April 5th, 2005

San Gabriel Valley Traffic Forum

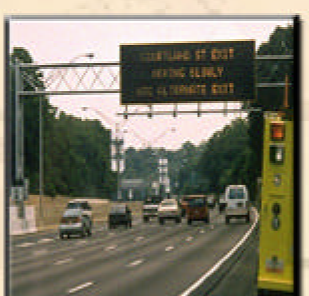
ATMS Improvement Project

ATMS Alternatives Analysis Document

(Deliverable 2.5.1.1)

Draft

Prepared by:



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SAN GABRIEL VALLEY TRAFFIC FORUM

ATMS ALTERNATIVES ANALYSIS DOCUMENT

Deliverable 2.5.1.1

DRAFT

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April 5th, 2005

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1 INTRODUCTION

1.1 PROJECT OVERVIEW

The San Gabriel Valley Traffic Forum (SGVTF) is one of the planned Intelligent Transportation Systems (ITS) improvement projects that the Los Angeles County Department of Public Works (County) is developing as part of the Traffic System Management (TSM) program in order to improve traffic flow and enhance arterial capacity in a cost-effective way where roadway widening is not possible. The purpose of the SGVTF project is to design, develop, and deploy an Advanced Transportation Management System (ATMS) that can be tailored to each Agency's operational needs so that traffic signals can be synchronized and ITS systems integrated across jurisdictional boundaries. The SGVTF project focuses on the specific needs of each Agency to manage their ATMS and recommends improvements to field infrastructure (e.g., controllers, detection systems, communications, etc.) and centralized Traffic Control Systems (TCSs) and/or Traffic Management Centers (TMCs) to meet those requirements. When the SGVTF is successfully completed, each of the Agencies responsible for traffic signal operations will have full access to an ATMS that monitors and controls the traffic signals within their jurisdiction. In addition, Agencies will be able to synchronize their signals and exchange traffic information in real-time with neighboring Agencies. This will allow the Agencies to respond to recurrent and non-recurrent congestion in a coordinated fashion across jurisdictional boundaries.

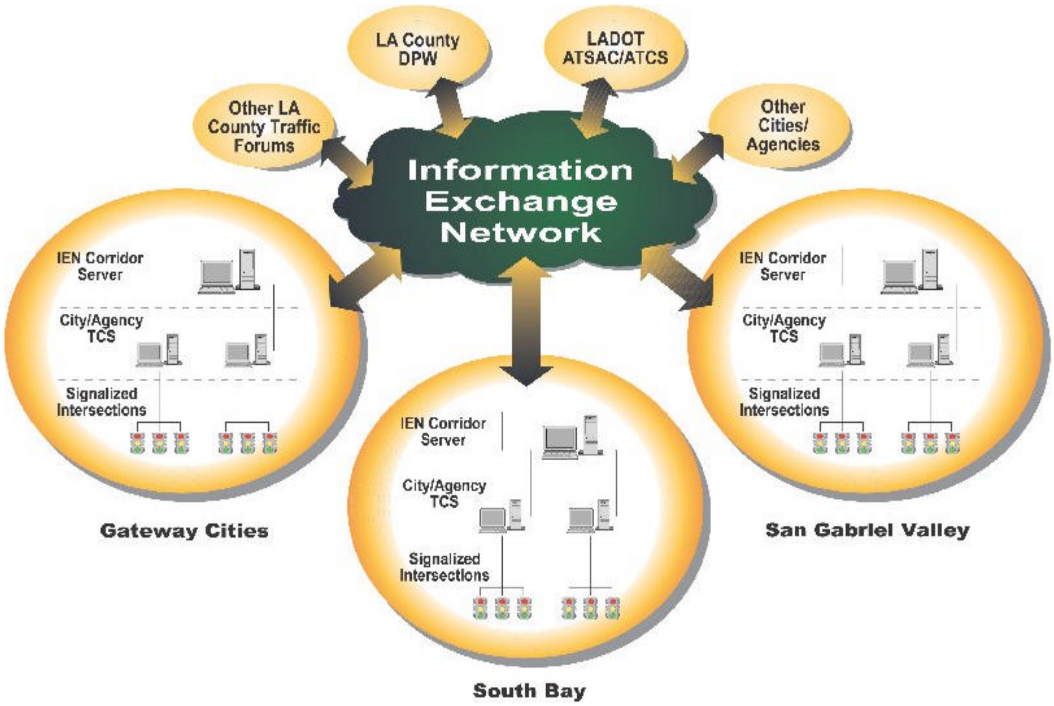
The SGVTF project area ranges from Cities bordering the California State Route (CA SR) 110 and I-710 freeways to the west, I-210 freeway to the north, CA SR 57 freeway to the east, and the CA SR 60 freeway to the south. It encompasses 24 municipalities as well as unincorporated portions of Los Angeles County. The traffic signals in this region are operated by many of the individual Agencies, County, and Caltrans District 7.

Developed by the County, the Countywide Information Exchange Network (IEN) is the integrated system framework that connects participating Agency ATMSs into a regional network to support the operational goals identified above. The Countywide IEN supports traffic signal operations at the Local level, Corridor level, and Regional level. The SGVTF assumes the availability of the Countywide IEN at the Corridor and Regional levels. Therefore, the SGVTF project is focused on the selection of TCSs and the integration of those systems to the Countywide IEN at the Local level. The eventual ATMS design for the SGVTF will take into account the interface to the Countywide IEN and its requirements at the Local level and encompass the following six (6) core components:

- ATMS and/or TCS (Individual Agency)
- Detection and Surveillance
- TMC and/or Workstation Layouts (ATMS and/or IEN)
- Communications Network
- SGVTF Participation/Coordination (City-specific and/or SGVTF-Regional integration)
- Operations and Maintenance (O&M)

The Countywide IEN comprises a series of computer servers, communication networks, and software applications that integrates these components for the collection and transfer of data to support Corridor and Regional functions throughout Los Angeles County. Exhibit 1.1 provides a high-level graphical representation of the Countywide IEN framework.

Exhibit 1.1 – Countywide IEN



1.2 STAKEHOLDERS

This section identifies all the Agencies and Cities participating in the SGVTF. This section defines the project participants categories, different Agency Levels, and their direct or indirect involvment with managing traffic operations and incidents. The four (4) Agency Levels that have been defined (Levels 1, 2A, 2B, and 3) are based upon the level of direct involvement an Agency has in managing traffic operations within its jurisdiction/boundaries.

1.2.1 SGVTF Stakeholders Identification

Within the SGVTF, there are three (3) categories of project participants: City Agencies, Transit Agencies, and "Other" Agency types of Stakeholders. The most prevalent are Cities. "City Agencies" Stakeholders operate/manage the traffic-related roadside and central systems/equipment (e.g., traffic signals, controllers, communications, etc.) for themselves and/or for other Local Agencies.

"Transit Agencies" (for the purpose of this project) operate/manage transit systems that traverse the study area in multiple jurisdictions. While many of the Cities in the SGVTF operate some type of intra-City transit, para-transit, and/or Dial-A-Ride service, these entities were not included as additional Stakeholders due to their limited operational and geographical span.

The final Stakeholder category, "Other", are for those entities that do not clearly fall into either of the previously discussed categories.

1.2.2 City Agencies

The following SGVTF Agencies manage traffic operations and systems within their jurisdiction, and possibly for other Stakeholders:

- City of Arcadia
- City of Alhambra
- City of Azusa
- City of Baldwin Park
- City of Bradbury
- City of Covina
- City of Duarte
- City of El Monte
- City of Glendora
- City of Irwindale
- City of La Puente
- City of Monrovia
- City of Montebello
- City of Monterey Park
- City of Pasadena
- City of Rosemead
- City of San Dimas
- City of San Gabriel
- City of San Marino
- City of Sierra Madre
- City of South El Monte
- City of South Pasadena
- City of Temple City
- City of West Covina
- LA County Dept. of Public Works
- Caltrans District 7

1.2.3 Transit Agencies

The following Agencies conduct or administer transit operation/services across the SGVTF project area:

- Los Angeles County MTA (Metro)
- Foothill Transit
- Montebello Bus

1.2.4 Other Agencies

The following Agency does not fall into either of the prior categories:

- Alameda Corridor East (ACE)

1.3 AGENCY LEVEL DEFINITION

Regardless of the size, every Agency performs a variety of tasks related to traffic and incident management. Obviously, Agencies with fewer signals, traffic issues, staff, etc. will generally perform fewer or less complex activities. Also, as the level of cooperation/collaboration between Agencies increases, understanding what is expected of each Agency becomes increasingly important.

Below are the four (4) Levels that have been defined (Level 1, 2A, 2B, and 3) based upon the level of direct involvement an Agency will have in managing traffic operations within its boundaries, tasks required to be performed on their respective systems, and the level of data sharing with other IEN member Agencies.

Level 1 Agency

Agency does NOT operate its traffic signals

- Agency wants to be “Agency B” on another Agency’s ATMS
- Another Agency operates its traffic signals (e.g., LA County DPW)

Provided with an IEN W/S to monitor traffic signals & incident management activities

No separate ATMS W/S provided

Level 2A Agency

Agency passively manages its traffic signals

- Establish initial signal timings, monitor system status daily, etc.
- May operate on an exception/as-needed basis
- Monitor mainly for alarms & malfunctions

Agency wants to be “Agency B” on another Agency’s ATMS

Provided with an IEN W/S to monitor traffic signals & incident management activities [Regional view]

Maintains a separate ATMS W/S connected to “host” Agency’s ATMS [Local view]

Level 2B Agency

Agency manages & operates its own ATMS

- Actively manages ATMS during exceptions
- Passively manages ATMS during AM & PM peak periods

Agency may operate some other ITS devices (small amount)

Agency may operate other Agencies’ traffic signals (Level 1)

Agency may “host” other Agencies’ traffic signals (Level 2A)

Maintains an LCCS facility to manage traffic signals & incident management activities

- IEN W/S [Regional view]
- ATMS W/S [Local view]
- CDI between the ATMS & IEN

Level 3 Agency

Agency actively manages its own ATMS & other ITS devices (large amount)

- Typically AM & PM peak period traffic operations & incidents
- May support 24/7 operations

Agency may operate other Agencies’ traffic signals (Level 1)

Agency may “host” other Agencies’ traffic signals (Level 2A)

Agency will have a TMC from which to operate its ATMS, the IEN, & other ITS devices

Maintains a TMC/LCCS facility to manage ATMS & incident management activities

- IEN W/S (Regional view)
- ATMS W/S (Local view)

Exhibit 1.2 defines the SGVTF Agencies per Level.

Exhibit 1.2 – SGVTF Agencies Per Level

Level 1 Agencies	Level 2A Agencies	Level 2B Agencies	Level 3 Agencies
Duarte La Puente San Marino South El Monte South Pasadena Temple City	Azusa Baldwin Park El Monte Glendora Monrovia Montebello Monterey Park San Gabriel	Alhambra Arcadia Covina Irwindale Rosemead San Dimas West Covina	Caltrans LACO DPW Pasadena

1.4 PURPOSE OF DOCUMENT

This document is Deliverable 2.5.1.1 - ATMS Alternatives Analysis (Draft). The objective of this report is to evaluate different ATMS, vehicle detection systems, and CCTV systems for use in the Forum area. The evaluation of the ATMS consists of preparing a comparison matrix to show the benefits and limitations of each system that was evaluated. The comparison matrix addresses the following:

- Conformance to User requirements
- Conformance to Functional requirements
- Software requirements
- Hardware requirements
- Intersection control equipment
- Communications requirements
- Estimated capital cost
- Estimated maintenance cost
- Interface requirements and ability

In addition to the comparison matrix, separate alternatives analyses for the ATMS were performed for each Agency in Level 2B and Level 3. The alternatives analysis for each Agency was tailored to the specific options and features that are applicable for that Agency.

The evaluation of the vehicle detection system comprises of a comparison of technologies and identification of functionality rather than an evaluation of specific products from individual suppliers.

The evaluation of the CCTV system examines potential locations, how to prioritize locations, and operational alternatives to support multiple Agencies.

1.5 ORGANIZATION OF DOCUMENT

After this introduction, the report is broken into the following sections:

- Section 2: ATMS Alternatives Methodology
- Section 3: ATMS Survey/Matrix
- Section 4: Agency ATMS Recommendations

- Section 5: Detection Systems
- Section 6: CCTV Systems
- Appendices

1.6 REFERENCED DOCUMENTS

The following documents have been used as reference material in the preparation of this report:

- San Gabriel Valley Traffic Forum Project
    - Deliverable 2.1.2: Operational Objectives
    - Deliverable 2.2.2: System Needs
    - Deliverable 2.3.1.1: Concept-of-Operations
    - Deliverable 2.3.2.1: ATMS User Requirements
    - Deliverable 2.3.3.1: ATMS Functional Requirements
    - Deliverable 2.3.4.1: Local Agency Workstation Site Requirements
    - Deliverable 2.3.5.1: Sub-Regional TMC Requirements
- I-5/Telegraph Road Corridor Project
    - Deliverable 5.1.2: System Alternatives Analysis and Recommendations
- Pomona Valley ITS Project
    - Deliverable 7.1.2: ATMS Alternative Analysis
- Elana, L., Mimbela, Y., and Klein, L. A., *A Summary of Vehicle Detection and Surveillance Technologies Used in Intelligent Transportation Systems*, the Vehicle Detector Clearinghous, New Mexico State University, 2000.
- Klein, L. A., Sensor Technologies and Data Requirements for ITS, Norwood, MA, Artech House, 2001.
- Martin, P., Feng, Y., and Wang, X., Detector Technology Evaluation, University of Utah Traffic Lab, 2003.
- Middleton D., Jasek D., and Parker, R., Evaluation of Some Existing Technologies for *Vehicle Detection*, Texas Transportation Institute, 1999.

2 ATMS ALTERNATIVES METHODOLOGY

The ATMS alternatives analysis for the San Gabriel Valley Traffic Forum is based on the work performed by County staff and its consultants on other Traffic Forum projects. The work performed on other Traffic Forum projects has been updated to meet the specific requirements of the San Gabriel Valley region.

Meyer, Mohaddes Associates, Inc. (MMA), one of the County's Consultants for the Pomona Valley ITS Project, conducted an ATMS analysis. MMA collected information from various Vendors on their systems' functionality. Appendix A contains the resulting comparison matrix from the Pomona Valley ITS Project. TransCore's scope of work for this analysis was structured to use previous analyses as a starting point and to add additional features to the comparison matrix created for the Pomona Valley ITS Project as to meet the specific requirements for the San Gabriel Valley region.

TransCore contacted various Vendors asking them to provide information about their systems' functionality with respect to the features identified in the Pomona Valley ITS project and the additional features added for the San Gabriel Valley region. The list of ATMS candidate systems includes:

1. QuicNet/4 by BI Tran Systems
2. icons by Econolite
3. PYRAMIDS by Econolite
4. KITS by Kimley-Horn
5. ATSAC by LADOT
6. MIST by PB Farradyne
7. i2TMS by Siemens ITS
8. *TransSuite* by TransCore

TransCore contacted the seven (7) Vendors with questionnaires asking them to update the information previously collected and provide cost estimates for their systems. All Vendors responded to the survey except for BI Tran. Since BI Tran did not provide any updated information regarding their system, the information previously collected by other Traffic Forum projects was used. The information collected was used to determine which ATMS systems meet the needs for each Agency in the SGVTF.

3 ATMS ALTERNATIVES SUMMARY

The focus of the ATMS alternatives analysis is to identify reliable and cost-effective systems that best meet the needs of the Agencies in the San Gabriel Valley Traffic Forum for traffic management and signal operations. The following sections summarize TransCore's and the County's recent research of various off-the-shelf ATMS.

3.1 ATMS CANDIDATES

The County of Los Angeles evaluated the following Advanced Traffic Management Systems (ATMS) for use in the San Gabriel Valley Traffic Forum:

1. QuicNet/4 by BI Tran Systems
2. *icons* by Econolite
3. PYRAMIDS by Econolite
4. KITS by Kimley-Horn
5. ATSAC by LADOT
6. MIST by PB Farradyne
7. *i2TMS* by Siemens ITS
8. *TransSuite* by TransCore

These ATMS have the capabilities and features of a typical ATMS and are considered to be initial candidates for the alternatives analysis. The evaluated ATMS packages are supported by established Vendors (except ATSAC, which is owned by LADOT) that specialize in traffic control systems and ATMS applications. With the exception of PYRAMIDS and ATSAC, the systems support the State-mandated AB3418/AB3418E communication protocol, and generally can be upgraded to meet the current National Transportation Communications for Intelligent Transportation System (NTCIP) protocol. Both protocols are discussed later in this section.

3.2 SYSTEM FEATURES

The ATMS alternatives analysis compared the major system features of the eight (8) candidate systems. It should be noted that information presented in this document is based on supporting data or information provided by the Vendor or from web-based research as of the date of the first draft of this deliverable, April 5th, 2005. This information should be used for guidance only. The exact specifications of the ATMS should be obtained during the design or procurement phase.

Following is a description of the items in this document's ATMS comparison matrix (Exhibit 3.1) that are not self-explanatory (both the features described in Pomona Valley ITS: ATMS Alternatives Analysis Report as well as the features added for the San Gabriel Valley):

Control Strategy - Refers to the method used by the ATMS to control the traffic signal controllers.

- *Sync Pulse Strategy* sends an electrical signal from the central TCS server to all field controllers once per cycle at the beginning of the current plan's master cycle timer. The controllers' internal coordinators are, in effect, re-synchronized once each cycle. The controllers provide coordination using locally-stored timing plans.
- *Closed-Loop Systems - (CLS)* generally have one or more supervisory machines on the street (termed "master controllers" or "on-street masters"). Each on-street master oversees a group of intersections in a contiguous area, all of which run the same coordination pattern. CLS connections to a central master are ad-hoc and temporary, often manually activated using a dial-up telephone modem connection.
- *Time-Based Coordination (TBC)* relies on a common time base. The ability of the controllers to stay in coordination depends on the accuracy of that time base. Some time-based coordinators rely on power line frequency to maintain their clocks. When power is interrupted, batteries maintain time of day, but they are generally less accurate than line frequency counters. TBC can be combined with centralized management so that clocks are synchronized, alarms can be reported, new data can be up- or downloaded, etc. Even if a full-time Centralized Management connection to controllers is present, a system using a TBC strategy by definition will execute only predefined timing plans, based on a time-of-day and day-of-week schedule.
- *Centralized System* controls operations from the central TCS server, which generally requires second-by-second communication. The central system may issue forceoffs, holds, pattern changes, and other direct control commands to effect coordination at each intersection. Or, the central system may command intersections to execute timing plans that are stored locally in the controller, making those decisions based on either time-of-day or current traffic volumes on critical network links.

LAN/WAN Capabilities - LAN (Local-Area Network) capability refers to the ability to display data or send control signals over a local-area network. Most centralized systems utilize a LAN setup to distribute system tasks (field communications, data storage, user interface, etc.) among multiple, linked computer servers. WAN (Wide-Area Network) capability refers to the ability to exchange data between different local-area networks; that is, over a wide area. Many municipalities have the required network infrastructure already in place for other Agency needs.

- *VPN Access* is the ability to monitor and control the ATMS from a remote or mobile terminal via a secure connection.
- *Center-to-Center Communications (C2C)* is the ability to monitor and/or control devices connected to a different center which uses the same ATMS within the same application window.

Capacity - Some systems are limited in the number of field devices (e.g. local intersection controllers, on-street masters, system detectors, etc.) or signal timing patterns they can manage. Other components of the signal system might also impose limits (e.g. the communication infrastructure); this evaluation factor does not take such other limitations into account since they are out of the scope of this analysis.

- *On-Street Masters* are machines that supervise operations in an area, without constant communication with a central system. Closed-loop systems use on-street masters. Some centralized systems can also utilize the distributed control that is afforded by on-street master controllers.

- *Control Areas* (sections or groups) are combinations of intersections that are operated in a coordinated fashion, usually with a common cycle length. The signal groupings could be different by the time of day, so that intersections might be members of more than one group.
- *System Detectors* are vehicle detectors used to gather measures of effectiveness such as volume or occupancy, but are not generally used directly for extension or termination of green. The typical traffic responsive mode of coordination has the on-street master or central system dynamically calculating the "best" coordination pattern based on comparisons of real-time system detector data with a stored lookup table.
- *Coordination Timing Plans* are one combination of cycle length, split, and offset. In some cases, the limit on the number of coordination timing plans is the mathematical product of just the number of cycle lengths and splits.

Local Controller Compatibility - The controller types listed in the table fall into three (3) general categories:

- *NEMA Controllers*: NEMA is an acronym for the National Electrical Manufacturers' Association. Its controllers are not interchangeable with Model 170 controllers. NEMA controllers adhere to a standard set of input/output definitions, which provide for basic signal operation. The standard does not define "enhanced" operations. NEMA controllers generally have proprietary firmware controlling the hardware.
- *Model 170 Controllers* also adhere to a hardware specification, but hardware and firmware are separated, so one company's firmware can be used in another's hardware.
- *Advanced Transportation Controllers* (*ATC or 2070*) controllers were developed as a successor to Model 170 controllers, offering more computational power, advanced features, and a menu-driven front-panel interface while maintaining an open hardware standard. The Model 2070N controller is a Model 2070 controller with NEMA connectors, allowing it to be retrofitted into a NEMA cabinet.

Protocol Support - Three (3) forms of communication protocols are generally used in California for system-to-controller communication:

- *Proprietary*, where the manufacturer determines the protocol (and generally keeps it as confidential information not freely shared outside of the company). All controllers support the Vendor's proprietary protocol, so this basic functionality is not tabulated.
- *NTCIP* (*National Transportation Communications for ITS Protocol*), is a national standard in the public domain; its goal is to replace proprietary protocols with no loss of functionality.
- *AB3418*, (a protocol named after the California assembly bill that mandated its use) is required to be supported by all traffic signal controllers deployed in California, to promote interoperability and interconnectivity between controllers. It supports control and monitoring functions, but does not support upload and download of controller data. An enhanced version, AB3418E, is also available. These two (2) protocols can be viewed as an intermediate solution between proprietary protocols and the NTCIP.

Communication Requirements - The bandwidth, or throughput, of a communication channel is measured in bits per second (bps). The figures reported in the Exhibit 3.1 report the system's limitations (i.e., they assume the communication channel is not the bandwidth-limiting factor).

- *Full Duplex* allows messages to be sent to and from the controller simultaneously.
- *Half Duplex* requires full use of the channel in one direction only; return messages must wait for the originating message to be completed.
- P*olling Rate* is the frequency with which data is exchanged with the supervising system. Once-per-second polling allows close monitoring of the actual beginning and ending of greens, detector status, pre-empts, etc., but requires additional bandwidth and consumes a greater amount of the available communications system resources.
- *Upload/download Duration* is the length of time required to transmit the entire controller database to or from the controller. The duration is dependent both on the quantity of data to be transmitted and the speed of the transmission.
- *Auto-Upload, Auto-Download, and Auto-Compare* is the ability to schedule the system to upload, download, or compare the central and controller databases.
- *Field Initiated Downloads* are requests made at the controller to download the controller's database from central to the field.

Coordination Plan Selection Methods – The type and capabilities of the ATMS to select coordinated timing plans.

- *Traffic-Responsive Plan Selection* refers to selection of timing plans from a table of pre-developed coordination patterns based on measured traffic characteristics such as volume and/or occupancy at a system detector.
- *Critical Intersection Control* refers to the ability of the controller to change splits at a key intersection in response to traffic demand.
- *Dynamic Change of Subgroups* allows intersections to change groups by time of day, or in response to traffic demands.
- *Override Capability* means that the Operator can manually command one or more intersections (or one or more groups of intersections) to change to a different pattern than the system would otherwise be using.
- *Data Logging* provides the capability to collect and store in a system file, either as needed or continuously, a variety of user-selected real-time operational data from one or more supervised intersections.

Alarms – The means available to alert system Users to issues that need attention.

- *Prioritization* means more important alarms can be treated differently.
- *Paging Capability* means the system supports delivering alarm messages to pagers.
- *Offline Capability* defines the coordination method that the individual controllers will "fall back" to in the event that required full-time communications with the central system is temporarily lost.

Graphical User Interface (GUI) - The "look and feel" of the software.

- *Graphics Format* defines the types of software supported for the creation of displays such as intersection status displays.
- *Display Priority/Pre-emption Data* allows for an automated display or indication that a particular intersection has been locally commanded to provide a revised phase timing in response to a pre-emption call.
- *Object Configuration* allows different objects (icons) to be visible at different zoom or detail levels.
- *Event Layers* allows different activities such as construction, incidents, planned events, etc. to be displayed on the ATMS map.

Evaluation – Display of raw collected data allows for evaluation of individual data points (e.g., counts, splits, etc.) for analysis and export to a spreadsheet program.

System Detection – The type of data/information collected to help an ATMS make timing plan selections based on measured, on-street traffic characteristics. Said data can also help the Operator to better view/manage traffic flow patterns on a corridor and/or section basis.

- *Volume* counts are collected locally in an intersection controller, and aggregated into bins for a User-selected time duration (usually 5 or 15 minutes). The control system gathers these "system" volume counts from the controller for bins that are completed.
- *Occupancy* is the percentage of time that a presence detector has a call; this also is aggregated and averaged for the User-selected time duration and stored in historical bins.
- *Density* and *Speed* data are useful additional Measures-of-Effectiveness (MOEs) that are generally used for off-line evaluation and decision-making.

Video Detection – The ability for an ATMS to utilize video detection technology to detect vehicles.

ATMS/ATIS – ATMS (Advanced Transportation Management System) and ATIS (Advanced Traveler Information System) are enhanced features that provide the system user with additional tools and capabilities. The capability of a system to have these features integrated directly into the ATMS user interface (as opposed to being a separate, standalone application that could be running in the background concurrently) is indicated.

Advanced Functions – The type of features/capabilities that an ATMS provides that goes beyond just basic day-to-day traffic control operations.

- *Transit Priority* is generally used with light rail or bus rapid transit. Support for transit priority may involve interfacing with logic implemented locally at the signal controller, at the central system level, or a combination of both.
- *Incident Management* refers to the ability of the system to ease Operator workload and/or support decision-making in the event of a traffic incident or special event.
- *Multi-Jurisdictional Access* reflects the capability to segment and limit access to different groups of signals by security passwords, for different entities. A common system could control coordination in two (2) or more adjacent entities to provide cross-jurisdiction seamless coordination patterns.

- *Off-Line Preparation of Timing Plans* allows for the system Vendor's own proprietary (or, alternately, a customized/integrated 3rd-Party software) computation tool to directly extract stored data in the ATMS database for the purpose of preparing updated coordination timing plans. (Some systems supply a separate utility, not integrated with the primary user interface, to provide this function. The tool's results may or may not be able to be directly inserted into the signal system's timing plan database.) Commonly used programs supported by each platform for data exchange are listed below this item.
- *Real-Time Space/Time Diagrams* are dynamically prepared diagrams, using actual controller splits, which the console Operator can use to evaluate the effectiveness of a currently-running coordination pattern in terms of platoon width and progression speed. Real-time split monitors gather dynamic phase timings at an intersection, and time-stamp each cycle's results in a tabular format. Split monitors are useful for microscopic evaluation of an intersection's operation, as well as providing raw data for identifying both average and abnormal split values.
- *Data Exchange* refers to the ability of the ATMS to transmit/receive data to/from an external 3rd -Party system.
- *External Control* refers to the system having a Command/Data Interface (CDI). The CDI allows 3rd-Party systems to monitor and/or control the devices connected to the ATMS.

The results of the analysis are summarized in Exhibit 3.1.

Exhibit 3.1 - ATMS General and System Features Comparison

Vendor System	BI Tran QuicNet IV	Econolite icons	 PYRAMIDS	KHA KITS	LADOT ATSAC	PB Farradyne MIST	Siemens i2TMS	TransCore *TransSuite*
Control Strategy Capability								
Sync Pulse	No	No	No	No	No	Yes	No	Yes
Closed-Loop with On-Street Masters	Yes	No	Yes	No	No	Partial	In Development	No
Time-Based Coordination with Centralized Management	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Centralized	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Server Hardware	Pentium	Pentium III or higher	Pentium III or higher	Pentium II - IV, Intel Xeon	IBM Compatible Server & Workstations	Yes	Pentium III or higher	Intel Xeon
Operating System	Win 98, NT, or 2000	Win 2000, XP, or Server 2003	Win 2000, XP, or Server 2003	Win NT, 2000, XP, or Server 2003	Win 2000 or XP	Workstation: Win 2000 or XP Server: Server 2003	Win 2000	Win NT, 2000, XP, or Server 2003
LAN Capabilities	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WAN Capabilities								
Fire/Police Remote Workstation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
VPN Access	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Computer Requirements	N/A	Same as workstation	Same as workstation	Same as workstation	Same as workstation	Same as workstation	Same as workstation	Same as workstation
Bandwidth Required	N/A	56k	56k	9,600 bps	56k	56k	26k min 384k recommended	T1 recommended
Center-to-Center Communications	N/A	No	No	Yes	Yes	Yes	Yes	Yes
Capacity								
Local Traffic Signals	4,000	9,999	Unlimited	Unlimited	512 per Server	10,000	9,999	9,600+
On-Street Masters	2,000	N/A	Yes	N/A	N/A	N/A	N/A	N/A

Vendor System	BI Tran	Econolite		KHA	LADOT	PB Farradyne	Siemens	TransCore
	QuicNet IV	icons	PYRAMIDS	KITS	ATSAC	MIST	i2TMS	*TransSuite*
Control Areas (Sections or Groups)	2,000	Yes	Yes	Unlimited	256	Unlimited	9,999 each	300+
System Detectors	4,000	9,999	Yes	Unlimited	8,192	15,000	9,999	9,600+
Coordination Timing Plans	32	Function of controller firmware	Function of controller firmware	Unlimited	100	Function of controller firmware	Function of controller firmware	Function of controller firmware
Local Controller Compatibility (Communications)								
NEMA (Hardware/Software)								
Eagle	No	Yes	No	No	No	No	Yes	Yes
Econolite	No	Yes	No	Yes	No	Yes	Yes	Yes
IDC-Multisonics	No	AB3418	No	Yes	No	No	Partial	Yes
CSC	No	AB3418	No	No	No	No	No	No
Peek-Transyt, TCT	No	AB3418	No	No	No	Yes	Yes	Yes
IDC-Traconex	No	Partial	No	No	No	No	Partial	Yes
Other (Identify)	McCain TS1 Vector TS1 Vector TS2	McCain Vector	Any NEMA controller with an Interface unit (ICM)	Yes (with modification)	No	No	McCain Vector Naztec 900 (NTCIP)	All NEMA with RCU (Remote Control Unit)
Type 170/Type 170E (Firmware)								
Type 170/Type 170E	Yes	AB3418	Yes	Yes	Yes	Yes	In Development	Yes
Preferred Firmware	BI Tran 200 BI Tran 233	No	W4IKS v55a+	BI Tran 233	BI Tran 172.3	BI Tran Wapiti	BI Tran 233/2033	BI Tran 222C Wapiti W4IKS
Other Compatible Firmware	No	No	OASIS	BI Tran Wapiti	No	No	Caltrans C8 (AB3418) - Partial	BI Tran Wapiti
Plan to support LACO IV				Yes				Yes
ATC (2070/2070N) (Software)								
Type 2070/Type 2070N	Yes	Type 2070 Type 2070 N Type 170 ATC	All 1999 Caltrans approved 2070s	Yes	Yes	Yes	Type 2070 Type 2070 N Type 170 ATC	Yes

Vendor System	BI Tran QuicNet IV	Econolite icons	Econolite PYRAMIDS	KHA KITS	LADOT ATSAC	PB Farradyne MIST	Siemens i2TMS	TransCore *TransSuite*
Preferred/Compatible Software	BI Tran 233 BI Tran 2070	NextPhase SEPAC ASC 2070 (AB3418/NTCIP supported)	OASIS-2070 Software	BI Tran LADOT 2070 (with transit priority)	LADOT TSCP	VS-Plus Econolite D4 BI Tran	NextPhase SEPAC ASC 2070	Econolite (Level 1B) Eagle (SEPAC) Siemens (NextPhase)
Protocol Support								
NTCIP Communication Protocol Support	No	Yes	No	Yes	No	Yes	Yes	Yes
AB3418 (or AB3418E)	Yes	Yes	No	Yes	No	Yes	Yes	Yes
Multiple Protocols	N/A	Yes	No	Yes	No	Yes	Yes	Yes
Communications Media/Technology								
Fiber Optics Cable	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Twisted Pair	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Radio	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Phone Dial Up	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Microwave	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CDPD	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Ethernet	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Coax Cable	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Multiple Media Support	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Communication Requirement (Half Duplex/Full Duplex)	Full	Half/Full	Half/Full	Half/Full	Full	Full	Half/Full	Half/Full
Communication Baud Range								
Master Controller (bps)	19,200	N/A	1,200 to 38,400	N/A	N/A	N/A	N/A	N/A
Local Controller (bps)	1,200 to 9,600	1,200 to 57,600	1,200 to 38,400	1,200 to 19,200	1,200	1,200 up to 1 GB	1,200 to 57,600	1,200 to 19,200
# of Signals on one (1) 1,200 Baud Line	32	8	8	8	4	30	3	7 (based on protocol)
Local Communications Interface	RS-232	All common communication interfaces	RS-232	RS-232 or Ethernet	RS-232	Serial	All common communication interfaces	All common communication interfaces

Vendor System	BI Tran QuicNet IV	Econolite icons	Econolite PYRAMIDS	KHA KITS	LADOT ATSAC	PB Farradyne MIST	Siemens i2TMS	TransCore *TransSuite*
Controller Polling Rate								
Typical/Recommended	Once per second	Once per second	Once per second	Once per second	Once per second	Once per second	Once per second	Once per second
Maximum	Once per second	Continuous (at least once per second)	Once per second	Once per second	Once per second	Once per second	Continuous (at least once per second)	Once per second
Controller Upload/Download								
Communication Upload/Download Duration (per controller)	Based on size of up/download (Typical 1 min)	Based on size of up/download (Typical 13.7 sec for upload & 26.6 sec for download)	Based on size of up/download (Typical 20 sec to 2 min)	Based on size of up/download (Typical 20 to 30 sec)	Based on size of up/download & comm. rate	Based on size of up/download & comm. rate	Based on size of up/download (Typical 13.7 sec for upload & 26.6 sec for download)	Based on size of up/download & comm. rate
Auto-Upload, Auto-Download, and Auto-Compare	N/A	Auto-Compare for ASC2/2S & ASC2070	Auto-Compare for 170E-Wapati & 2070 OASIS	Auto-Compare	No	Auto-Upload Auto-Download	Auto-Upload & Auto-Compare (for ASC2)	Auto-Compare Auto-Upload Auto-Download
Field Initiated Downloads	N/A	Yes	No	Yes	Yes	No	Yes	Yes
Multiple Databases	N/A	No	Yes	Yes	Yes	Yes	NextPhase Naztec	Yes
Traffic Control Features								
Unattended System Operation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Backup Operation	Local controller time-based coordination	Local controller time-based coordination	Local controller time-based coordination or On-street Master control	Local controller time-based coordination	Local controller time-based coordination	Local controller time-based coordination	Local controller time-based coordination	Local controller time-based coordination
Coordination Plan Selection Methods								
Time of Day	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Day of Week	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Vendor System	BI Tran QuicNet IV	Econolite icons	Econolite PYRAMIDS	KHA KITS	LADOT ATSAC	PB Farradyne MIST	Siemens i2TMS	TransCore *TransSuite*
Traffic Responsive Plan Selection	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Manual	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Critical Intersection Control	Yes	No	Yes	Yes	Yes	Yes	No	Yes
Dynamic change of subgroups to allow different cycle lengths for different subareas	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Allow Multiple Remote Users	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Override Capability	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Data Logging Features	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Error/Failure Logging and Diagnostics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Alarms								
Prioritize	Yes	No	Yes	Yes	Yes	Yes	In Development	No
Pager	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Offline Capability During Communication Failure (ability to operate when there is no communication between the central system and the field element)	Controller reverts to Local Time Base Control	Controller reverts to Local Time Base Control	Controller reverts to Local Time Base Control	Controller reverts to Local Time Base Control	Controller reverts to Local Time Base Control	Controller reverts to Local Time Base Control	Controller reverts to Local Time Base Control	Controller reverts to Local Time Base Control
Graphical User Interface (GUI)								
Signalized Network	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Real-Time Display of Intersection Operation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Display Other ITS Elements (CCTV, DMS)	Yes	In Development	Yes	Yes	Yes	Yes	Yes	Yes
Display Priority/Pre-emption Data	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Vendor System	BI Tran QuicNet IV	Econolite icons	Econolite PYRAMIDS	KHA KITS	LADOT ATSAC	PB Farradyne MIST	Siemens i2TMS	TransCore *TransSuite*
Display Police/Fire AVL/AVI Data	Yes	No	No	Yes	Yes	No	Yes for AVI	No
Ability to Display a GIS-Based Map	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Graphics Format	CAD BMP ESRI file format	Win 2000 & XP based graphics format	CAD BMP ESRI file format	All industry standard graphical formats	TransCore Softgraph	Win 2000 & XP based graphics format	Win 2000 based graphics format	TIFF JPEG DXF etc.
GIS-Based Map Format	CAD BMP ESRI file format	Multiple shape file types supported	CAD BMP ESRI file format	ESRI	ETAK	DXF	ESRI	ESRI
Object Configuration	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Event Layers	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Evaluation								
Off-Line Calculation of MOEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
On-Line Calculation of MOEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Display Raw Collected Data	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Plan Storage Duration	Indefinite	Indefinite	Indefinite	Indefinite	Indefinite	Indefinite	Indefinite	Indefinite
Easy Copy Features	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Reports	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Relational Database	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Database Options								
SQL	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Microsoft Access	Yes	Partial	Yes	Yes	No	Yes	Partial	Yes
Oracle	Yes	No	No	Yes	No	Yes	Yes	Yes
Other	Paradox Sybase	No	No	Interbase	Flat file MySql	Fully ODBC compliant	No	Crystal Reports & other 3rd-Party SQL tools
Detection								
Stop-Line Detectors	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Advance Detectors	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Vendor System	BI Tran QuicNet IV	Econolite icons	Econolite PYRAMIDS	KHA KITS	LADOT ATSAC	PB Farradyne MIST	Siemens i2TMS	TransCore *TransSuite*
Detector Faults	N/A	Yes ASC/2 No Activity Max Presence Erratic Counts	Yes No Calls Constant Call Detector Failure	Yes No Activity Stuck on/off Chatter	Yes Min Pulse & Max Pulse errors	Yes Controller Specific	Yes AB3418/NTCIP short alarm status supported	Yes High/low volume Occupancy Stuck on/off High speed etc.
Volume	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Occupancy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Density	Yes	Derived	Derived	Yes	No	Yes	Derived	Derived
Speed	Yes	Yes	Derived	Yes	Yes	Yes	Yes	Derived
Video Detection	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ATMS/ATIS								
Closed Circuit Television (CCTV)	Yes	In Development	Yes	Yes	Yes	Yes	Yes	Yes
Dynamic Message Signs (DMS)	Yes	In Development	No	Yes	No	Yes	Yes	Yes
Traveler Information	No	No	No	Yes	No	Yes	Export from real-time data	Yes
Video Display Wall	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Advanced Functions								
Transit Priority Interface	Yes	Yes (ASC/2 Controllers)	No	Yes	Yes	Yes	Yes	Yes
Emergency/Rail Pre-emption	Yes	Yes	Yes (Local Control)	Yes	Yes	Yes	Yes	Yes
Incident Management	Yes	No	Yes	Yes	No	Yes	Yes	Yes
Multi-Jurisdictional Access	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Off-Line Preparation of Timing Plans	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Transyt 7F Upload/ Download	Yes	Not directly (possible via Synchro)	Not directly (possible via Synchro)	Not directly (possible via Synchro)	No	Yes	Not directly (possible via Synchro)	Yes
Synchro Upload/Download	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes

Vendor System	BI Tran QuicNet IV	Econolite icons	Econolite PYRAMIDS	KHA KITS	LADOT ATSAC	PB Farradyne MIST	Siemens i2TMS	TransCore *TransSuite*
PASSER	No	No	No	No	No	Yes	No	No
Other Upload/Download (Identify)	NETSIM	No	CORSIM (via Synchro)	CORSIM (via Synchro)	No	No	NextWeb (with NextPhase) NextEdit (with laptop & PDA support)	No
Real-Time Time-Space Diagrams	No	Yes	Yes	Yes	In Development	Yes	Yes	Yes
Data Exchange	In Development	Yes	Yes	Yes	Yes	Yes	Yes	Yes
External Control	In Development	In Development	No	Yes	No	No	Yes	Yes
Other (Identify)	No	Split Monitor Color Coded Links	CCTV snap shot video of wall data to any workstation Split Monitor Generation of customized reports	CCTV scheduling Web Interface Intelligent user-interface Split Monitor Real-time input/output pin display Turning movement count entry & analysis	Adaptive Control	No	Split Monitor Color Coded Links	Traffic optimization via Synchro
Security								
User Name/Password	N/A	Yes	Yes	Yes	Yes	Yes	Yes Proper security relies on a combination of Windows & i2TMS access control	Yes User Authenticated by host operating system & privileges are assigned based on authentication used

Note: N/A means that there is not sufficient data to support a response.

3.3 ATMS COST

In addition to detailing the functionality of their systems, the Vendors were asked to provide general information for the cost of their system. As every installation is different, these costs should only be used to estimate the order of magnitude for the different costs associated with installing a TCS.

Exhibit 3.2 - ATMS Cost Information as Provided by Vendor

Vendor/ System	License Fee		Computer Hardware	Third Party COTS	Subtotal (Hardware & 3rd-Party COTS)	System Integration	Total System Cost	Annual Maintenance
	TCS	CCTV						
BI Tran QuicNet IV								
Econolite icons								
Econolite PYRAMIDS[1]	$185,000	Included with TCS	$30,525	$5,279	$35,804	$67,000	$287,804	$25,000
KHA KITS	$75,000 (No Fee for Agencies in LA County)	$15,000	$15,000 – $25,000	$5,000 – $12,000	$20,000 – $37,000	$45,000 – $90,000	$80,000 – $142,000	$15,000
LADOT ATSAC	$30,000 (No Fee for Agencies in LA County)							
PB Farradyne MIST	$65,000	Included with TCS	$25,000	$5,000 – $10,000	$30,000 – $35,000	$75,000	$170,000 – $175,000	
Siemens i2TMS	$45,000	$15,000	$15,000	$5,000	$20,000	$85,000	$165,000	$5,000 – $12,000
TransCore *TransSuite*	$65,000	$25,000	$43,360	Included in Hardware Costs	$43,360	$100,750	$234,110	$21,390

Note: System cost information for Econolite PYRAMIDS was previously provided for the I-5/Telegraph Road Corridor Project System Alternatives Analysis and Recommendations.

4 AGENCY ATMS RECOMMENDATIONS

ATMS alternatives analyses were performed for each Agency in Level 2B or 3, except for those Agencies that have already made such an ATMS selection – LA County, Pasadena, and San Dimas. The alternatives analyses are based on specific features that are applicable to that Agency, where these features were taken from the Operational Objectives and System Needs report (Deliverables 2.1.2 and 2.2.2) for the SGVTF Project. The systems were screened by whether or not they support the controller types used by the Agency (systems that are developing support for the controller type were also included in the analysis for the Agencies). A comparison matrix was prepared showing the specific needs of that Agency to the features supported by the ATMS, which passed the initial screening. For brevity, the following features are not shown in each Agency analysis because they are supported by most or all the systems evaluated:

- Signal Monitoring/Control – All systems support this feature if they support the specific controller types.
- CCTV – All systems support this feature.
- Communications Media/Technology - ATSAC does not support all the Communications Media/Technology listed in the Vendor Survey.
- NTCIP and AB3418 Protocols – QuicNet IV, PYRAMIDS, and ATSAC do not support these protocols.
- Coordination Strategy Capability – All systems support these features.
- System Detection – All systems support these features.
- Transit Priority Interface – PYRAMIDS does not support this feature.
- LRT Priority - All systems support this feature.
- Incident Management – icons and ATSAC do not support this feature.

In addition to the features desired by the individual Agency, the comparison matrices include support of features that are applicable to the system's ability to interface with the Countywide IEN. These features include:

- *Interface to IEN* – A CDI has either been developed or is under development for use in the Los Angeles Countywide IEN.
- *External Control* – A CDI has been developed for a different Agency. A Vendor having developed a CDI for their system can reduce the risk and possibly the cost of developing a CDI to the Los Angeles Countywide IEN.

4.1 ALHAMBRA - LEVEL 2B

The City of Alhambra is currently using both Econolite controllers and type 170 controllers with LACO firmware. Since the LACO firmware does not currently support communications with a central TCS Server, support of 170 controllers is used for the initial screening. Four (4) of the systems evaluated support both Econolite and type 170 controllers; KITS, MIST, i2TMS, and *TransSuite*.

The City of Alhambra currently has two (2) on-street masters in use, which none of these systems fully support. MIST partially supports this feature and this feature is under development for i2TMS.

Exhibit 4.1 - ATMS Feature Comparison for the City of Alhambra

Feature	KHA KITS	PB Farradyne MIST	Siemens i2TMS	TransCore *TranSuite*
Econolite	Yes	Yes	Yes	Yes
Type 170	Yes	Yes	In Development	Yes
Plan to Support LACO IV Firmware	Yes			Yes
On-Street Masters	No	Partial	In Development	No
External Control	Yes	No	Yes	Yes
Interface to IEN	In Development	No	No	Yes

All of these systems would be excellent choices for use by the City of Alhambra. All of them have similar support of the features identified as being important by the City of Alhambra as well as most of the other features identified in the Vendor survey. All of these systems would require some development work to be done to either support On-Street Masters or interface with the Countywide IEN.

4.2 ARCADIA - LEVEL 2B

The City of Arcadia is currently using both Multisonics and type 170 controllers with LACO firmware, however Multisonics controllers were not used in the initial screening since the City of Arcadia plans to upgrade these controllers. Since the LACO firmware does not support communications with a central TCS Server, support of 170 controllers is used for the initial screening. Three (3) of the systems evaluated support both Multisonics and type 170 controllers; KITS, i2TMS, and *TransSuite.*

Exhibit 4.2 - ATMS Feature Comparison for the City of Arcadia

Feature	BI Tran QuicNet IV	Econolite PYRAMIDS	KHA KITS	LADOT ATSAC	PB Farradyne MIST	Siemens i2TMS	TransCore *TransSuite*
Multisonics	No	No	Yes	No	No	Partial	No
Type 170	Yes	Yes	Yes	Yes	Yes	In Develop-ment	Yes
Plan to Support LACO IV Firmware			Yes				Yes
Incident Management	Yes	Yes	Yes	No	Yes	Yes	Yes
NTCIP	No	No	Yes	No	Yes	Yes	Yes
AB3418	Yes	No	Yes	No	Yes	Yes	Yes
External Control	In Develop-ment	No	Yes	No	Yes	Yes	Yes
Interface to IEN	In Develop-ment	No	In Develop ment	No	No	No	Yes

Five (5) of the systems evaluated meet the needs for the City of Arcadia; QuicNet IV, PYRAMIDS, KITS, MIST, and *TransSuite*. Additionally, i2TMS will meet the specific needs for the City of Arcadia once the development of an interface to the type 170 controllers is completed. KITS, MIST, i2TMS, and *TransSuite* have similar support of the features identified as being important by the City of Arcadia as well as most of the other features identified in the Vendor survey.

4.3 CALTRANS – LEVEL 3

Caltrans is currently using their own system (CT-NET) and is not planning to develop a new system. An alternatives analysis is not required.

4.4 COVINA – LEVEL 2B

The City of Covina is currently using type 90 controllers and type 170 controllers with LACO firmware. Since the LACO firmware does not currently support communications with a central TCS Server, support of 170 controllers is used for the initial screening. None of the systems support type 90 controllers and every system except icons supports the type 170 controller.

Exhibit 4.3 - System Feature Comparison for the City of Covina

Feature	BI Tran QuicNet IV	Econolite PYRAMIDS	KHA KITS	LADOT ATSAC	PB Farradyne MIST	Siemens I2TMS	TransCore *TransSuite*
Type 170	Yes	Yes	Yes	Yes	Yes	In Develop-ment	Yes
Plan to Support LACO IV Firmware			Yes				Yes
Incident Management	Yes	Yes	Yes	No	Yes	Yes	Yes
NTCIP	No	No	Yes	No	Yes	Yes	Yes
AB3418	Yes	No	Yes	No	Yes	Yes	Yes
External Control	In Develop-ment	No	Yes	No	Yes	Yes	Yes
Interface to IEN	In Develop-ment	No	In Develop-ment	No	No	No	Yes

Five (5) of the systems evaluated currently meet the specific needs for the City of Covina; QuicNet IV, PYRAMIDS, KITS, MIST, and *TransSuite*. Additionally, i2TMS will meet the specific needs for the City of Covina once the development of an interface to the type 170 controllers is completed. KITS, MIST, i2TMS, and *TransSuite* have similar support of the features identified as being important by the City of Covina as well as most of the other features identified in the Vendor survey.

4.5 IRWINDALE – LEVEL 2B

The City of Irwindale is currently using type 170 controllers with the LACO firmware. Since the LACO firmware does not currently support communications with a central TCS Server, support of 170 controllers is used for the initial screening. Every system except icons supports the type 170 controller.

Exhibit 4.4 - System Feature Comparison for the City of Irwindale

Feature	BI Tran QuicNet IV	Econolite PYRAMIDS	KHA KITS	LADOT ATSAC	PB Farradyne MIST	Sieme ns i2TMS	TransCore *TransSuite*
Type 170	Yes	Yes	Yes	Yes	Yes	In Develop-ment	Yes
Plan to Support LACO IV Firmware			Yes				Yes
Incident Management	Yes	Yes	Yes	No	Yes	Yes	Yes
NTCIP	No	No	Yes	No	Yes	Yes	Yes
AB3418	Yes	No	Yes	No	Yes	Yes	Yes
External Control	In Develop-ment	No	Yes	No	Yes	Yes	Yes
Interface to IEN	In Develop-ment	No	In Develop-ment	No	No	No	Yes

Five (5) of the systems evaluated currently meet the specific needs for the City of Irwindale; QuicNet IV, PYRAMIDS, KITS, MIST, and *TransSuite*. Additionally, i2TMS will meet the specific needs for the City of Irwindale once the development of an interface to the type 170 controllers is completed. KITS, MIST, i2TMS, and *TransSuite* have similar support of the features identified as being important by the City of Irwindale as well as most of the other features identified in the Vendor survey.

4.6 LACODPW – LEVEL 3 & RC

The County selected an ATMS in October of 2004. An alternatives analysis is not required.

4.7 PASADENA – LEVEL 3

The City of Pasadena selected an ATMS in October of 2004. An alternatives analysis is not required.

4.8 ROSEMEAD – LEVEL 2B

The City of Rosemead is currently using type 170 controllers with BI Tran and LACO firmware. Since the LACO firmware does not currently support communications with a central TCS Server, support of BI Tran firmware for type 170 controller is used for the initial screening. Every system except icons and PYRAMIDS supports type 170 controller with BI Tran firmware.

Exhibit 4.5 - System Feature Comparison for the City of Rosemead

Feature	BI Tran QuicNet IV	KHA KITS	LADOT ATSAC	PB Farradyne MIST	Siemens i2TMS	TransCore *TransSuite*
Type 170	Yes	Yes	Yes	Yes	In Develop-ment	Yes
BI Tran Firmware	200 233	233	172.3	Yes	233 2033	222C

Feature	BI Tran QuicNet IV	KHA KITS	LADOT ATSAC	PB Farradyne MIST	Siemens i2TMS	TransCore *TransSuite*
Plan to Support LACO IV Firmware		Yes				Yes
Incident Management	Yes	Yes	No	Yes	Yes	Yes
NTCIP	No	Yes	No	Yes	Yes	Yes
AB3418	Yes	Yes	No	Yes	Yes	Yes
External Control	In Develop-ment	Yes	No	Yes	Yes	Yes
Interface to IEN	In Develop-ment	In Develop-ment	No	No	No	Yes

Four (4) of the systems evaluated currently meet the specific needs for the City of Rosemead; QuicNet IV, KITS, MIST, and *TransSuite*. Additionally, i2TMS will meet the specific needs for the City of Rosemead once the development of an interface to the type 170 controllers is completed. KITS, MIST, i2TMS, and *TransSuite* have similar support of the features identified as being important by the City of Rosemead as well as most of the other features identified in the Vendor survey.

4.9 SAN DIMAS – LEVEL 2B

The City of San Dimas is also a participant within the Pomona Valley ITS Traffic Forum. Within this Forum, an ATMS has already been selected for them. An alternatives analysis is not required.

4.10 WEST COVINA – LEVEL 2B

The City of West Covina is currently using Multisonics, Econolite, and type 170 controllers. KITS is the only system that supports these three (3) controller types. i2TMS and *TransSuite* support Econolite and type 170 controllers, but only partially support Multisonics.

Exhibit 4.6 - System Feature Comparison for the City of West Covina

Feature	KHA KITS	Siemens i2TMS	TransCore *TranSuite*
Multisonics	Yes	Partial	Partial
Econolite	Yes	Yes	Yes
Type 170	Yes	In Development	Yes
External Control	Yes	Yes	Yes
Interface to IEN	In Development	No	Yes

Any of these three (3) systems would be excellent choices for use by the City of West Covina. All of them have similar support of the features identified as being important by the City of West Covina as well as most of the other features identified in the Vendor survey.

5 VEHICLE DETECTION SYSTEMS

Vehicle detection systems are an important tool for traffic management. The vehicle detection system provides real-time data about vehicle presence and vehicular traffic characteristics such as volume, occupancy, and speed. Typically, stop bar and advanced detection are used to provide a controller with the presence information and system detection is used to provide vehicular traffic characteristics. Ideally, system detectors are located such that the data they are collecting is unaffected by queues from the traffic signal. This means that their placement is further upstream than the advanced detection.

The vehicle presence information is used by the local controller for signal actuation. The vehicular traffic characteristics can be used by a local controller, master controller, or traffic control system for traffic responsive or adaptive signal control. The vehicular traffic characteristics can also be used to provide traveler information, to evaluate system performance, or as an input for developing new signal timing plans.

This section of the report will identify, evaluate, and compare candidate vehicle detection technologies.

5.1 TECHNOLOGY OVERVIEW

Various detection technologies are available for use as detection systems. The most common types of detection technologies used are:

- Inductive Loops – Inductive loop detectors have traditionally been the primary means of vehicle detection used nationally. Loop detectors are wire loops imbedded in the roadway surface. The wire loop is excited with a signal. When a vehicle stops on or passes over the loop, the inductance of the loop is decreased, which increases the frequency of the signal and causes the electronics unit to send a pulse to the controller, indicating the presence or passage of a vehicle.
- Magnetic Sensors – Magnetic sensors are passive devices that indicate the presence of a metallic object by detecting perturbations in the Earth’s magnetic field the object creates.
- Infrared Detectors – Infrared detectors consist of both active and passive models. An active infrared detector illuminates a detection zone with low power infrared energy. The infrared energy reflected from vehicles traveling through a detection zone is focused by an optical system onto a sensor matrix. A real-time signal processing technique analyzes the received signal and determines the presence of a vehicle. A passive infrared sensor detects the energy emitted from objects in the detector’s field of view. When a vehicle enters the detector’s field of view, it causes a change in emitted energy. The change in emitted energy is used to detect the vehicle.
- Microwave Radar – A microwave radar detector transmits energy toward the roadway from the detector's antenna. When a vehicle passes through the antenna’s beam of energy, a portion of the transmitted energy is reflected back to the antenna causing a detection to be made.
- Acoustic Detectors – Acoustic Detectors consist of both active and passive models. The active acoustic detectors (a.k.a. ultrasonic detectors) transmit pulses of sound energy toward the roadway. A portion of the transmitted energy is reflected back

toward the sensor and used to measure a distance. A vehicle is detected when distance other than that to the background road surface is measured. Passive acoustic detectors sense energy or signals emitted by the vehicles and roadway. When a vehicle passes through the detection zone, an increase in sound energy occurs which triggers a vehicle presence signal. When the vehicle leaves the detection zone, the sound energy drops and the vehicle presence signal is terminated.

- Video Image Processor – Video image processor detectors analyze the imagery from detection zones to determine changes between successive frames. Changes between successive frames cause a vehicle to be detected. The image processing algorithms are designed to remove variations in the image background caused by weather conditions, shadows, and position of the sun and retain objects identified as vehicles.

The evaluation of each detector technology is provided in tabular format. Exhibit 5.1 lists the advantages and disadvantages of each detector technology. Exhibit 5.2 shows the data supported, and qualitative measure of costs for each vehicle detector technologies. Exhibit 5.3 is a qualitative evaluation of the ease of installation, ease of calibration, and maintenance requirement for each detector technology.

Exhibit 5.1 - Advantages and Disadvantages of Detector Technologies (Martin, 2003)

Technology	Advantage	Disadvantages
Inductive Loop	• Flexible design to satisfy large variety of applications • Mature, well-understood technology • The equipment cost is lower when compared to non-intrusive detector technologies • Provides basic traffic parameters (e.g., volume, presence, occupancy, speed, headway, and gap) • High frequency excitation models provide classification data • Operability in harsh environment	• Installation and maintenance require lane closure • Installation requires pavement cut • Decreases pavement life • Failure associated with poor installation in road surfaces • Subject to stresses of traffic and temperature • Resurfacing of roadways and utility repair can create the need to reinstall • Multiple detectors usually required to instrument a location • Routine maintenance requirement
Magnetic	• Can be used where loops are not feasible (e.g., bridge decks) • Less susceptible than loops to stresses of traffic • Some models transmit data over wireless RF link • Some models installed under roadway without need for pavement cuts	• Installation requires pavement cut or tunneling under roadway • Installation and maintenance require lane closure • Decrease pavement life • Some models have small detection zones • Induction magnetic detectors cannot detect stopped vehicles

Technology	Advantage	Disadvantages
Infrared	• Active sensor transmits multiple beams for accurate measurement of vehicle position, speed, and class • Multizone passive sensors measure speed • Multiple lane operation available	• Operation of active sensor may be affected by fog when visibility is less than 20 ft or blowing snow is present • Passive sensor may have reduced sensitivity to vehicles in its field of view in rain and fog
Microwave Radar	• Generally insensitive to inclement weather • Direct measurement of speed • Multiple lane operation available	• Antenna beam width and transmitted waveform must be suitable for the application • Doppler sensors cannot detect stopped vehicles • Doppler microwave sensors have been found to perform poorly at intersection locations as volume counters
Ultrasonic	• Easy installation	• Some environmental conditions such as temperature change and extreme air turbulence can affect performance • Temperature compensation is built into some models • Large pulse repetition periods may degrade occupancy measurement on freeways with vehicles traveling at moderate to high speeds
Passive Acoustic	• Passive detection • Insensitive to precipitation • Multiple lane operation available	• Cold temperatures have been reported to affect data accuracy • Specific models are not recommended with slow moving vehicles in stop and go traffic
Video Image Processor	• Monitors multiple lanes and multiple zones/lane • Easy to add and modify detection zones • Rich array of data available • Provides wide-area detection when information gathered at one camera • Locations can be linked to one another	• Inclement weather, shadows, vehicle projection into adjacent lanes, occlusion, day-to-night transition, and vehicle/road contrast can affect performance • Water, salt grime, icicles, and cobwebs on the camera lens can affect performance • Requires 50- to 60-ft camera mounting height (in a side-mounting configuration) for optimum presence detection and speed measurement • Some models susceptible to camera motion caused by strong winds • Generally cost-effective only if many detection zones are required in the field of view of the camera

Exhibit 5.2 - Traffic Sensor Output Data and Cost (Elena, et al, 2000)

Technology	Output Data					Multiple Lane Detection Zone Data	Sensor Purchase Cost1
	Count (Accuracy)[10]	Presence	Speed	Occupancy	Classification		
Inductive Loop	X (Excellent)	X	X	X[2]	X[3]		Low[9] ($500 to $800)
Magnetic	X (Excellent)	X	X	X[2]			Low to Moderate[9] ($385 to $6,300)
Microwave Radar	X (Excellent/ Fair)	X[4]	X	X[4]	X[4]	X[4]	Low to Moderate ($700 to $3,300)
Infrared	X (Passive: Fair Active: Excellent)	X	X	X[5]	X[6]	X[6]	Passive: Low to Moderate ($700 to $1,200) Active: Moderate to High ($6,500 to $14,000)
Ultrasonic	X (Excellent)	X		X			Low to Moderate (Pulse Model: $600 to $1,900)
Acoustic Array	X (Fair)	X	X	X		X[7]	Moderate ($3,100 to $8,100)
Video Image Processor	X (Excellent)	X	X	X	X	X	Moderate to High ($5,000 to $26,000)

Notes:

1. Installation, maintenance, and repair costs must also be included to arrive at the true cost of a sensor solution as discussed in the text.
2. Speed can be measured by using two (2) sensors a known distance apart.
3. With specialized electronics unit containing embedded firmware that classifies vehicles.
4. From microwave radar sensors that transmit the proper waveform and have appropriate signal processing.
5. With multi-detection zone passive or active mode infrared sensors.
6. With active mode infrared sensor.
7. Models with appropriate beam forming and signal processing.
8. Depends on whether higher-bandwidth raw data, lower-bandwidth processed data, or video imagery is transmitted to the Transportation Management Center (TMC).
9. Includes underground sensor and local receiver electronics. Receiver options are available for multiple sensor, multiple lane coverage.
10. From Martin 2003.

Exhibit 5.3 - Ease of Installation and Maintenance of Detector Technologies (Martin, 2003)

Detector Technology		Ease of Installation	Ease of Calibration	Maintenance Requirement[1]
Inductive Loop		Difficult	Easy	High
Magnetic		Moderate	Moderate	Unknown
Active Infrared		Easy	Easy	Low
Passive Infrared		Easy	Easy/Difficult 2	Low
Microwave Radar	Doppler	Easy	Easy	Medium
	True Presence	Easy	Easy	Low
Passive Acoustic		Easy	Easy	Low to Medium
Ultrasonic		Easy	Easy	Low
Video Image Processor		Easy	Difficult	Medium

Notes:

1. From Middleton, 1999.
2. Sidefire installation is difficult because of alignment complications.

The selection of a detection system should be based upon the requirements of the component for which the detection is required or desired.

The following vehicle detector technologies are not recommended for use as a detection system:

- Passive Infrared - Does not provide sufficient count accuracy.
- Passive Acoustic - Does not provide sufficient count accuracy.

The following vehicle detector technologies are recommended for use as a detection system:

- Inductive Loop – Proven technology, good performance, reasonable cost.
- Microwave Radar – Good performance, multiple lane operation, reasonable cost.
- Ultrasonic - Good performance, reasonable cost.
- Video Image Processor – Capable of providing live video from the field, multiple lane operation, rich array of data available.

6 CCTV SYSTEMS

6.1 POTENTIAL LOCATIONS

Potential locations for CCTV in the San Gabriel Valley region include all the main arterials and intersection as well as corridors surrounding the traffic generators listed for each Agency in the Operational Objectives and System Needs Report for the SGVTF Project (Deliverables 2.1.2 and 2.2.2). To help prioritize potential CCTV locations, TransCore recommends developing a mathematical ranking system.

The ranking system would use a set of weighted criteria to determine an overall mathematical prioritization of the potential CCTV locations. Each criterion is assigned a weight to signify its importance in determining the CCTV priorities. Each potential location would receive a mathematical ranking for each criterion used; for example a value between 1 and 4 with 4 being a high priority and 1 being a low priority. The overall mathematical ranking for each location would then be equal to the sum product of the criterion weight and the mathematical ranking for the criterion.

Possible criterion, weights, and mathematical ranking for the system include:

- *Intersection LOS* – Weight = 8, Ranking = (4) if LOS E or F; (3) if LOS D; (2) if LOS C; (1) if LOS B or A
- *Intersection AADT* – the AADT traffic volume for all approaches. Weight = 5, Ranking = (4) if AADT => 60,000; (3) if AADT between 40,000 and 59,999; (2) if AADT between 20,000 and 39,999; (1) if AADT between 0 and 19,999
- *Special Events* – CCTV would be used to monitor special event traffic and signal timing is adjusted for the special event. Weight = 5, Ranking = (4) if true; (1) if false
- *Freeway Detour* – CCTV would be used to monitor a logical detour route for a severe incident on a freeway or a freeway closure and signal timing would be adjusted along the detour route. Weight = 7, Ranking = (4) if true; (1) if false

This overall ranking can be used as a starting point to help determine where the CCTV may be most useful, but the cost of providing communications to the location will need to be estimated to determine if it is feasible to install a camera at a specific location.

6.2 OPERATIONAL ALTERNATIVES

There are two (2) operational alternatives with regards to the CCTV system. The operational alternatives have procurement and maintenance effects as well as operational effects on the individual Agencies. While the cost of the communications network necessary to support each alternative may be the driving force in determining which alternative should be selected, this section will focus only on the effects for procurement, maintenance, and operations. The evaluation is based on the assumption that digital video is being used rather than analog video. Two (2) options considered for the CCTV system are:

Centralized System – A single CCTV system is deployed for the whole Forum. Operationally, each Agency will be able to view all Agencies' CCTV and control its own CCTVs.

Exhibit 6.1 - Advantages and Disadvantages of a Centralized CCTV System

Issue	Advantage	Disadvantage
Procurement	• Purchase fewer licenses for the CCTV system	• Communications required between all Agencies & central server
Maintenance	• Localize video specialists in central location • Video specialists only need to know one system	
Operations	• One main location to manage video	• Failure at main location causes all Agencies to lose video • Agencies may use different ATMS systems for local TCS & camera control

Individual Local Systems – Each Agency has their own CCTV system. Operationally, each Agency will be able to view all Agencies' CCTV and control its own CCTVs.

Exhibit 6.2 - Advantages and Disadvantages of Individual CCTV Systems

Issue	Advantage	Disadvantage
Procurement	• Communications is not required between all Agencies & central server	• Software license for each CCTV system
Maintenance		• Each Agency will need to maintain their own system, or video specialists need to know multiple systems
Operations	• Failure at single location does not bring down all of the video (limited damage base on communications architecture) • Single ATMS system used for local TCS & camera control	

While the centralized system may be ideal for procurement and maintenance issues, it is not desirable operationally. Having a failure at a single location can cause the loss of all video to all Agencies and should not be acceptable. In addition, the cost for the communications to support a single centralized system may outweigh any savings from having a single CCTV system. The inherent redundancy of having individual local systems make it the better alternative.

It is also important to note that the Countywide IEN will analyze the feasibility and/or methods of sharing video between Agencies as part of a separate project. This means that Agencies may have the ability to view all video images regardless of the type of system (centralized or independent) implemented.