managing incident traffic, including periodic reassessment of the incident management strategies. In order to have the system operate efficiently, stakeholders must collectively commit staff and budget to operate the system. The staff and budget required to effectively operate the system will be a continuous investment. Some stakeholders may provide more staff than others depending on available resources.

An important strategy in promoting regional collaboration and addressing regional issues is the establishment of operational goals. These goals will provide guidance on how ITS tools will enhance the operations of the Smart Corridors. The identification of these goals provides a basis for forming, maintaining, and sharing agreements between agencies in the region. This section will begin to define system operation activities and highlight potential issues to be addressed prior to system deployment in order to achieve these goals.

In **Table 2** the goals and objectives for the Smart Corridors Program are presented. These goals have been established through input from the stakeholders.

Table 1 – Smart Corridors Program Goals

Goal Area	Smart Corridors Program Goals
Traffic Incident Management	• Proactively manage traffic already diverted from the freeway to minimize impacts on local arterials, and return regional traffic back to the freeway as soon as possible by: ○ Actively managing traffic signal operations on selected routes to maximize traffic flow around a major incident and minimize delays caused by diverted freeway traffic. ○ Improving collection of current travel condition information along local arterials on the alternate routes. (Future) ○ Providing accurate and timely route guidance information about the corridors to agency transportation managers. (Future) ○ Minimizing the intrusion of freeway traffic on local streets due to major freeway incidents.
Normal Operations	• Remotely upload and download traffic signal timing parameters to optimize normal traffic conditions. • Remotely monitor traffic flow conditions. • Coordinate across jurisdictions to control and manage normal traffic flow along the entire corridor.
Interagency Coordination	• Provide the capability for shared control and operation of the Smart Corridors components by the agencies. • Improve sharing of resources between agencies for more unified transportation management operations across jurisdictions • Improve communications between the agencies during major freeway incidents

7.2 Operational Objectives

The stakeholders have agreed with the project concept of a Smart Corridors Program as a response to the needs defined in the previous section. The Smart Corridor will utilize ITS elements in four major system categories (as defined by FHWA) including Incident Management, Arterial Management, Transit Management (future phase) and Traveler Information (future phase). The key objectives of each category are described in detail below and cover both immediate and long-term objectives.

The objectives identified below should not adversely impact a local agency's current operations. For example, existing equipment should not be upgraded without considering how the upgrade will impact other existing equipment along the corridor.

7.2.1 Incident Management

- Install trailblazer signs along designated local streets and El Camino Real (SR-82) to guide diverted freeway traffic around a major incident on the freeway. Trailblazer signs are used solely to direct motorists who unfamiliar with a route.
- Integrate traffic incident management strategies across multiple local agencies and Caltrans operations to coordinate the operations of arterial dynamic message signs (ADMS), trailblazers, and traffic signals during normal operating conditions and major freeway incidents. This would allow agencies to operate Smart Corridor devices located in other jurisdictions during non-incident conditions. Integrated communications to Caltrans ramp meters and freeway CMS are not part of the Smart Corridor program but could be considered in the future.
- Implement devices on local streets and El Camino Real (SR-82) so Caltrans and local agencies can manage freeway traffic that diverts around major freeway incidents.
- Proactively manage traffic that diverts from the freeway to minimize congestion impact on local arterials, and return freeway traffic back to the freeway downstream of the mainline incident, when feasible. No active diversion of freeway traffic is planned.
- Integrate operations and communications of the San Mateo Smart Corridors with Caltrans and other Bay Area Smart Corridors via the Bay Area Center-to-Center Network so information can be exchanged between systems.
- Provide for remote monitoring of local streets and El Camino Real (SR-82) traffic flow through the use of CCTV cameras.
- Maximize green phasing along the specific routes to flush the traffic bypassing the incident.
- Provide monitoring and operations through a local control site.
- Provide a Hub in San Mateo County that allows for central monitoring and management of traffic on local streets; and serves as a back-up facility to Caltrans District 4 TMC. Additional hubs may be used for communication purposes.

7.2.2 Arterial Management

- Remotely implement traffic responsive and time-of-day signal timing to improve traffic signal coordination from a remote location.
- Maximize green phasing to reduce delays along major corridors.
- Upgrade the traffic signal controllers and communications infrastructure to enhance signal operations.
- Improve data collection and dissemination of real-time travel conditions along local streets and El Camino Real (SR-82) through system detection to manage daily traffic. Dissemination of real-time travel conditions is a possible future enhancement.
- Enable agencies to remotely monitor real-time travel conditions through data and video access.

- Integrate traffic signals across jurisdictions to enable sharing of accurate and timely traffic information to local cities, Caltrans and to the public.
- Improve traffic management for normal traffic operations.
- Maintain functionality of existing legacy systems.

7.2.3 Traveler Information (Possible Future Enhancement)

- Provide traveler information on local street travel times by utilizing system detection or other technology.
- Integrate the San Mateo Smart Corridor with Caltrans and other Bay Area Smart Corridors via the Bay Area Center-to-Center Network so information can be exchanged between systems.
- Integrate with Bay Area 511 so that local traveler information can be easily disseminated. This is not yet approved by MTC but could be a feature added in the future.

7.2.4 Transit Management (Possible Future Enhancement)

- Enhance SamTrans service on local streets by implementing transit signal priority.
- Enhance SamTrans service on local streets by disseminating transit travel times.
- Enhance at-grade rail crossings on local streets to provide advanced warning and advanced clearance of at-grade crossing when heavy traffic is diverting off the freeway.
- Utilize transit GPS on SamTrans vehicles to collect and disseminate transit travel time information.

7.2.5 System Operations and Maintenance

- Clear notation of which agency owns and operates each element of the Smart Corridor program.
- Utilize proven and reliable technology and will not require substantial software development. Provide device status and failure notification.
- Not dependent on other systems for operability.
- All Caltrans elements operate during power outages using back-up power sources.

8.0 System Overview

The San Mateo County Smart Corridor System will be implemented to proactively manage the traffic on local streets during normal operating conditions and the traffic that has diverted off the freeway due to a major incident on US 101 or other freeway. The rest of the section will describe the system that will be developed and deployed.

8.1 Regional Roadway Network

Figure 1 illustrates the roadway network in San Mateo County. The roadway network consists of two north-south freeways; two bridge links; a single, continuous north-south arterial; and a host of local routes within each city. Due to the topography of mountains on one side and the Bay on the other, the roadway network is primarily built-out within the urban areas of the County. There are three continuous north-south routes that run the entire length of the County—El Camino Real (SR-82), US-101 and I-280. There are 2 major east-west freeways (I-380 and SR 92) that create a grid with the north-south routes and there are numerous local connector streets that link these corridors together.

Figure 1 – San Mateo County Roadway Network

This network of primary and secondary routes presents a regional network suitable for developing a Smart Corridors program. Each of the primary roadway segments are described below.

- US-101 is the primary corridor connecting the North Bay to the San Jose region. It is an 8- to 10-lane north-south freeway that carries over 250,000 vehicles per day at its peak.

- Interstate 280 is a state highway that provides regional access between San Francisco and San Jose. It is a 6- to 12-lane freeway that carries 220,000 vehicles per day at its peak.

- El Camino Real (State Route 82) runs continuously through the County in parallel between US 101 and I-280. It provides secondary regional access and carries over 50,000 vehicles per day at its peak. It traverses through most of the local cities in the County.

- Interstate 380 provides a direct freeway link between US 101 and I-280 in the City of San Bruno. It is an important link to the San Francisco Airport as well as regional commuters traveling between the US 101 and I-280. This is a primary route used for diverting regional traffic from US 101 onto I-280.

- State Route 92 provides an east-west freeway connection to US 101 and I-280 within the central part of the County. It carries 150,000 vehicles per day at its peak and is a primary route for travelers to and from the East Bay (Alameda County) via the San Mateo Bridge.

- State Route 84 provides another east-west freeway connection across the Bay to and from the East Bay (Alameda County) via the Dumbarton Bridge. It carries 75,000 vehicles per day at its peak. Within San Mateo County, Highway 84 is a secondary arterial (Woodside Road) that connects US 101 and I-280.

San Francisco International Airport (SFO) is located on US 101 (just south of I-380) and is a major traffic generator in the county. In 2006, around 32 million passengers used this airport.

8.2 Arterial Roadways in Smart Corridor Limits

The roadway network within San Mateo County presents many viable alternate routes to the freeway. Table 2 lists the primary parallel arterial streets that traffic typically diverts to during a freeway incident. Table 3 lists the connector roadways that link the parallel streets to the freeways. Appendix C is a graphical depiction of the arterial roadways that make up the Smart Corridors.

Table 2 – Parallel Arterials

No.	Parallel Arterial	Limits	Jurisdiction
1	El Camino Real	I-380 to Whipple Avenue	Caltrans
2	Airport Boulevard	Broadway to Peninsula Avenue	Burlingame
3	Bayshore Highway	Millbrae Avenue to Broadway	Burlingame, Millbrae

No.	Parallel Arterial	Limits	Jurisdiction
4	Rollins Road	Millbrae Avenue to Broadway	Burlingame, Millbrae
5	Delaware Street	Peninsula Avenue to Saratoga Drive	San Mateo
6	San Mateo Drive	Peninsula Avenue to Poplar Avenue	San Mateo
7	Saratoga Drive	Delaware St. to Hillsdale Blvd.	San Mateo
8	California Drive	Broadway to Peninsula Avenue	Burlingame
9	Industrial Road	Harbor Boulevard to Whipple Avenue	Belmont, San Carlos
10	Middlefield Road	Willow Street to Willow Road	Redwood City, Atherton, Menlo Park

Table 3 – East-West Arterial-to-Freeway Connectors

No.	Arterial to Freeway Connector	Limits	Jurisdiction
1	San Bruno Avenue	El Camino Real to NB US-101	San Bruno
2	Millbrae Avenue	El Camino Real to Bayshore Highway	Millbrae
3	Broadway	El Camino Real to Bayshore Highway	Burlingame
5	Peninsula Avenue	El Camino Real to Airport Boulevard	Burlingame
6	Poplar Avenue	El Camino Real to US-101	San Mateo
7	3rd Avenue	Delaware Street to US-101	San Mateo
8	4th Avenue	El Camino Real to US-101	San Mateo
9	Hillsdale Boulevard	El Camino Real to US-101	San Mateo
10	Ralston Avenue	El Camino Real to US-101	Belmont
11	Harbor Boulevard	El Camino Real to US-101	Belmont
12	Holly Street	El Camino Real to US-101	San Carlos
13	Whipple Avenue	El Camino Real to US-101	Redwood City
14	March Road	SR-84 to US-101	Atherton
15	Marsh Road	Middlefield Road to US-101	Atherton
16	Willow Road	Middlefield Road to US-101	Menlo Park

8.3 Existing ITS Infrastructure

Local streets within the Smart Corridor have very limited deployment of ITS elements. Some cities have existing traffic signal systems with central software. The City of Redwood City has a Gardner central system with ASC2/3 traffic controllers. The City of Menlo Park and Caltrans operate a SCATS adaptive traffic control system on El Camino Real. Caltrans has existing

copper traffic signal interconnect along the entire length of El Camino Real. Some local agencies have existing cabling for communicating with traffic signals.

Approximately 253 signalized intersections are within the project limits with 141 are operated and maintained by Caltrans.

The following are details of existing infrastructure that is known within the corridor. This does not represent a complete inventory of all existing infrastructure that may be integrated into the Smart Corridors program.

- Caltrans has copper traffic signal interconnect along El Camino Real for the entire length of the project corridor.
- Burlingame has an existing traffic signal system with central software. Some existing communications infrastructure exists for the traffic signals that allows for remote control of the signals. The City of Burlingame currently utilizes QuicNet to communicate to Model 170 controllers (field masters) over leased-line with copper interconnect connections to controllers. QuicNet is not connected to all controllers in the City.
- San Mateo has an existing traffic signal system with central software. Some existing communications infrastructure exists for the traffic signals that allows for remote control of the signals. The City currently maintains two central control systems: i2TMC and an older Multisonics control system. These control systems do not connect to all the controllers in the City. The i2TMS system is linked to nine Model 2070 controllers (1 hub) in the vicinity of Bay Meadows (Saratoga Avenue). The Multisonics system is linked via dial-up to some on-street masters connected to copper interconnect to secondary controllers. There are some geographical locations (e.g., downtown) where the masters are connected to other controller by copper interconnect, but is not linked to the central system.
- Belmont has an existing traffic signal system with central software along with some existing fixed and PTZ cameras. The fixed cameras are currently only used for video detection and do not capture video for traffic monitoring.
- Redwood City has an existing copper network for communications to traffic signal controllers.

8.4 System Concept

The stakeholders have agreed with the project concept of a Smart Corridors Program as a response to the project needs. The Smart Corridor will utilize ITS elements in four major system categories (as defined by FHWA) including Incident Management, Arterial Management, Transit Management (future phase) and Traveler Information (future phase). The systems that are incorporated within these system groups include:

- Traffic Control Subsystem

- Directional Sign Subsystem
- ADMS Subsystem
- CCTV Camera Subsystem
- Detection System Subsystem
- Communications Subsystem

8.5 System Components

The system components as listed in the project reports are:

- Trailblazer signs: a trailblazer sign (TBS) is a directional static sign with a full matrix electronic board mounted above the sign. The electronic board may show an arrow that will activate to proceed left, right or straight ahead and ability to show text. The sign can be mounted on dual wood post, single post, or cantilever with bracket arm attached to new post. Some TBS are installed with a static guide sign denoting "TO US-101" to complement the electronic board.
- ADMS can be mounted on an overhead cantilever sign post.
- Fixed CCTV Camera: fixed cameras are proposed to be affixed to existing traffic signal post. Fixed cameras are directed at roadway traffic in each direction where four fixed cameras are needed at a four-leg intersection. The purpose of the cameras is to provide the operator with ability to retrieve all views of the intersection simultaneously.
- PTZ CCTV Camera: PTZs provided corridor views and can also be implemented on street intersections where the operator may pan to obtain directional intersection views.
- Vehicle Detection Station: Vehicle detection stations provide traffic data such as speed, occupancy and volume to the traffic signal system.
- Communication Lines - The Smart Corridor will utilize fiber optic cabling as the preferred media for local and State traffic signals, cameras, and TBS locations. Fiber optics is merited for the bandwidth required for transmission of camera signals and TBS or ADMS. It is proposed to use existing conduit throughout the project limits for fiber optic installation in combination with new installations. Wireless communication options will be used at locations where it is not cost effective to trench. The system is to be installed as an independent separable system at signal controllers with independent cabinets.
- The San Mateo County Hub is the main communication hub for the San Mateo Smart Corridor and is designed to perform backup operations if the D4TMC connection from the SMC Hub to D4TMC fails. The SMC Hub is located in the City of San Mateo's Police Station and was selected because it is centrally located within the county; the facility is secure; it is accessible by local agencies and Caltrans; and is a suitable office environment to maintain a computer network/workstation. In addition, this location may be strategic to operations in an event of an emergency. All field devices will be

connected to the hub, and the hub will be connected to the D4TMC via BART fiber connection at the Millbrae Bart Station.

8.6 System Users

The system will be used by three different groups of users: operators, managers and users. Operators are those that are involved in the operation of the system. Managers are those users that are responsible for high level monitoring of the system and involved in specifying the strategic direction of the system. Users are those users that receive the benefit from the system but do not actively operate the system.

8.7 System Interfaces

Interface to Caltrans District 4 TMC and local agency TMCs enable TBS and ADMS to be accessed and controlled by any stakeholder. Similarly video images from CCTV cameras located within the project will be accessible to any stakeholder throughout the corridor on any remote computer attached to the network.

8.8 System Modes and States

The San Mateo Smart corridor system can be operated using one of three modes. The modes differ in the amount of user input required for the system to operate. The three modes are:

- Automatic mode;
- Semi-automatic mode; and
- Manual mode.

8.9 System Goals and Objectives

The objectives of the Smart Corridors program are as follows:

- Proactively manage traffic on local streets that has diverted off the freeway due to a major incident on US-101 or other freeway;
- Proactively manage traffic on local streets during normal operating conditions;
- Minimize the delay that traffic experiences on local streets during major freeway incidents;
- Instrument local streets and provide traffic managers and operators with the tools to proactively manage diverted traffic due to an incident;
- Enhance the communications and coordination between local agency public safety, Caltrans, CHP, and local agency public works to create a regional approach to managing incident traffic; and
- Enable local agencies to share information and control strategies to enhance traffic management both during an incident and under normal operating conditions.

8.10 System Architecture

The logical architecture for the San Mateo Smart Corridors Project with a configuration based on the SMC Hub acting as a backup for the D4 TMC and overseeing the non-Caltrans ITS elements until such time the local TMC take control is shown in **Figure 5.**

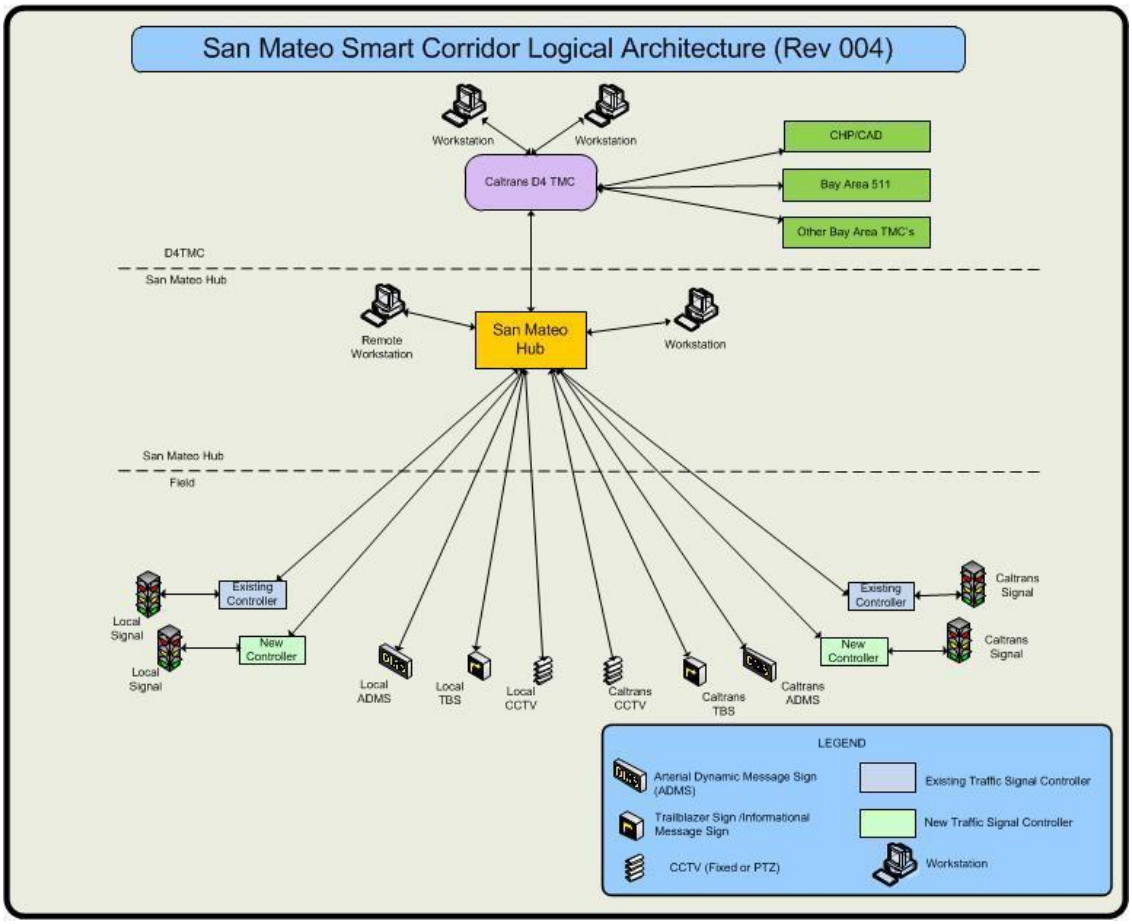

Figure 2 – Logical Architecture

9.0 Operational Environment

This chapter describes the physical environment in terms of facilities, equipment, computing hardware, software, personnel, operational procedures and support necessary to operate the deployed system.

9.1 Facilities

The San Mateo Smart Corridor System will consist of a number of facilities:

- Traffic Management Center at Caltrans District 4
- Traffic Management Centers at each of the cities along the corridor
- San Mateo County Hub

9.2 Equipment

The San Mateo Smart Corridor System will consist of a number of devices located in the field, Caltrans D4 TMC, and local agency TMCs.

9.2.1 Field Devices

The field devices that will be part of the Smart Corridor System are:

- Directional Signs– Trailblazer Signs (TBS) will be deployed to assist in diverting motorists around an incident on US 101.
- Surveillance Cameras – Fixed and Pan-Tilt-Zoom (PTZ) cameras and encoders will be installed throughout the project area to assist stakeholder agency staff in managing incidents along the US 101 Corridor.
- Arterial Dynamic Message Signs (ADMS) – ADMS will be deployed to assist in diverting motorists around an incident on IS 101.
- Vehicle Detector Stations – Microwave Vehicle Detection Stations will be deployed to provide mid-block detection at critical intersections.

9.2.2 District 4 TMC

The San Mateo Smart Corridor's video streams will be integrated into the BAVU application. ADMS and TBS units will be controlled using Skyline's Envoy software application. Traffic signals will be controlled using KITS software.

9.2.3 Local Agency TMC's

All local agencies in the program have "virtual TMC's"; meaning a dedicated workspace for managing an agency's ITS infrastructure does not exist. Rather, local agency staff manages their systems from their own workspaces (offices, cubicles, etc.). A solution will be designed and deployed at each local agency to establish access to the agency Wide Area Network (WAN) through their LAN.

9.2.4 Communication Network

The system is comprised of several ITS field elements managed and shared by the local agency stakeholders and Caltrans operations staff for improved traffic management capabilities between the freeway and arterial corridors. The critical component of this system is the communication infrastructure which consists of fiber optic cable, copper twisted pair, wireless, and Ethernet switching and routing. All ITS field devices are accessed and controlled at each agency through the communication infrastructure.

9.3 Facilities

A variety of personnel will be used to operate the Smart Corridor system, including:

- Caltrans TMC operators;
- Caltrans Operations Division staff; and
- City Engineers/TMC staff.

There will be no change to the experience or skill level required of the personnel. No other training requirements is expected other than some initial training on operating the system.

9.4 Operational Procedures

Under normal operations, local agencies and Caltrans will have the ability to coordinate traffic operations.

Caltrans has agreed to commit to active operation and control of the Smart Corridor tools by the District 4 TMC operators with support from local agencies. Active operation during major freeway incidents will include activating trailblazers and monitoring CCTV camera images to optimize the flow of traffic along local streets. If necessary, it will also require adjusting device parameters in response to changing conditions. The system will also require communication and coordination between agencies, adjustment of signal timing, notifications to travelers, and other operational strategies along the affected portion of the corridor in an event of major freeway incidents. During normal operations the respective agencies have control of their respective roadways.

9.4.1 Special Operational Considerations

Video Access and Recording (Viewing Video Images)

The video images from cameras located within the project should be accessible to any jurisdiction or agency throughout San Mateo County in accordance with Caltrans and local jurisdictional policies in order to monitor traffic flow on local streets. It should be noted that the Bay Area Center-to-Center project is moving toward a system to share video between agencies and that this network may eventually be used. Caltrans has the ability to cut off

video access during certain freeway events so others cannot view the video during these events.

While it is technically possible to record video and archive video from these cameras, the Smart Corridors policy will be to prohibit recording. Regarding field of vision, owners of the cameras will have the ability to block any portion of the field of view. This will be to protect the privacy of residents along the corridor.

Video Use by Operation (Joint Control of CCTV Cameras)
Control of cameras (pan/tilt/zoom capability) will be shared among agencies within the corridor, including Caltrans. This functionality will include individual agency-definable security on a per camera, per agency, and per person basis to allow an agency to define which cameras are available to which users, pre-set views (if any), and to allow for an agency to maintain a priority control during normal operations of the cameras in their ownership. An interagency operating agreement would include the parameters of allowable use by each agency that owns CCTV cameras, including Caltrans.

Video Use by Public (General Public Access to Video Images)
With joint control and viewing ability of cameras and camera images by multiple agencies, there is a need to clearly define "reuse" or "redistribution" guidelines. This would apply to the distribution of video to the media and/or general public either through direct feeds or through a website. Clearly defined guidelines will be included in the interagency operating agreement that address this issue from the perspective of all involved stakeholders and CCTV camera owners in the corridor. At locations where privacy may be an issue (e.g., in the vicinity of residential development), care will need to be taken to create the privacy zones where the view is blacked out or inaccessible.

9.5 Supporting Objectives

Several supporting objectives could be added in the future. These future supporting objectives include improve safety, enhance transit information, allow for emergency vehicle preemption, and more active traffic management of arterials surrounding and leading to the corridor. The following sections describe the operations related to these supporting functions.

9.5.1 Safety Improvement: Advanced at-grade Crossing Warning and Coordination System

Caltrain crosses several of the connector roadways at-grade. These crossings are currently equipped with standard crossing arms and warning lights. With the Smart Corridor project, additional safety systems and interconnect to upstream and downstream signals can be installed to provide additional control and warning to prevent vehicles from being trapped on the tracks during periods of unusually high traffic flow during an incident. Existing at-grade crossings are shown in **Table 5**.

Table 4 – Existing at-grade Crossings

No.	Jurisdiction	Corridor
1	Redwood City	Whipple Ave
2	San Mateo	4rd Ave
3	Burlingame	Peninsula Ave
4	Burlingame	Broadway
5	San Bruno	San Bruno Ave
6	Menlo Park	Ravenswood

9.5.2 Encourage Transit Usage: Transit Travel Times

SamTrans buses are equipped with Automatic Vehicle Location (AVL) equipment as part of SamTrans Bus Management System (Orbital). This provides the ability to use a GPS-based system for transit signal priority. With this system, SamTrans buses can request a green phase, a green phase extension or an early granting of a green phase at the approaching intersection under certain conditions (e.g., bus is behind schedule). Within the Smart Corridor system, algorithms for determining preemption can reside in the central system and be modified and updated to the local controllers.

The Smart Corridor will have the ability to provide the existing location of buses and predicted transit travel times through an interface with the Orbital system. This information can be disseminated to the public. This functionality is not anticipated as part of the initial Smart Corridor phases.

Other information that could be provided includes bus arrival information. SamTrans has a bus arrival time system in place at its hub facility at the Millbrae BART station and MTC is coordinating efforts for a regional system.

9.5.3 Enhance Traveler Information: Arterial Travel Times

System detection installed at midblock locations will make it possible to calculate arterial travel times on local corridors. This information could be displayed on arterial trailblazer signs (if a dynamic message sign type is used) or through the Bay Area 511. This would allow local drivers to use travel time information on local streets to alter route choice. This functionality is not anticipated as part of the initial Smart Corridors implementation.

9.5.4 Enhanced Agency Coordination: System Integration

For the San Mateo County Smart Corridors to operate effectively, the local arterial system, the state freeway system, and the regional 511 systems must be able to share data and information. The Bay Area Center-to-Center link will allow information to be shared across various systems, allowing them to work as one system and present the same or

complementary information. The key elements include 511 traveler information service (phone and web) and the freeway ramp meters and changeable message signs (CMS) operated by Caltrans. Integration of these systems will enhance the traffic management and information dissemination expected by this system. It is recognized that not all coordination among agencies in the corridor will be accomplished by technology. Some of the coordination will require phone, fax, or related techniques.

10.0 Support Environment

In accordance with U.S. Department of Transportation Federal Highway Administration (FHWA) Systems Engineering Guidebook for Intelligent Transportation System (ITS), this chapter describes the planned physical support environment to maintain the deployed system in terms of facilities, utilities, equipment, computing hardware, software, personnel, operational procedures, maintenance and disposal.

10.1 Support Facilities

Caltrans District 4 is responsible for Smart Corridor elements located in their right-of-way. C/CAG is responsible for supporting the Smart Corridor elements located in local agency right-of-way with the exception of electrical costs that will be paid by the local agencies. There are no additional facilities required to support the system.

10.2 Support Utilities

All Smart Corridor System support is facilitated by the use of the existing PG&E infrastructure.

10.3 Support Equipment

The system does not require additional equipment for supporting the proposed system.

10.4 Computing Hardware

The system may deploy additional hardware to secure the network from unauthorized access. This will be determined as part of the detailed network design.

10.5 Computing Software

The system may deploy additional software to secure the network from unauthorized access. This will be determined as part of the detailed network design. .

10.6 Support Personnel

Support for the San Mateo Smart Corridor system is provided by Caltrans Division of Electrical Systems and C/CAG.

10.7 Support Procedures

Caltrans District 4 and C/CAG are responsible for developing their own support procedures. Where support procedures require coordination between multiple agencies, each agency is responsible for working together to develop and maintain the procedures.

10.8 Maintenance

The maintenance program will need to be developed to include routine preventative maintenance activities to be effective. Continual maintenance of system devices will ensure effective, optimal, and uninterrupted operation of the equipment. The maintenance plan is typically comprised of the following key sections:

- Preventive maintenance;
- Response maintenance;
- Configuration management/design modifications;
- Equipment maintenance contracts; and
- Training requirements.

10.8.1 Preventive Maintenance

Preventive maintenance activities are some of the most effective ways to reduce overall expense of the system while ensuring that the devices operate in a reliable and optimum fashion. Common preventive maintenance activities include inspection, record keeping, cleaning, replacement, and testing. To be most effective, a well-planned maintenance program should be scheduled on a regular basis, taking into account proper resources (including both staff and equipment).

Procedures should be clearly understood by all responsible parties, and all maintenance activities should be documented. Maintenance procedures should be stored electronically so they can be easily accessed to maintain the system. This information is necessary to identify trends in maintenance needs and to plan and forecast maintenance requirements and expenses.

10.8.2 Response Maintenance

The initial response by a city or Caltrans to any reported malfunction of the system or device is known as response maintenance. Response maintenance includes both field procedures used to restore device operation and shop procedures used to repair and test the malfunctioning equipment. As an integral part of the response maintenance, procedures for reporting and scheduling repairs will need to be established. As part of these procedures, a standard prioritization process will need to be determined which will require defining a hierarchical system of potential device malfunctions and the subsequent appropriate response. This hierarchical approach will serve as the basis for planning maintenance activities

as well as defining the order in which those activities will be conducted. Under conditions when inadequate resources are available to address all necessary maintenance activities, this hierarchical approach will establish which activities will be given priority.

Special consideration will need to be given to those potential malfunctions that create immediate safety issues to the public and agency staff. Response procedures should be developed for normal operating circumstances, and to address unusual circumstances such as malfunctions which occur during periods when staff are not readily available.

10.8.3 Configuration Management

Occasionally problems with the design or operation of a system are not detected until after installation. Continual collection of data regarding maintenance activities and malfunction rates is an important element. This data should be used to update the system(s) as appropriate to ensure that changing trends in maintenance requirements and performance are recognized. This data will serve as an important tool for forecasting maintenance budgets and allocating and planning for resources and staff.

As technology advances during the implementation of the Smart Corridors, the configuration management process will address technology lifecycles and equipment upgrades.

10.8.4 Equipment Maintenance Contracts

There are several options available to address maintenance of field devices in the Smart Corridors. The preferred option is highly dependent on the availability of resources that can be committed to the corridors by the participating stakeholders. If the stakeholders collectively have the available maintenance resources but lack the technical knowledge to assume the role of maintaining the system, the contractor awarded the system deployment contract can be required to provide operational support and training to agency personnel for a specified period of time. At the end of the operational support period, the stakeholders would assume responsibility for the operations of the system in accordance with the agreed upon Maintenance Plan.

10.8.5 Training

Training should provide those technical skills needed to effectively operate and maintain all system features and components. The training should reflect the actual needs of the agency and its personnel. A continual training program for operations and maintenance staff is essential to ensure that devices are continually kept in optimal working condition. Training is also essential to ensure that staff is up to date on the safest and most efficient methods for conducting repairs.

10.8.6 Operations and Maintenance Agreements

A Memorandum of Understanding and Ownership, Operation & Maintenance agreement were executed between C/CAG and each of the stakeholders to detail specific O&M responsibilities and cost sharing for labor or expenses among the stakeholders. The

Ownership, Operation & Maintenance agreement outlines and defines the roles, responsibilities, terms, and conditions for the ownership, operation, and maintenance of equipment and components that are incorporated and integrated into the San Mateo County Smart Corridor Project.

10.8.7 Operations and Maintenance Costs

The costs for O&M will be refined as the design progresses, depending on the equipment and technology selected for each phase as well as the level of integration. These costs will include communication costs for the hybridized system (if necessary), repairing broken or damaged equipment, routine inspection and testing of devices, and cleaning of cameras lenses. Detailed annual O&M costs will be provided in the O&M Plan.

11.0 Operational Scenarios

Successful implementation of the Smart Corridors program requires several key components:

- Local cities and Caltrans sharing information and cooperating with other agencies operating Smart Corridor components. The Smart Corridor crosses jurisdictional boundaries and should provide seamless operation to drivers along those routes. Communication and coordination between agencies, adjustment of signal timing, notification to travelers, and other operational strategies must be established for the program to be a success.
- Local cities and Caltrans proactively utilizing the Smart Corridor devices during normal conditions. This involves using cameras, signal timing modifications, and other devices to optimize traffic flow along the corridors.
- Close coordination between the Incident Commander (typically CHP) and Caltrans during freeway incidents.
- Caltrans should commit to active operation and control of the ITS tools by the District 4 TMC operators with support from local agencies as agreed upon. Active operation during major freeway incidents includes activating trailblazers and monitoring camera images to optimize flow of traffic along local streets. If necessary, activate additional devices and/or modify device parameters in response to or preparation of changing conditions.

These three activities must occur in order for the Smart Corridor to meet the goal of improving transportation mobility, efficiency and safety during incidents. The following sections describe different operational scenarios in more detail. Some of the specific responsibilities will be dependent on available resources, which will be defined at a later time. Operations and maintenance cost scenarios are presented later in this document.

11.1 Operational Scenario: Normal Operations

Scenario Objective: The objective of this scenario is to manage traffic on the roadway network under normal operation conditions.

Scenario Definition: Normal operation on the freeway is defined as periods when there is no freeway congestion, crashes, construction and maintenance or other event that reduces the freeway level of service.

Operations: Each agency will own within its jurisdiction. During normal operations, each agency will operate its respective system components including traffic signals and Smart Corridor equipment, managing traffic on its own roadways. Data will be shared among agencies within and outside the corridor with the objective of improving coordinated traffic management and of providing more and better information to travelers. Provisions will be made for coordination of traffic signals across jurisdictional boundaries. As a part of the Smart Corridor program, each agency agrees to support strategies to encourage greater transit use in the corridor such as providing for transit vehicle priority in a future phase at key intersections along the corridor. Emergency vehicle preemption may be deployed to a greater extent in future phases, to support faster incident response and clearance, and enhance safety within the corridor and beyond. As a part of this program, agencies would support this functionality within the corridor.

11.2 Operational Scenario: District 4 TMC Unavailable

Scenario Objective: The objective of this scenario is to identify how the system will operate in the event that the Caltrans District 4 TMC is unavailable.

Scenario Definition: District 4 TMC being unavailable is defined as the Smart Corridor program elements being unreachable from the District 4 TMC in Oakland.

Operation: The Smart Corridor program will ultimately involve Caltrans as the primary operator during incidents. That integrated concept will be achieved following completion of the Bay Area Center-to-Center (C2C) Network. Before that connection is made, the San Mateo County Hub will initially serve as the central location for communications equipment.

In early phases, before the center-to-center communication link is established between San Mateo County and the Caltrans District 4 TMC and as back-up when communications to Caltrans are not available, the SMCHub will have the responsibility for implementing and controlling traffic management devices and strategies. Local agency TMCs will communicate directly with the SMCHub. When the center-to-center connection to the Caltrans TMC is operational, the Caltrans TMC will be the main operational control point, with the local control site as a redundant center in case of emergency. The SMCHub will also serve as a local agency control point during normal operations.

11.3 Operational Scenario: US-101 Major Incident

Scenario Objective: The objective of this scenario is to manage traffic on the roadway network when there is a major crash on the freeway.

Scenario Definition: A major crash is defined as one that blocks more than 50% of the lanes for at least 30 minutes. This is a non-recurring, non-planned event.

Operations: When a major incident occurs, the California Highway Patrol (CHP) will assume the role of Incident Commander. CHP will communicate to Caltrans relative to actions that need to be taken to address the traffic impact. Caltrans may also identify incident information via CHP Computer Aided Dispatch (CAD). Caltrans will determine if it is a major or minor incident. If it is a major incident where more than 50% of the freeway lanes are blocked, Caltrans will activate the appropriate devices on the local streets that Caltrans determines will be most impacted by diverted freeway traffic. This approach respects and utilizes the established process that is currently in place to manage incidents. There is no plan to actively divert traffic off the freeway.

The first action Caltrans will take is to alert and encourage travelers heading in the direction of the incident to take alternate freeways to bypass the incident location. For the traffic that could not avoid the incident area the Smart Corridor will be activated by Caltrans.

In response to major incidents, Caltrans TMC operators will select the appropriate route(s) for diverted traffic and assume "control" of devices along the route(s) that will likely be heavily used by freeway traffic in order to move a large amount of diverted freeway traffic around the incident and back to the freeway as quickly as possible. The routes are considered based on the location of the incident, anticipated routes from historical traffic patterns, and congestion on other routes. Caltrans should also coordinate with local agencies to avoid any local road construction or other impacts that could affect the performance of an alternate route. The first preference for an alternate route is to use I-280. If I-280 is not deemed appropriate, El Camino Real should be considered. If El Camino Real is deemed unsuitable due its ability to accommodate incident traffic, then other pre-approved local routes should be used individually or in combination with El Camino Real and adjacent routes. Field devices will also be used on major state routes (i.e., SR-84 and SR-92 between US-101 and I-280) to monitor traffic.

Caltrans will select the devices to activate, and will immediately notify CHP and the local agencies.

Caltrans, in coordination with local cities, will also be the agency that controls the deactivation of the Smart Corridor devices. Upon clearance of the incident as indicated by CHP or upon a determination by Caltrans that arterial volumes no longer require the use of Smart Corridor devices, the signal timing plans and associated ITS equipment will revert to normal operations and local agencies will again be responsible for operation and management.

Cameras located on local arterials and Caltrans' routes (freeway and state highway) will be accessible for control and viewing by all agencies and to allow optimization of traffic management on local streets. A control hierarchy will be established by Caltrans and local agencies based on identified priorities. **Figure 3** depicts the decision flow of a US 101-based incident and describes each step in the process and the related responsibilities of each partner through the process. These processes are not currently in place, but are planned for the Smart Corridor program.

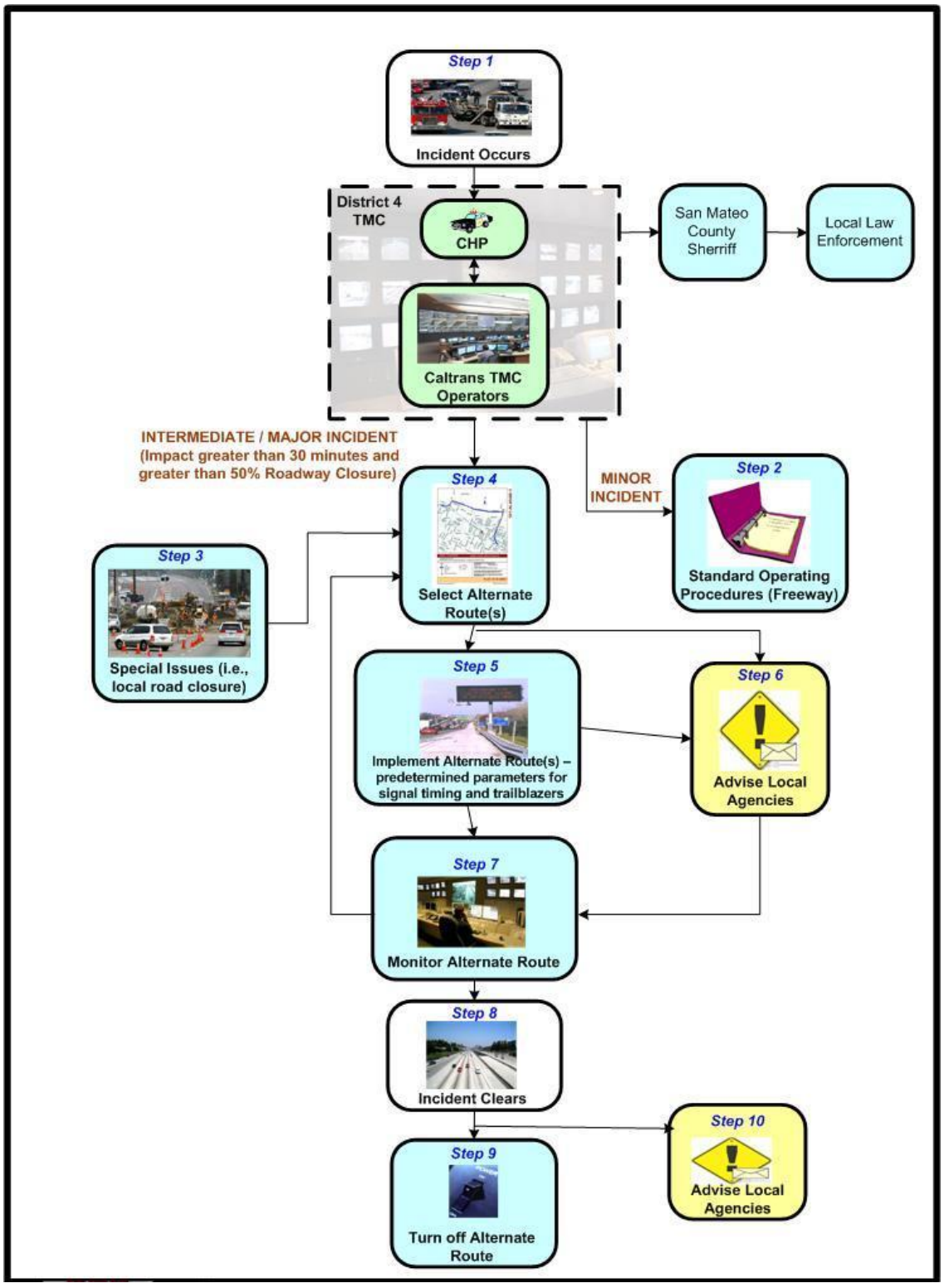

Figure 3 – US 101 Major Incident Process Flow Diagram

Table 5 – US 101 Major Incident Process Flow Description

Step No.	Function	Agency Responsibilities		
		CHP	Caltrans	Local Agencies
1	Recognize Incident	Inform the location of the incident to Caltrans (via radio, telephone, or Computer Aided Dispatch).	Determine the severity level of the incident. If the incident is minor, go to step 2, else go to step 3. Inform local agencies about the incident. - Minor incident is < 50% of lane blocked.	
2	Minor Incident	Invoke standard operating procedures to clear incident.	Invoke standard operating procedures.	
3	Special Issues (i.e. Road Closures)		The incident is determined as major, so road closure information is obtained from local agencies before activating a Smart Corridor for an incident.	Maintain up-to-date and accessible road closure information. Provide the information to Caltrans as requested.
4	Select Alternate Routes		Select relevant Smart Corridor devices. Consider incident location, severity, local road closures, and other special issues. Immediately convey the route(s) to the CHP and local agencies.	
5	Implementing Alternate Routes – predetermined parameters for signal timing and trailblazers		Activate signs and traffic signal timing modifications at selected locations.	
6	Notify local agencies		Notify local agencies about the occurrence of an incident and the activated devices.	
7	Monitor Alternate Routes		Monitor the activated devices and traffic flow via CCTV cameras. If more congestion results on the freeway due to prolonged incident, return to Step 4 and consider activating additional devices.	Monitor traffic flow on local streets via CCTV cameras. Assess performance of corridor and determine if modifications to the strategy are required.
8	Incident is cleared		Monitor the traffic flow until the incident is cleared from the freeway. Then, monitor the traffic flow on local streets.	
9	Deactivate Smart Corridor for an incident.		As queue clears from incident and arterial traffic flow returns to normal, and revert signs and traffic signals to normal operation.	
10	Notify all the local agencies		Notify all the local agencies that the incident is cleared and the Smart Corridor alternate routes have been deactivated.	Retake control of local agency equipment

12.0 Summary of Impacts

This chapter provides the impacts of the proposed system on the stakeholders. Metrics for assessing system performance are also included.

12.1 Stakeholder Impacts

The stakeholders of the Smart Corridor must fully commit to active operation and maintenance of the project concept elements. The technologies that will be deployed will not achieve the goals of the project unless they are actively used to manage traffic. In order to have the system operate efficiently, stakeholders must collectively commit staff and budget to operate the system.
Under normal operations, local agencies and Caltrans will have the ability to coordinate traffic operations.

Caltrans has agreed to commit to active operation and control of the Smart Corridor tools by the District 4 TMC operators with support from local agencies. The system will also require communication and coordination between agencies, adjustment of signal timing, notifications to travelers, and other operational strategies along the affected portion of the corridor in an event of major freeway incidents. During normal operations the respective agencies have control of their respective roadways.

12.2 System Constraints

The system must be developed and deployed within the time and budget dictated by the terms and conditions of the project funds.

12.2 Performance Measures

The following are potential measures for evaluating the Smart Corridor performance:

- Percentage of incidents that do not require active traffic monitoring on local streets;
- Results of user surveys on the use of the Smart Corridor tools;
- Reduction in measured congestion;
- Reduction in system travel time;
- Reduction in queue clearance duration;
- Reduction in amount of traffic filtering through local network;
- Average time after an incident when Caltrans notifies local agencies;
- Average time to activate alternate routes;
- Average time required for traffic signals to transition to flush plan;

- Percentage of time that the use of Smart Corridor devices provides satisfactory traffic flow; and
- Amount of resources expended for managing traffic on local streets during freeway incidents.

The procedures and specific metrics for evaluating these measures will be documented as part of a future Systems Engineering documents.