Pomona Valley
ITS Project

Project Deliverable 7.1.2

ATMS Alternative Analysis Report

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PROJECT DESCRIPTION

The County of Los Angeles, in cooperation with the cities within the Pomona Valley, has determined that development of an Intelligent Transportation System (ITS) in the Pomona Valley would help to reduce congestion, enhance mobility, provide traveler information during non-recurring and event traffic congestion, and manage event traffic. The Pomona Valley Intelligent Transportation Systems (PVITS) project was conceived as a recommendation from the Pomona Valley ITS Feasibility Study completed by the Los Angeles County Metropolitan Transportation Authority (LACMTA) in 1995. The ultimate objectives of the Project are to:

- Improve mobility by optimizing traffic management on arterials and freeways;
- Enhance Route 60 capacity by better coordinating freeway traffic with parallel arterials;
- Improve agency efficiency by coordinating management of operations and maintenance efforts among and between agencies; and
- Increase agency staff productivity by providing low-maintenance, high-quality communications and computational tools to assist in daily traffic management and inter-agency/intra-agency coordination activities.

Phase 1 of the PVITS project is the development of a conceptual design that defines solutions to enhance capacity, reduce congestion, and improve traveler information in the Pomona Valley.

1.0 BACKGROUND

1.1 Purpose of Report

The purpose of this task is to evaluate the options available for implementation of the Advanced Traffic Management System(s) (ATMS) for the Pomona Valley (PV) Traffic Forum. This report builds upon the results of the ATMS User Requirements report, ATMS Functional Requirements Report and the Concept of Operations/Area Architecture Report. It will identify potential ATMS and compare and contrast the most appropriate alternatives with regards to requirements compliance, effectiveness, reliability, cost, equipment availability, potential risks and liabilities, and other pertinent factors. Finally, this report will recommend a specific system configuration for the PVITS project.

1.2 Approach

The Concept of Operations/Area Architecture Report identified a series of Market Packages for the PVITS region. These include services for the entire subregion, not just those for ATMS. Some of those services that were identified would be provided by stakeholders and partners other than the Cities and LA County that this project primarily focuses on. Among these 22 Market Packages, Incident Management, Network Surveillance, Regional Traffic Control, Surface Street Control, and Traffic Information Dissemination are the ones which are most closely related to the system control and operational features for the Pomona Valley Traffic Signal Forum (these are bold in the table below).

1. Broadcast Traveler Information
2. Emergency Response
3. Emergency Routing
4. Freeway Control
5. HAZMAT Management
6. **Incident Management System**
7. Interactive Traveler Information
8. ITS Data Mart
9. ITS Data Warehouse
10. Multi-Modal Coordination
11. **Network Surveillance**
12. **Regional Traffic Control**
13. Standard Railroad Grade Crossing
14. **Surface Street Control**
15. Traffic Forecast and Demand Management
16. **Traffic Information Dissemination**
17. Transit Fixed-route Operations
18. Transit Passenger and Fare Management
19. Transit Security
20. Transit Traveler Information
21. Transit Vehicle Tracking
22. Yellow Pages and Reservation

The proposed ATMS, which includes a Traffic Control System, Vehicle System Detection, Closed Circuit Television (CCTV) Cameras and control of Dynamic Message Signs (DMSs) (which are considered part of the ATIS—Advanced Traveler Information System—but are controlled by the ATMS software), should be able to address the same operational and system functional capabilities as required by these identified Market Packages. It should be noted that the impact and benefits of the ATMS is not simply the sum of the individual element improvements. Therefore, instead of evaluating its individual components, such as CCTV cameras or DMSs, this analysis will examine the ATMS as a whole.

The ATMS alternative analysis started with identifying a listing of ATMS candidate alternatives. Those candidates included existing systems that are currently being operated by agencies as well as commercial-off-the-shelf (COTS) systems. Additionally, other ATMS that were identified via an Internet search are also included for the analysis. The list of ATMS candidate alternatives, which will be discussed in detail in the section 3 and 4, includes:

1. QuicNet/4 by BI Tran Systems
2. Actra by Siemens-Eagle Traffic Control Systems
3. *i2 TMS* by Siemens-Gardner Transportation Systems
4. Series 2000/Transuite by Transcore
5. KITS by Kimley-Horn
6. Pyramids by Econolite-AECOM (formerly DMJM)
7. Streetwise by Naztec Traffic Systems
8. Multigraphics ATS by US Traffic

A general review of these candidate systems was performed to identify systems that meet the basic requirements, such as vendor responsiveness, technical support and warranty, etc. Systems which were not suitable for the ATMS were eliminated. Then the general features and capabilities of the remaining candidates were studied. In addition, these systems were evaluated against specific criteria such as conformance to user and functional requirements, system performance, reliability, expandability, etc. Finally, benefits and limitations of each system were addressed. A comparison matrix was prepared for each analysis to summarize the findings.

1.3 Report Organization

The information in this report is presented in the following sections:

Section 1 – Background

Section 2 – ATMS Architecture Analysis

Section 3 – ATMS Alternative Analysis Summary

Section 4 – Vehicle Detection System Alternative Analysis

Section 5 – Recommendations

2.0 ATMS ARCHITECTURE ANALYSIS

2.1 Deployment Options

The first step in the ATMS alternative analysis is to identify the deployment options for the ATMS. The deployment options have procurement and maintenance effects more than operational effects on the agencies. From a city's perspective, operations should be similar regardless of which deployment option is chosen.

Three options are considered for ATMS deployment as described here and depicted in **Figure 2.1** on the following page.

Option 1, Single System Shared By All Agencies – A single ATMS deployment for the whole Forum in which each City would have a workstation for ability to control and/or operate their own ATMS elements. Each City will communicate with other cities and the County through this workstation. All ATMS workstations will be connected to the Los Angeles County Information Exchange Network (IEN) for data and control sharing.

Option 2, Separate System for Each Agency – A separate ATMS deployment for each City; individual systems would be linked via the IEN for data and control sharing.

Option 3, Hybrid Procurement – A hybrid deployment where some cities procure their own ATMS and others share deployments, thereby reducing maintenance costs and responsibilities in some cases. Regardless of the procurement (single-agency owned system or a shared system), the effect is the same from an operational perspective – each city that desires it will have remote control capabilities over their traffic signals.

Primarily, Model 170 controllers are used in the Pomona Valley ITS project cities as indicated in Table 2.1 in Deliverable 5.1.2. A small number of NEMA controllers are used as well. The type of controller, whether it is Model 170 or NEMA, will affect the choice of the ATMS. **It is recommended that existing NEMA controllers be replaced with Model 170 or 2070 controllers for consistency within an agency.**

For Option 3 (the hybrid deployment), three groupings of agencies are proposed. Within each group, a recommendation will be made for either procuring a system for each City, or procuring a system for all of the agencies in the group to share. It should be noted that the type and quantity of traffic signal controllers does not include Caltrans-maintained intersections.

POMONA VALLEY intelligent transportation system

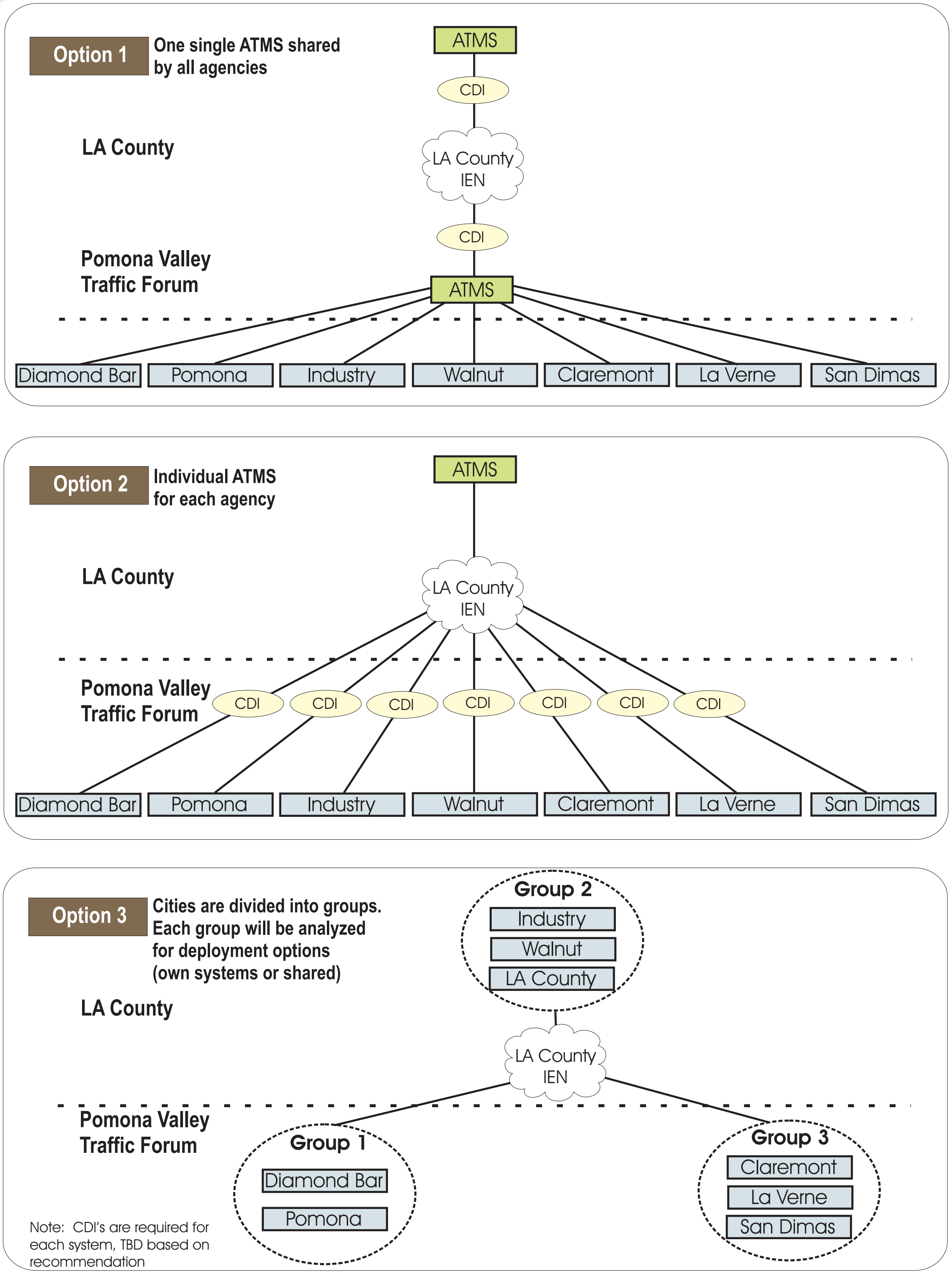


FIGURE 2.1 - ATMS DEPLOYMENT OPTIONS

Kimley-Horn and Associates, Inc.

Group 1
Diamond Bar – 46 Type 170 controllers
Pomona- 91 Type 170 and 1 NEMA controller

Group 2
Industry – 93 Type 170 and 2 NEMA controllers
Walnut – 15 Type 170 controllers
LA County – 52 Type 170 controllers

Group 3
Claremont – 24 Type 170 controllers
La Verne – 17 Type 170, 8 NEMA controllers
San Dimas – 13 Type 170 controllers

The grouping is based on the following general criteria:

- *Agency staff size and quantity of signals* – Group 1 cities are large cities with more staff available and dedicated to traffic-related responsibilities, and have a sizable quantity of traffic signals to operate and maintain. Group 2 includes signals in unincorporated Los Angeles County and cities that contract with Los Angeles County for traffic signal maintenance. It is likely that the current maintenance agreements between the County and these cities would continue and be enhanced to include operations, as these cities have limited staff available for traffic operations and maintenance. Group 3 cities are smaller in terms of in-house staff for traffic operations and maintenance and quantity of signals.
- *Proximity to each other within the Forum* - Group 1 agencies are located in the western part of the project area. Group 3 cities in the eastern part of the project area.
- *Roadway network layout and traffic management across jurisdictions* - Group 1 cities are located along the SR-60 and SR-57 freeways and some arterials (i.e. Valley Boulevard, Colima Road and Grand Avenue) are continuous through these cities. The Group 3 cities are located along I-10 and I-210 freeways and some arterials (i.e. Foothill Boulevard, Indian Hill Boulevard, Towne Avenue, Garey Avenue) are continuous through these cities.
- *Incident and event management* - Group 1 cities will manage incidents in the vicinity of SR 60 and SR 57 and could have shared incident management plans. Group 3 cities will primarily manage incidents along the I-210 and I-10 freeways and could have shared incident management plans. Events at Fairplex impacts traffic operations in all three groups and shared event management plans could be established between these cities.

2.2 Analysis

Several factors were considered in recommending a deployment option:

- Cost – this refers to the total deployment cost, which includes engineering and design, construction, procurement, integration, configuration, and testing.
- Ease of Procurement – this includes the availability of product and the purchase lead time.
- Interoperability – this is the capability to allow a seamless access of data across hardware platforms and software products. Proprietary products normally offer limited compatibility. In order to achieve interoperability, vendors need to develop and share common standards for data translation and exchange. Interoperability between agency systems for this project will be achieved through the IEN.
- Compatibility – this refers to the compatibility with legacy systems. There is only one legacy system in place in the Pomona Valley that is not currently in use, so compatibility is not considered to be an issue.

These options were analyzed against these factors and the following summarizes the analysis.

Option 1 –Deploying one large, combined ATMS for all PV traffic Forum cities would save cost at the expense of individual city flexibility. The cost savings would derive from a reduction in engineering and design effort, procurement cost, and integration effort. Within the Forum, only the City of Pomona currently owns a traffic control system (QuicNet 2), which is currently not utilized. If this option were selected, Pomona's current system would be upgraded or replaced with the proposed ATMS for the region. Interoperability would be a given. The disadvantage of this option is that the cities would have to achieve consensus on one common ATMS.

Option 2 – Deploying a different ATMS for each city would maximize city flexibility at a higher cost. The total deployment cost would be dependent on which ATMS each city selects. This approach may have issues regarding interoperability because some ATMS do not have an open architecture, but this could be addressed by requiring development of an IEN interface as a prerequisite to funding each deployment. The deployment schedule would likely be extended when compared with the other options, since more vendors would be involved, some of whom would need to implement software modifications (e.g. to deploy an IEN interface). However, this approach allows each agency to select its own ATMS.

Option 3 – This option attempts to balance cost and flexibility by dividing the Forum cities into groups based on the criteria presented above. Under option 3, the best ATMS for each group should be similar or identical to the best ATMS for each individual city, since the cities in each group have similar characteristics. Another benefit of Option 3 is that cities with fewer resources would join forces with a larger city or another smaller city. Subsequent to the initial analysis completed for this recommendation, each of the Group 3 Cities (as noted above: Claremont, San Dimas, and La Verne) have consulted their internal IS staff and management, and discussed with each other the pros and cons of procuring a shared system, and have determined that separate systems would be desired. This decision comes from a standpoint of schedule in terms of inter-agency agreements that would be necessary to share a system.

Table 2.1 summarizes the results of this analysis.

Table 2.1 Summary of ATMS Deployment Options

Option	Cost	Procurement Effort	Interoperability	Compatibility
1	Least expensive	Least number of procurements	100% Interoperable	No accommodation for legacy systems
2	Most expensive	Most number of procurements	Interoperability achieved through IEN	Accommodates legacy systems
3	Intermediate cost	Intermediate effort	Interoperability achieved through IEN	Accommodates legacy systems

2.3 Deployment Recommendation

Based on the analysis above, and the size of the staff at each of the Cities for maintenance and operations, Option 3 is recommended because it best balances cost and flexibility. The following hybrid deployment is recommended:

Group 1
Diamond Bar – select and procure its own system
Pomona – upgrade to QuicNet IV or select from shortlist

Group 2
Industry – establish agreement for LA County to operate/control and continue to maintain signals
Walnut – establish agreement for LA County to operate/control and continue to maintain signals
LA County signals – Add project area signals into system under procurement through a separate project.

Group 3 – select and procure separate systems for each of the three cities:
Claremont
La Verne
San Dimas

With the implementation of this option, each group of cities will be able to select its own ATMS and the forum cities in each group can select the ATMS that is best tailored to their needs. Additionally, it enables cities with fewer resources to join forces with a larger agency or other smaller cities if desired.

3.0 ATMS ALTERNATIVE ANALYSIS SUMMARY

The PVITS ATMS will comprise a Traffic Control System, Vehicle System Detection, CCTV Cameras and DMS control. The focus of the ATMS alternative analysis is to identify a reliable and cost-effective system that best meets the PV Traffic Forum's needs for traffic management and signal operations. The following sections will summarize the County's recent research of various off-the-shelf ATMS and evaluate the candidate ATMS against the Forum's requirements.

3.1 ATMS Candidates

The County of Los Angeles recently evaluated the following Advanced Traffic Management Systems (ATMS):

1. QuicNet/4 by BI Tran Systems
2. Actra by Siemens-Eagle Traffic Control Systems
3. *icons/*i2 TMS (offered by Econolite Control Products and by Siemens-Gardner Transportation Systems, respectively)
4. Series 2000/Transuite by Transcore
5. KITS by Kimley-Horn
6. Pyramids by Econolite-AECOM (formerly DMJM)
7. Streetwise by Naztec Traffic Systems

These ATMS have the capabilities and features of a typical ATMS and are considered to be initial candidates for the alternative analysis. To the list of ATMS software evaluated by LACDPW, the following additional ATMS was added for consideration in the Pomona Valley:

8. Multigraphics ATS by US Traffic

The evaluated ATMS packages are supported by established vendors that specialize in traffic control systems and ATMS applications. Some are widely deployed, while others have been developed more recently and have limited deployment experience. The systems (except Pyramids) 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.

Systems not evaluated here were screened out due to their unavailability, limited flexibility, and/or obsolescence.

3.2 Initial Screening

The nine systems selected for evaluation were screened based on an initial set of pass/fail criteria. Results of the initial screening are summarized in **Table 3.1**.

Table 3.1 ATMS Initial Screening

General Description

1. Was the ATMS Vendor responsive to the request for information?
2. Will the ATMS Vendor be capable of providing technical support?
3. Will the ATMS Vendor provide a comprehensive warranty and system updates?
4. Does the ATMS comply with either NTCIP or AB3418(E) communication protocol standards?
5. Is the ATMS Windows-based and reside on an Intel-based server?
6. Can the ATMS operate with 170 controllers without modifications?

Item/Criteria	1	2	3	4	5	6	Conclusion
1. BI Tran **QuicNet/4**	Yes	Yes	Yes	Yes	Yes	Yes	Continue to Step 2 of Analysis
2. Eagle **ACTRA**	Yes	Yes	Yes	Yes	Yes	No	Does not support Model 170 controllers, so eliminate from further consideration.
3. Gardner Systems ***i2 TMS*** **/** Econolite ***icons****	Yes	Yes	Yes	Yes	Yes	No	Would only support AB3418 protocol. Continue to Step 2 of Analysis for other comparison purposes.
4. TransCore **Series 2000/ Transuite****	Yes	Yes	Yes	Yes	Yes	Yes	Continue to Step 2 of Analysis
5. Kimley-Horn **KITS**	Yes	Yes	Yes	Yes	Yes	Yes	Continue to Step 2 of Analysis
6. AECOM **Pyramids**	Yes	Yes	Yes	No	Yes	Yes	Continue to Step 2 of Analysis
7. Naztec **Streetwise**	Yes	Yes	Yes	Yes	Yes	No	Since modifications to the 170 controller require additional cost and extra effort to the ATMS, Streetwise was not considered for further analysis.
8. U.S. Traffic **Multigraphics ATS**	No	Yes	Yes	Yes	Yes	Yes	U.S. Traffic did not respond to numerous requests for information for this evaluation.

*—Econolite's *icons* system is now available under a different name from Siemens-Gardner. Future software development will render these two systems different from each other; however, at the time of this writing, the two products are functionally very similar.
**—This system's name changed from Series 2000 to Transuite during the preparation of this document.

Based on this general overview, the following six systems will be considered for further analysis.

1. QuicNet/4 by BI Tran
2. ACTRA by Siemens/ Eagle
3. *icons* by Econolite Control Products/i2 TMS by Siemens-Gardner
4. Series 2000/Transuite by Transcore
5. KITS by Kimley-Horn
6. Pyramids by Econolite-AECOM

3.3 System Features

The ATMS alternative analysis compared the major system features of the six candidates. **It should be noted that information presented in this table 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, 5/10/2002. 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 the table that are not self-explanatory:

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

- A *sync pulse* strategy sends an electrical signal from the center to all controllers once per cycle at the beginning of the current plan's master cycle timer. The controllers' internal coordinators are, in effect, re-sync'd 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.
- A *centralized* system controls operations from the central computer, 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 typical office-sized computer 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.

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 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 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 included in Table 3.2.
- **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 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 table 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.

- The *polling 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.

Coordination Plan Selection Methods –

- *Traffic-responsive plan selection* refers to the selection of timing plans from a table of pre-developed coordination patterns based on measured traffic characteristics such as volume 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 – Alarms refer to 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.

GUI – GUI stands for Graphical User Interface and refers to 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 / Preemption 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 preemption call.

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

System Detection –

- *Volume* counts are collected locally in an intersection controller, and aggregated into bins for a user-selected time duration (usually five 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. Volume and Occupancy of system detectors are most frequently the parameters used by a system's Traffic Responsive 'calculator'.

- *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 a system to utilize video detection technology to detect vehicles.

ATMS / ATIS – ATMS stands for Advanced Transportation Management System and ATIS for Advanced Traveler Information System. These are enhanced features that provide the system user with additional tools and capabilities as listed here. 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 –

- *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 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 resulting 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 producing identifying both average and abnormal split values.

The results of the analysis are summarized in **Table 3.2**.

Table 3.2 ATMS General and System Features Comparison

Vendor	BI Tran	Siemens/ Eagle	Gardner/ Econolite	Transcore	Kimley-Horn	Econolite/ AECOM
System	**QuicNet/4**	**Actra**	***i2 TMS/icons***	**Series 2000/ Transuite**	**KITS**	**Pyramids**
Control Strategy Capability						
Sync Pulse	No	Once per cycle	No	No	No	No
Closed-loop with On-Street Masters	Yes	Yes	In Development	No	No	Yes
Time-Based Coordination with Centralized Management	Yes	Yes	Yes	Yes	Yes	Yes
Centralized	Yes	Yes	Yes	Yes	Yes	Yes
Server Hardware	Pentium	Pentium	Pentium III	Pentium III (will be available in early 2004)	Pentium II - IV	Pentium IV
Operating System	Win NT Win 2000 Win 98	Win NT Win 2000	Win NT Win 2000 Win 2003	Win NT, 2000, XP (will be available in early 2004)	Win NT, 2000, XP	Win 2000 Win 2003
LAN Capabilities	Yes	Yes	Yes	Yes	Yes	Yes
WAN Capabilities (Fire/Police Remote Workstation)	Yes	Yes	Yes	Yes	Yes	Yes
Capacity						
Local Traffic Signals	4000	5000	9999	9,600+	Unlimited	Unlimited
On-Street Masters	2000	Unlimited	Unlimited	Information not provided	Unlimited	Yes
Control Areas (Sections or Groups)	2000 groups	Unlimited	Yes	300+	Unlimited	Yes
System Detectors	8 per controller, 4000 max.	Unlimited	9999	9,600+	Unlimited	Yes/limit unknown
Coordination Timing Plans	32	48	Function of controller firmware	256, depending on controller firmware	Unlimited	Yes/limit unknown
Local Controller Compatibility (communications)						
NEMA (Hardware/Software)						
Eagle	No	Yes	Yes	No	No	No
Econolite	No	Yes	Yes	Yes	Yes	No
IDC-Multisonics	No	Yes	Yes	Yes	No	No
CSC	No	Yes	No	No	No	No
Peek-Transyt, TCT	No	Yes	Under Development	Yes	No	No
IDC-Traconex	No	Yes	Partial	Yes	No	No
Other (Identify)	McCain TS1 Vector TS1 Vector TS2	No	McCain Vector	All NEMA with RCU (Remote Control Unit)	Yes, with modification	Any NEMA controller with a DMJM supplied Interface unit (ICM)

Vendor	BI Tran	Siemens/ Eagle	Gardner/ Econolite	Transcore	Kimley-Horn	Econolite/ AECOM
System	**QuicNet/4**	**Actra**	***i2 TMS/icons***	**Series 2000/ Transuite**	**KITS**	**Pyramids**
Type 170/Type 170E (Firmware)						
Type 170 / Type 170E	Yes	No	No	Yes	Yes	Yes
Preferred Firmware	BI Tran 200, 233	No	No	BI Tran 222 and W4IKS	BI Tran 222, 233	W4IKS v.48a+
Other Compatible Firmware	No	No	No	BI Tran and Wapiti	BI Tran and Wapiti	No
ATC (2070/2070N) (Software)						
Type 2070 / Type 2070N	BI Tran 233 2070	Both	Type 2070 Type 2070N Type 170 ATC	Both	Both	All Caltrans approved 2070s
Preferred/Compatible Software	No	SE-PAC	NextPhase, EPAC, ASC 2070	Econolite	BI Tran	OASIS-2070 Software
Protocol Support						
NTCIP Communication Protocol Support	Yes, DMS only	Yes	Yes	Yes	Yes	In process
AB3418 (or AB3418E)	Yes	No	Yes	Yes	Yes	No
Communications Media/Technology						
Fiber Optics Cable	Yes	Yes	Yes	Yes	Yes	Yes
Twisted Pair	Yes	Yes	Yes	Yes	Yes	Yes
Radio	Yes	Yes	Yes	Yes	Yes	Yes
Phone Dial Up	Yes	Yes	Yes	Yes	Yes	Yes
Microwave	Yes	Yes	Yes	Yes	Yes	Yes
CDPD	Yes	No	Yes	No	Yes	Yes
Ethernet	Yes	Yes	Yes	Yes	Yes	Yes
Coax Cable	Yes	Yes	Yes	Yes	Yes	Yes
Communication Requirement (Half Duplex/Full Duplex)	Full	Half/Full	Half/full	Half/full	Half/full	Half/full
Communication Baud Range						
Master Controller (bps)	19,200	1,200 to 19,200	1,200 to 57,600	Not applicable	Not applicable	1,200 to 38,400
Local Controller (bps)	1,200 to 9,600	1,200 to 19,200	1,200 to 57,600	1,200 to 19,200	1,200 to 19200	1,200 to 38,400
# of Signals on one 1200 Baud Line	32	32	1-2 (NTCIP) 3-4 (AB3418E)	4	1-32 (protocol-dependent)	32
Local Communications Interface	RS-232	TWP, RS232, Fiber	All common communication interfaces	Internal and External via modem or RCU	RS-232 or Ethernet	RS-232
Controller Polling Rate						
Typical/Recommended	Once per second	Once per minute/once per second	Once per second	Once per second	Once per second	Once per second
Maximum	Once per second	Once per second	Continuous (at least once per second)	Once per second	Once per second	Once per second

Vendor	BI Tran	Siemens/ Eagle	Gardner/ Econolite	Transcore	Kimley-Horn	Econolite/ AECOM
System	**QuicNet/4**	**Actra**	***i2 TMS/icons***	**Series 2000/ Transuite**	**KITS**	**Pyramids**
Communication Upload/Download Duration (per controller)	Based on size of up/download. Typical one minute.	Based on size of up/download. Typical 10 sec to 4 minutes	Based on size of up/download. Typical 13.7sec for upload 26.6 sec for download	Based on size of up/download	Based on size of up/download. Typical About 30 seconds for entire controller database	Typical 20 sec to 2 minutes, based on size of up/download
Traffic Control Features						
Unattended System Operation	Yes	Yes	Yes	Yes	Yes	Yes
Backup Operation	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	Local controller time-based coordination
Coordination Plan Selection Methods						
Time of Day	Yes	Yes	Yes	Yes	Yes	Yes
Day of Week	Yes	Yes	Yes	Yes	Yes	Yes
Traffic Responsive Plan Selection	Yes	Yes	Yes	Yes	Yes	Yes
Manual	Yes	Yes	Yes	Yes	Yes	Yes
Critical Intersection Control (CIC)	Yes	Yes	No	Yes	Yes	Yes—configured using traffic responsive feature
Dynamic change of subgroups to allow different cycle lengths for different subareas	Yes	Yes	Yes	Yes	Yes	Yes
Allow Multiple Remote Users	Yes	Yes	Yes	Yes	Yes	Yes
Override Capability	Yes	Yes	Yes	Yes	Yes	Yes
Data Logging Features	Yes	Yes	Yes	Yes	Yes	Yes
Error/Failure Logging and Diagnostics	Yes	Yes	Yes	Yes	Yes	Yes
Alarms						
Prioritize	Yes	Yes	Yes	Yes	Yes	Yes
Pager	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
Graphics Format	CAD, BMP, ESRI file Format	CAD Microstation ESRI format	Win 2000 based graphics format	User defined with ATMS Explorer	All industry standard graphical formats	CAD, BMP, ESRI file format
Graphical User Interface (GUI)	Yes	Yes	Yes	Yes	Yes	Yes
Signalized Network	Yes	Yes	Yes	Yes	Yes	Yes
Real-time Display of Intersection Operation	Yes	Yes	Yes	Yes	Yes	Yes
Display Other ITS Elements (CCTV, DMS)	Yes	Yes	Yes	Yes	Yes	Yes
Display Priority/Preemption Data	Yes	Yes	Yes	Yes	Yes	Yes
Display Police/Fire AVL/AVI data	Yes	No	Yes for AVI	No	Yes	No
Ability to display a GIS-based map	Yes	Yes	Yes	Yes	Yes	Yes

Kimley-Horn and Associates, Inc.

Vendor	BI Tran	Siemens/ Eagle	Gardner/ Econolite	Transcore	Kimley-Horn	Econolite/ AECOM
System	**QuicNet/4**	**Actra**	***i2 TMS/icons***	**Series 2000/ Transuite**	**KITS**	**Pyramids**
GIS-based Map Format	CAD, BMP, ESRI file Format	CAD Microstation ESRI format	ESRI	(Unknown)	ESRI	CAD, BMP, ESRI file format
Evaluation						
Off-Line Calculation of MOEs	Yes	Yes	Yes	Yes	Yes	Yes
On-Line Calculation of MOEs	Yes	Yes	Yes	Yes	Yes	Yes
Display Raw Collected Data	Yes	Yes	Yes	Yes	Yes	Yes
Plan Storage Duration	Indefinite	Indefinite	Indefinite	Indefinite	Indefinite	Indefinite
Easy Copy Features	Yes	Yes	Yes	Yes	Yes	Yes
Reports	Yes	Yes	Yes	Yes	Yes	Yes
Relational Database	Yes	Yes	Yes	Yes	Yes	Yes
Database Options						
SQL	Yes	Yes	Yes	Yes	Yes	Yes
Microsoft Access	Yes	Yes	Partial	Yes	Yes	Yes
Oracle	Yes	No	Yes	Yes	Yes	No
Other	Paradox Sybase	No	No	No	Interbase Paradox	No
Detection						
Stop-line Detectors	Yes	Yes	Yes	Yes	Yes	Yes
Advance Detectors	Yes	Yes	Yes	Yes	Yes	Yes
System Detection						
Volume	Yes	Yes	Yes	Yes	Yes	Yes
Occupancy	Yes	Yes	Yes	Yes	Yes	Yes
Density	Yes	Yes	Derived	Derived	Yes	Derived
Speed	Yes	Yes	Yes	Derived	Yes	Yes
Video Detection	Yes	Yes	Yes	Yes	Yes	Yes
ATMS/ATIS						
Closed Circuit Television (CCTV)	Yes	Yes	Yes	Yes	Yes	Yes
Dynamic Message Signs	Yes	Yes	Yes	Yes	Yes	In process
Traveler Information	No	Web Server	Export from real-time data	Yes	Yes	Web Server
Video Display Wall	Yes	Yes	Yes	Yes	Yes	Yes
Advanced Functions						
Transit Priority Interface	Yes	Yes	Yes	Yes	Yes	In process
Emergency/Rail Preemption	Yes	Yes	Yes	Yes	Yes	Yes
Incident Management	Yes	Yes	Yes	Yes	Yes	Yes
Multi-jurisdictional Access	Yes	Yes	Yes	Yes	Yes	Yes
Off-line Preparation of Timing Plans	Yes	Yes	Yes	Yes	Yes	Yes
Transyt 7F Upload/ Download	Yes	Yes	Not directly (possible via Synchro)	Yes	Not directly (possible via Synchro)	Not directly (possible via Synchro)
Synchro Upload/Download	Yes	Yes	Yes	Yes	Yes	Yes
PASSER	No	Yes	No	No	No	No

Vendor	BI Tran	Siemens/ Eagle	Gardner/ Econolite	Transcore	Kimley-Horn	Econolite/ AECOM
System	**QuicNet/4**	**Actra**	***i2 TMS/icons***	**Series 2000/ Transuite**	**KITS**	**Pyramids**
Other Upload/Download (Identify)	NETSIM	No	nexWeb with Next Phase	No	CORSIM (via Synchro)	CORSIM (via Synchro)
Real-Time Time-Space Diagrams	No	No	Yes	No	Yes	Yes
Other (Identify)	No	No	Real-Time Split Monitor, Color Coded Links	1) A port to Win 2000/XP is in process 2) Support 1.5GC use of Transyt 7F	Windows XP, CCTV scheduling, Web Interface	CCTV snap shot video of wall data to any workstation, split monitor, generation of customized reports

3.4 Analysis Criteria

The following criteria were considered for analyzing the ATMS alternatives.

- **Requirements Satisfaction** – The ability to meet the Pomona Valley ATMS user and functional requirements is required. An ATMS that meets the requirements without any modification or customization is preferred over an ATMS that requires customization. For example, if a product has built-in features to control CCTV cameras, it is considered more favorable than those products which rely on an external CCTV control application.
- **Technology Maturity/System Readiness** – Some degree of risk is always associated with designing, procuring, integrating, training, and maintaining an ATMS. Mitigation of this risk is usually associated with technology maturity and system readiness. A mature technology will have more industry support and a mature product is less likely to undergo radical changes in a new version, which can require significant cost investments and schedule delays. Therefore, a good ATMS alternative should be proven for successful implementations and operations. It should also support the most common hardware platforms and software technologies. Technologies with wider customer bases and longer time in the market are more favorable. Sometimes, technology maturity can be defined by the general attitude of long-time users toward the product.
- **Ease of Integration** – Integration includes expandability, flexibility, and interoperability with the existing traffic signal controllers. Expandability is the ease with which a system or its component can be modified to increase its functional capacity. Flexibility is the ease with which a system or its component can be modified for use in applications or environments other than those for which it was specifically designed. Interoperability is the ability of two or more systems or components to exchange information and to use the information that has been exchanged. Integration with legacy systems is a very important consideration if deployment Option 3 is chosen. An ATMS candidate that has previously been integrated with legacy systems is preferred. In addition, the ease of integration also depends on the responsiveness of the vendor.
- **Open Systems Protocol Support –** Each system must support AB3418 (with an upgrade path available to NTCIP) and IEN communication requirements.
- **Usability** – Is the software interface easy to learn? Is it tolerant of user mistakes? Is it flexible and efficient? Each ATMS user interface was rated on these qualities.
- **Deployment Experience** – If the ATMS has been deployed successfully in a configuration similar to that contemplated here, this criterion is considered satisfied.
- **Cost** – In general, the cost of an ATMS will be dependent on the required ATMS specifications and customization. Therefore, the cost to procure the ATMS for the PVITS

project cannot be determined until the ATMS specifications have been prepared. Based on recent experience on similar projects for cities of a size comparable to those in the Pomona Valley, costs can vary between approximately $180,000 and $300,000 for comparable functionality per procurement. These costs include software licensing for server and workstation applications, installation, minor integration, training, required peripheral equipment, basic management software, and a standard warranty. If customization, additional functionality, additional system support, spare parts, or extended warranty periods are requested, the initial installation cost will increase.

§ **Other Features** – This criterion considers the various features of the alternatives, including system performance (based on communication requirements), additional features, capacity, control strategy, etc.

3.5 Summary of Analysis

All ATMS alternatives satisfy the basic requirements, such as LAN/WAN and CCTV capabilities, identified in the ATMS User Requirement Report and the ATMS Functional Requirements Report. Specific requirements, which are dependent on the specifications of the ATMS, will be available through options or customizations.

With regards to technology maturity and system readiness, QuicNet/4 and Series 2000/Transuite are the most mature products among all alternatives. However, the ease of implementation of QuicNet/4 might be relatively low because of the vendor's reputation for lack of responsiveness.

Since no other Forum cities, except Pomona, have an existing ATMS (and theirs is not operational), there are no integration issues to address. The new systems procured within the Forum will be compatible/ integrated with the County's selected system due to the IEN. The City of Pomona should consider compatibility with the ACE demonstration project's system (which is located within the City of Pomona), which has selected QuicNet IV. Therefore, QuicNet IV is a logical upgrade for Pomona.

All the systems have been successfully deployed.

The cost of deployment of QuicNet/4 and Actra are in general lower than the other alternatives.

The six ATMS alternatives have many common features. For example, all systems have a GUI (Graphical User Interface), and support the most common communication media/technology, such as optical fiber, twisted pair, phone dial-up, and microwave. Each system now also supports prioritizing alarms and Ethernet-to-the-field communication, and runs on the current Windows platforms. However, each system also has its own strengths and shortcomings. The following bullets highlight the major strengths and shortcomings of each system:

- **QuicNet/4** – It has a limited capacity (4000 controllers) and does not support half-duplex communication. In addition, it only supports up to 32 coordination timing plans. It can support up to 32 signals on one 1,200-bps channel. In addition, QuicNet/4 supports the most types of control strategies and all three database platforms.

- **Actra** – Communication upload and download duration can take up to four minutes, depending on the size of upload and download. It does not support the Oracle database platform. Actra can support up to 32 signals on one 1,200-bps channel. Also like QuicNet, its capacity is limited (5,000 controllers) and it supports a limited number of coordination timing plans (48). However, because Actra does not support Model 170 controllers, it does not meet a mandatory functional requirement.

- ***i2 TMS*** – This ATMS does not currently support some legacy control strategies that other systems support (sync pulse, closed-loop), but this is not expected to impact the Pomona Valley. Support on a 1,200-bps line is dependent upon which communications protocol is used: 1-2 controllers can be supported with NTCIP and 3-4 with AB3418E. It supports all database platforms, with some limitations for Microsoft Access.

- **Series 2000/Transuite** – This ATMS offers the least control strategies and does not support on-street masters, which may be important to some users (although it is not a PVITS functional requirement). It supports four traffic signal controllers on a 1200-bps line with NTCIP or AB3418E. It can support over 9600 traffic signal controllers.

- **KITS** – KITS supports serial and Ethernet communications and supports the LACO-4 firmware. It is available to the Pomona Valley Forum cities for no license fee, as Los Angeles County has already negotiated a County-wide fee as part of its own deployment of KITS. This ATMS does not currently support some legacy control strategies that other systems support (sync pulse, closed-loop), but this is not expected to impact the Pomona Valley. It can support an unlimited number of traffic signal controllers. Just as with *i2 TMS*, the number of controllers that can be supported by KITS on a single 1200-bps communication channel depends on the protocol that is used and would range from 1-2 controllers with NTCIP to 32 controllers with the BI Tran protocol. It supports all database platforms.

- **Pyramids** – The maximum serial data rate for the master and local controllers is 38,400 bps. The system supports up to 32 controllers on a single 1200-bps communication channel. It supports any number of traffic signal controllers. It does not support the Oracle database platform.

Results of the ATMS Alternative Analysis are summarized in **Table 3.3**.

Table 3.3 Summary of ATMS Alternative Analysis

ATMS Alternative	Requirement Satisfaction	Technology Maturity/ System Readiness	Ease of Integration	Open Systems Protocol Support (NTCIP, AB3418, IEN)	Usability	Deployment Experience	Cost	Other Features
QuicNet/4	Yes	Very Good	Average	NTCIP (DMS only), AB3418	Good	Yes	Low	Very Good
Actra	Yes	Good	Good	NTCIP	Good	Yes	Low	Good
i2 TMS	Yes	Good	Good	NTCIP, AB3418	Good	Yes	High	Very Good
Series 2000/ Transuite	Yes	Very Good	Good	NTCIP, AB3418, IEN	Good	Yes	High	Average
KITS	Yes	Good	Good	NTCIP, AB3418, IEN	Good	Yes	High	Very Good
Pyramids	Yes	Good	Good	NTCIP (pending)	Good	Yes	High	Good

3.6 ATMS Recommendation

Based on the result of analysis, it is recommended that the following ATMS alternatives be considered for the PVITS project:

- QuicNet/4
- KITS
- i2 TMS

Series 2000/Transuite is not recommended for deployment in the Pomona Valley due to its high cost relative to available features. Pyramids is not recommended for deployment in the Pomona Valley because it has a higher cost and offers less potential for integration with other Los Angeles County systems as compared with other systems that were analyzed.

For Group 1 (Cities of Pomona and Diamond Bar), QuicNet/4 is a strong candidate for Pomona because Pomona has been using QuicNet/2 for its traffic control system and it will integrate seamlessly with the ACE demonstration project, which has provided QuicNet IV to the City. However, any of the three recommended systems can be selected by Pomona and still provide the necessary integration. It is recommended that Diamond Bar select one of the three recommended ATMS alternatives.

For Group 2, since the County will continue to operate and maintain signals for the group, the County's selected system (KITS) is recommended.

For Group 3, it is recommended that the three cities each select a system from this shortlist.

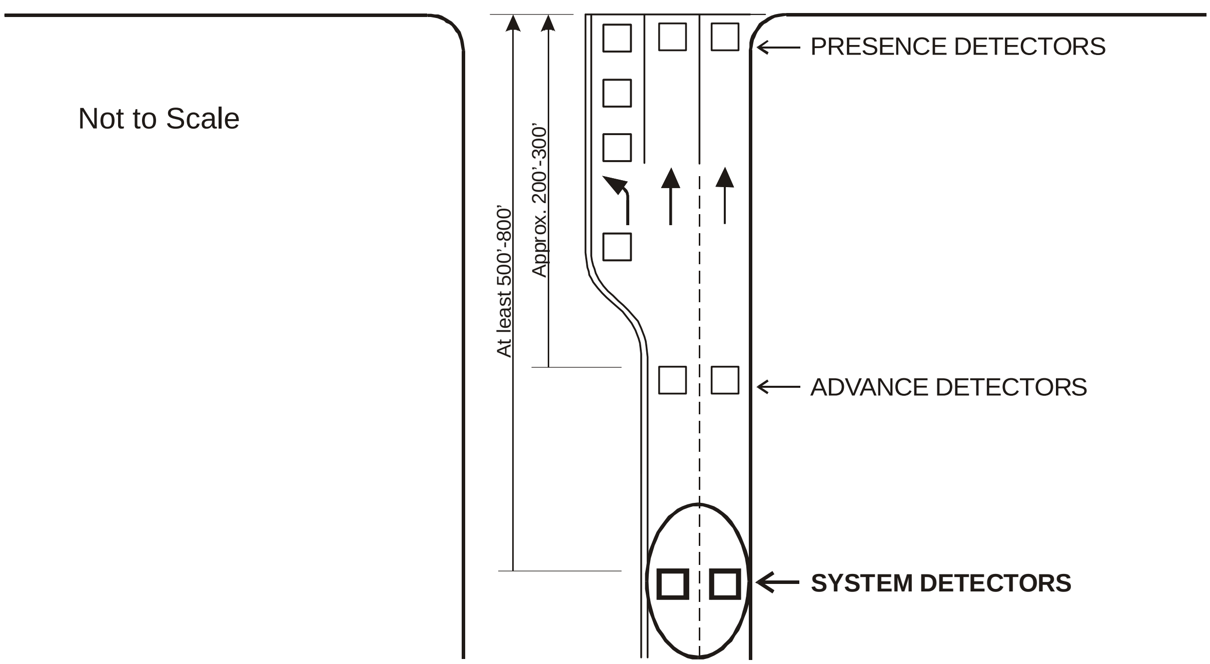
4.0 VEHICLE DETECTION SYSTEM ALTERNATIVE ANALYSIS

A vehicle detection system is a very important tool for traffic management. The primary purpose of a vehicle detection system is to provide real-time data about vehicle presence and other vehicular traffic features such as vehicular volume, density, and average speed. Presence and advance detectors inform the individual intersection controllers, the master controller or a traffic control system of traffic demands. They are located at the approaches of an intersection. Signal actuation is achieved through the use of presence (or limit-line) and advance detectors. The signals that have been included in the County's Traffic Signal Synchronization Program (TSSP) for traffic signal timing and coordination have been (or will be) outfitted with advance and presence detection.

Ideally, system detectors are placed in a location that is unaffected by traffic signal queues. This means that, their ideal placement is further upstream than advance detection. Using one set of loops for both advance detection and system detection is a compromise between deployment cost and functionality; however, this compromise is often found to be acceptable.

A typical intersection approach detection layout is provided in **Figure 4.1**.

Figure 4.1 Typical Intersection Approach Detection Layout



A key component to operating a centrally-controlled traffic responsive or adaptive system is the collection of speed, volume, and occupancy data from system detectors. System detectors collect speed, volume, and occupancy data at mid-block, ramp, and cross street locations and feed the data to a computerized traffic control system for traffic signal coordination adjustments or for use by the signal system operators for other traffic management strategies. **It is recommended that system detection be implemented for the PVITS project.** This section of the report will identify and evaluate candidate system detection technologies against the Forum's requirements.

4.1 Technology Overview

Various detection technologies are available for use as system detectors. The most common types of detection technologies 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. Vehicle passage cuts magnetic lines of flux generated around the loop. Resulting induced inductance change is detected and transmitted to any amplifying circuit recognized by the detector.
- Radar/Microwave Detectors – A radar/microwave detector transmits microwave energy toward the roadway from the detector's antenna. The presence of a vehicle causes a reflection returned to the antenna. Many microwave detectors sense the frequency change of the reflected energy (Doppler frequency) and obtain vehicle speed from this signal.
- Acoustic Detectors – This type of detector consists of active and passive models. The active acoustic detector transmits pulses of ultrasonic energy through a transducer toward the roadway. The presence of a vehicle causes these beams to reflect back to the transducer. The term passive denotes that energy is not transmitted by the detector as these devices sense energy or signals emitted by the vehicles and roadway. Passive acoustic detectors essentially act as sensitive acoustic microphones listening to the noise of vehicles as they pass through the detector's range.
- Video Image Detectors – Video technology and image process techniques are used for video detection of vehicles. Video image detection technology involves the use of a video camera with a video processor to identify and tack vehicles traveling within the camera's field of view.
- Infrared Detectors – Infrared detectors consist of both active and passive models. In the active system, detection zones are illuminated with low-power infrared light. The infrared light reflected from vehicles traveling through the zone of detection 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 detector operates by detecting the change in energy that occurs when an object with a temperature different from the ambient temperature (e.g., with a "hot" engine) enters the detector's field of view. Special signal processing techniques are used to screen most false signals.

4.2 Detection Technology Analysis

The detector technologies were evaluated against the system detector requirements. **Table 4.1** presents the results of the evaluation.

Table 4.1 Comparison of System Detection Technologies

Detection Technology	Feature and Measuring Capability										
	Accurate Count	Presence	Speed	Occupancy	Vehicle Classification	Delay at Intersection	Incident Detection	Queue Length	Directional capability	Ease of Installation*	Number of Lanes a Single Unit Can Cover	10-Year Life Cycle Cost per Approach (three through lanes)
Inductive Loops	X	X	X	X	X	N/A	N/A	N/A	X	1	1	$19,600
Radar/Microwave Detectors	X	X	X	X	X	N/A	N/A	N/A	X	1	8	$6,600
Acoustic Detectors	-	X	X	X	N/A	N/A	N/A	N/A	X	2	5	$9,800
Video Image Detectors	X	X	X	X	X	X	X	X	X	1	4	$29,800
Infrared Detectors	-	X	X	X	X	N/A	N/A	N/A	X	3	4	$12,800

* 1- Easy, 2- Average, 3- Difficult

The source for accuracy of count data is taken from a report entitled "Detection Technology for IVHS—Task L Final Report," published in 1995 by the Federal Highway Administration.

The cost estimates are for a typical major highway with three approach lanes per direction. The cost estimates are based on unit prices compiled from the various manufacturers and other similar projects. The cost estimates are based on a 10-year life cycle and have been converted into present values using a 10 percent interest rate over the 10-year period. The costs include initial capital investment and installation, maintenance cost, and replacement cost (for those with shorter life cycles than ten-years), based on the following assumptions:

- Radar/microwave, acoustic, and video detectors would be installed on existing street lighting poles.
- The detection is installed in a configuration that can produce volumes per lane, if the technology allows it.
- A 10 percent interest rate was used to calculate present values of the initial, maintenance, and replacement costs.
- Cost estimates are for one direction of travel only.

Based on the cost comparison only, the use of radar/microwave detectors for system detection is the most cost effective alternative over a 10-year life cycle. However, other factors must be considered to select the appropriate system detection technology, such as intersection conditions (geometry and sight distance), weather, and pavement type, and so forth. For example, inductive loop detectors require more effort to install in concrete pavement, while video detection systems require the camera unit to be installed at a certain height above the roadway to provide adequate line of sight.

The selection of a detection system should also consider the types of traffic information that need to be collected for a given application. Video detection is the only technology that provides all of the traffic flow measurements: vehicle counts, presence detection, vehicle speeds, lane occupancy, vehicle classification, intersection delay, incident detection, and queue length. It should be noted that video detection is unique in that it can actually be more cost effective in instances when it is installed to provide coverage at more than one of the detection zones (presence, advance, or system).

The following technologies are not recommended for use as system detectors:

§ *Acoustic*—Not capable of providing sufficient count accuracy.
§ *Infrared*— Not capable of providing sufficient count accuracy.

It is recommended that the following technologies be considered for use as system detectors:

§ *Inductive loops*—Reasonable cost, proven technology, local agencies are comfortable maintaining them.
§ *Video detection*—Greatest feature set; capable of returning live video from field
§ *Radar/microwave*—Good performance at low cost.

5.0 RECOMMENDATION SUMMARY

This report provides analysis of the ATMS architecture, ATMS alternative recommendations and vehicle system detection technologies. The recommendations are summarized in the **Table 5.1**.

Table 5.1 Summary of Recommendations

<table>
<tr><th>Analysis</th><th>Recommendation</th></tr>
<tr><td>ATMS Deployment Option</td><td>§ Option 3 – Divide the forum cities into three groups and select each ATMS deployment from the recommended list of alternatives below.
  § Group1:
    § Pomona should expand QuicNet IV to be used city-wide or select one of the three recommended systems listed below, to be deployed in Phase 2 of the PVITS project.
    § Diamond Bar should select one of the three recommended systems (QuicNet IV, KITS, or Pyramids), to be deployed in Phase 2 of the PVITS project.
  § Group 2: Since the County is currently operating the signals for the group, the County’s selected system will be used.
  § Group 3: The Cities of Claremont, La Verne, and San Dimas should each select one of the three recommended ATMS systems.</td></tr>
<tr><td>ATMS Alternatives</td><td>QuicNet/4, KITS, i2TMS</td></tr>
<tr><td>Vehicle Detection</td><td>§ Deploy system detection
§ Recommended technologies: Inductive loops, radar/microwave, and video. Choice is subject to maintaining agency preference.</td></tr>
</table>

LIST OF ACRONYMS

ATC	Advanced Transportation Controller
ATMS	Advanced Traffic Management System
ATIS	Advanced Traveler Information System
BMP	Bitmap
Bps	Bits per second
CCTV	Closed Circuit Television
CDI	Command Data Interface
CLS	Closed Loop System
COTS	Commercial-Off-The-Shelf
DMS	Dynamic Message Sign
GIS	Geographical Information System
GUI	Graphical User Interface
IEN	Information Exchange Network
I/O	Input/Output
ITS	Intelligent Transportation System
LAN	Local Area Network
LA County	Los Angeles County
LACMTA	Los Angeles County Metropolitan Transportation Authority
MOEs	Measures of Effectiveness
MOU	Memorandum Of Understanding
NEMA	National Electrical Manufacturers' Association
NTCIP	National Transportation Communications for ITS Protocol
PV	Pomona Valley
PVITS	Pomona Valley Intelligent Transportation System
TBC	Time-based Coordination
TSSP	Traffic Signal Synchronization Program
UOR	User Operational Requirements
WAN	Wide Area Network