SIEMENS

*Deliverable For:*

# Gateway Cities Traffic Signal Synchronization and Bus Speed Improvement Project

## I-5/Telegraph Road Corridor

## *Deliverable 4.1.2*

## High Level Design Definition Report

**Final**

**Version 1.0**

***Submitted To:***

**Los Angeles County**
**Department of Public Works**

***Submitted By:***

**Siemens Energy & Automation, Inc.**
**Gardner Transportation Systems Business Unit**

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# Revision History

| Version | Date Submitted | Comments |
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| Draft HLD Definition Report ATMS & LCC Sites | March 6, 2002 | Initial submittal |
| Final HLD Definition Report ATMS & LCC Sites | July 3, 2002 | Incorporates County comments |
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| Final HLD Definition Report | February 13, 2003 | Incorporates comments from County on Final HLD Definition Report ATMS & LCC Sites and Draft HLD Report VDS and combines the two reports |
| | | |

# TABLE OF CONTENTS

## LIST OF FIGURES AND TABLES

# 1 INTRODUCTION

## 1.1 Background

The County of Los Angeles Department of Public Works Traffic Signal Synchronization, Operation and Maintenance (SOM) Program has proven successful in creating an institutional infrastructure to coordinate the activities of the agencies responsible for traffic signal operations in the County. A key feature of this infrastructure is the Forums - groups of bordering agencies created to encourage and promote inter-agency cooperation. These Forums have enabled funding to be targeted at infrastructure improvements along arterial and arterial/freeway corridors in the County's sub-regions. Such projects are a critical part of what will eventually be a network of integrated ITS systems in Los Angeles County and in Southern California.

The I-5/Telegraph Road Corridor is one such project which will result in arterial infrastructure improvements along Telegraph Road in the South-East Los Angeles County (Gateway Cities) Forum. The Project area contains 39 intersections in 8 different jurisdictions, comprising 6 cities, the County and Caltrans.

The objective of this Project is to design, develop and deploy traffic control systems in the Corridor so that the signals along I-5/Telegraph Road can be synchronized across the jurisdictional boundaries. This Project concentrates on the needs of the agencies in this Corridor with respect to signal synchronization along Telegraph Road and recommends improvements to field infrastructure (including controllers, loops, detectors, and communications) and central traffic control systems to meet those needs.

When successfully completed, each of the agencies responsible for traffic signal operations in the I-5/Telegraph Road Corridor will have full access to an Advanced Traffic Management System (ATMS) that monitors and controls the traffic signals under their jurisdiction. Agencies will be able to synchronize their signals with neighboring agencies, and exchange traffic information in real-timethrough an Information Exchange Network (IEN).

Agencies will also be able to exchange data with other agencies in the Gateway Cities region. This will allow the agencies to respond to recurrent and non-recurrent congestion in a coordinated fashion across the jurisdictional boundaries. The traffic control systems therefore form part of a larger, regional approach supporting multi-agency traffic signal operations.

Previous reports for this Project have addressed the user and functional requirements for the ATMS systems, interface systems, communication system, and local control centers (LCC) for the I-5/Telegraph Road Corridor. This report presents a High Level Design for the Corridor ATMS based upon these previously define requirements. In addition, typical Local Control Center (LCC) designs for three types of control facilities envisioned to be employed in the I-5/Telegraph Road Corridor are also developed and presented.

## 1.2 Organization of Document

This document is organized into the following Sections:

Section 1: Introduction

Presents the Project background and introduces the document.

Section 2: System Overview

Describes the Information Exchange Network (IEN) architecture and the relationship between this and other projects.

Section 3: Concept of Operations

Describes the concept of operations for the cities in the I-5/Telegraph Road Corridor with respect to the Local City Control Sites.

Section 4: Definition of Functionality

Summarizes the functionality required for the ATMS services to be available for each partner agency as derived during the requirements definition.

Section 5: System Architecture

Derives a definition of the ATMS in the Corridor in terms of a logical architecture which reflects the desired functionality. This is translated into a high-level physical architecture identifying local and associated corridor level components.

Section 6: Local City Control Sites

Typical local city control sites are identified based upon the required functionality and local city control site physical architectures. Required equipment is derived for each typical site, and site layouts are developed and presented.

Section 7: Vehicle Detection System

Analysis of each of the three candidate detection technologies: inductive loops, microwave radar and video image detection. This section also does a comparison of the technologies including cost.

### 1.3 Regional Area and Agencies Involved

The I-5/Telegraph Road Corridor Project encompasses several jurisdictional boundaries. Furthermore, it will be integrated, or have the ability to integrate, with many other projects and existing systems in the region through the IEN architecture (see Section 2.1). The following cities and agencies are involved in the Project:

- Commerce
- Downey
- La Mirada
- Montebello
- Pico Rivera
- Santa Fe Springs
- Los Angeles County Department of Public Works
- Caltrans District 7

### 1.4 Referenced Documents

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

I-5/Telegraph Road Corridor Project

Deliverables 2.1/2.3: Stakeholder's Operational Objectives and Individual City Reports

Deliverable 3.1.2: Advanced Traffic Management System (ATMS) User Requirements

Deliverable 3.2.1: ATMS Functional and Local Traffic Control Center Requirements

Deliverable 3.3.1: Integration System Requirements

Deliverable 3.5.1: Communications System Requirements

I-105 Corridor Project

TSMACS User Requirements Report (Final)

Functional Requirements Report (Draft)

TMC High Level Design Definitions and Recommendations (Draft)

San Gabriel Valley Pilot Project

System Design Report, Final Version 1.0

System Overview and Status Update (October 2000)

# 2 SYSTEM OVERVIEW

## 2.1 The Information Exchange Network Architecture

The County DPW has developed a system architecture for integrating Advanced Traffic Management Systems (ATMS) for arterial traffic control systems into a regional framework to support the above operational goals. This is the Information Exchange Network (IEN) architecture represented in Figure 2.1. This is the architecture that will be followed in the design of the I-5 Telegraph Road Project.

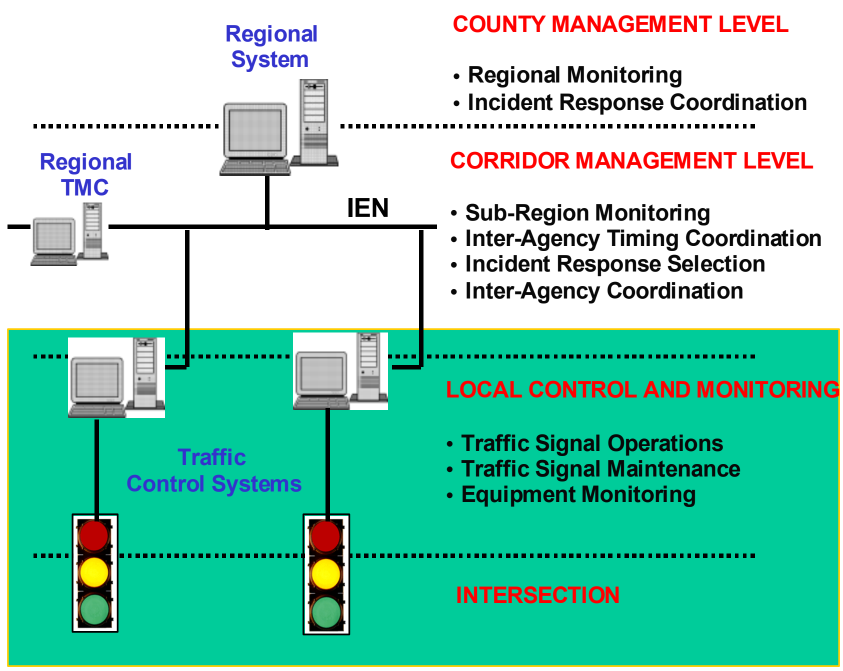



**Figure 2.1: The Information Exchange Network Architecture (IEN)**

The IEN architecture supports traffic signal operations in three levels. The local level comprises the day-to-day, traffic signal operations carried out by the individual agency – signal timing, maintenance and response to local traffic conditions and events. The Corridor level supports inter-agency coordination and joint signal operations – coordination across jurisdictional boundaries, exchange of local traffic data, and joint response to traffic conditions and events that affect more than one jurisdiction. The final level is the regional level. This permits the arterials of regional significance to be monitored and managed as a single entity (as Caltrans does with the freeway system). Multi-agency, cross-corridor data exchange is supported permitting a countywide response to traffic conditions and major events.

The physical elements of the architecture are ATMSs, interfaces between the ATMS and the regional system, workstations to display shared data (which may or may not be combined with the ATMS), and servers for the collection/transfer of data and to support corridor and regional functions. The components are connected via the IEN. The design of the IEN is being developed as part of the East San Gabriel Valley (ESGV) Pilot Project. The initial application of this structure in the Gateway Cities region is being done under the auspices of the I-105 Corridor Project which has jurisdictions in common with the I-5 Telegraph Road Project.

## 2.2 IEN Implementation Projects

### 2.2.1 ESGV IEN Project

The County has undertaken a project to develop the IEN as part of the East San Gabriel Valley (ESGV) Pilot Project. The IEN is focused on providing real-time second-by-second data to partner agencies from multiple traffic signal control systems. As well as developing the IEN communications software, the Project is also developing the following applications that will run on the IEN workstations on the IEN (see Figure 2.2):

- Incident Tracking
- Incident Management
- Planned Events (Scenario) Management
- Data Archiving
- Alarm Distribution
- Reporting

From the aspect of the I-5/Telegraph Road Project, the functional requirements for integrating systems must reflect the support of these functions.

### 2.2.2 I–105 Corridor Project

The I–105 Corridor Project will build a "Corridor System" over existing and future integrated ATMS's that will be housed in a Sub-Regional TMC. The Corridor system's purpose is to collect data from the individual local city control sites (that house local ATMS), share this data with other agencies within the system and disseminate information to the public. The main goal of the Corridor concept is to provide a mechanism for the local systems to act in a coordinated fashion to improve synchronization and traffic flow. Figure 2.2 illustrates the relationships between the local ATMS's and the Corridor system.

The I-105 Corridor Project will have a "Corridor Server" located at the Sub-Regional TMC to facilitate sharing data among local city control sites and County TMC. A single "County Server" at the County TMC will manage information obtained from all the Corridor Servers including the I-105 Corridor.

The Sub-Regional TMC will act as clearinghouse for information and recommended actions to be implemented by each local city control site. The Sub-Regional TMC will recommend specific plans of action from its library of response plans that are created during inter-jurisdictional planning/coordination. A Command Data Interface (CDI) will allow each ATMS to communicate with the Sub-Regional TMC. CDI's will be used to interface the ATMS's to the Information Exchange Network (IEN) and translate existing data into the IEN format for sharing with the Corridor member cities/agencies and ultimately with the County. The architecture provides:

- CDI Definition
- Information Exchange Network (IEN)
- Corridor Server
- County Server

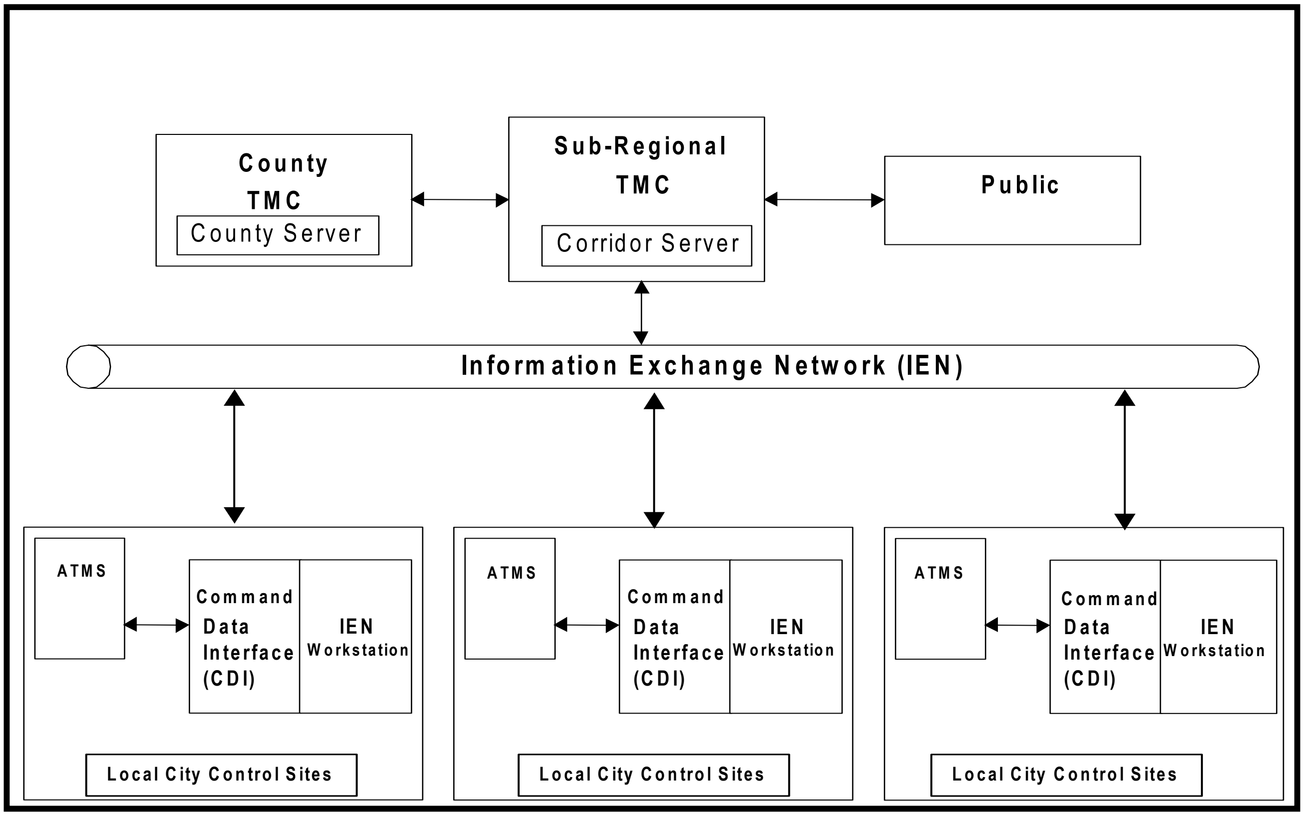



**Figure 2.2: I-105 Corridor System Relations**

Corridor management and control activities will be coordinated in order for traffic to move efficiently and safely between jurisdictions. This is achieved by the complementary selection of timing plans on adjacent ATMSs. The Corridor will have a WWV Clock serving as the time reference for each ATMS. The local WWV Clock at each ATMS, which, under regular operation is synced to the Corridor clock, will act as a back-up in the event the Corridor clock is not available.

### 2.2.3 <u>I-5/Telegraph Road Project Interfaces</u>

The I-5/Telegraph Road Project assumes the availability of the IEN at the corridor and regional levels as provided by the I-105 Corridor Project. The I-5/Telegraph Road focuses upon the selection and integration of multiple ATMSs (for the Cities included in the I-5/Telegraph Road Corridor Project) using the IEN.

The eventual design will include IEN workstations at the local level and the CDI's for the individual ATMSs. These are initially being defined and implemented as part of the ESGV Pilot

Project. Additional functionality supporting the Corridor Management Level tasks will be incorporated as part of the I-105 Corridor Project.

The key interface for an ATMS in the Corridor at the local level is therefore with the IEN (see Figure 2.3). This High Level Design addresses and identifies this interface in physical terms while staying independent of a particular communications plant.

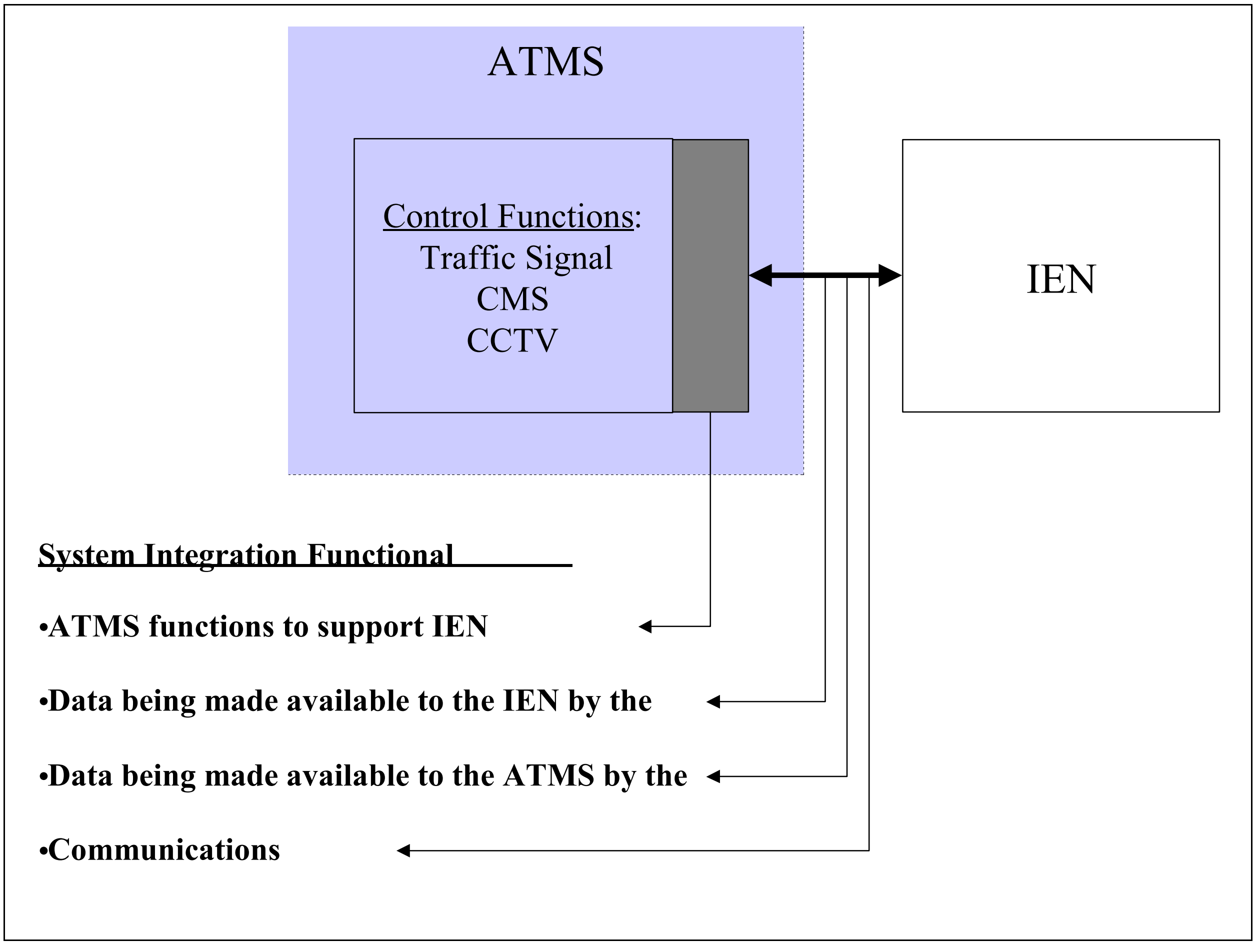



**Figure 2.3: ATMS/IEN Interface Definition**

# 3 CONCEPT OF OPERATIONS

## 3.1 Operational Enhancements

The I-5/Telegraph Road Corridor System will introduce the following operational enhancements into this part of the Gateway Cities area:

A traffic signal operations and management capability for all participating agencies.

This will be achieved through the implementation of one or more ATMSs in the Corridor providing a centralized capability to support signal timing plan generation, implementation and management (fine tuning and other modifications), equipment monitoring and reporting, traffic conditions monitoring and reporting, response to incidents and response to equipment failures.

Coordinated traffic signal management operations among participating agencies.

The overall objective is to distribute demand among all roadways of the Corridor so as to achieve minimum overall delay and optimum system utilization. This is particularly useful in managing incidents where the reduced capacity on one roadway is handled efficiently through increased throughput on other arterials.

Exchanging traffic information (link volume, occupancy, incidents, delays, etc.) between the local cities, regional agencies, TMC's, and the public.

The exchange of information will enable system managers to select proper control strategies and coordinate signals so as to achieve minimum overall delay throughout the entire Corridor. The demand can be controlled through informing the public of traffic conditions and advising them of alternate arterials within the Corridor. This will redistribute the demand proportionately in accordance with available freeway and arterial capacity.

The ability to respond to Caltrans freeway management system incident data.

This will permit the local agencies to be pro-active in managing the impact of incidents on the arterials by implementing pre-determined multi-jurisdictional coordinated signal timing.

## 3.2 Operational Concepts

The multi-city and agency participation in the IEN, dictate the consideration of two types of operations centers; a local city control center (LCC) and a Sub-Regional TMC. At this stage of the Project, final decision of the configuration of the Sub-Regional TMC has not been reached. For the purpose of the I-5 Telegraph Road Project, the focus is on the LCC.

The potential functions that could be provided at such a location can be divided into two categories:

- **Internal Functions.** These are functions that relate to the operation of system components within the jurisdiction of a specific city or agency. Examples include the operation of local traffic signal systems, local congestion, incident and event management using CCTV, system detection, CMS, etc. A full range of maintenance activities is also covered such as monitoring central, field and communications equipment and responding to alarms and equipment failures.

- **External Functions.** This includes the exchange of data, information, and/or video with outside users such as other cities, Caltrans, and the general public. The type of data/information exchanged with other agencies typically depends on multi-agency/city agreements and understandings that govern items such as type of data/information exchange, level of access/control, and permissions. For the general public, a key function of the ATMS is to provide information to the Sub-Regional TMC about roadway conditions, congestion, incidents, events, etc. The Local TCC may also receive information about signal problems, accidents, and other items from call-ins by the public.

These functions are illustrated in Figure 3.1 below. External functions are enabled by the integration of ATMS through the IEN . They are described in the following subsection.

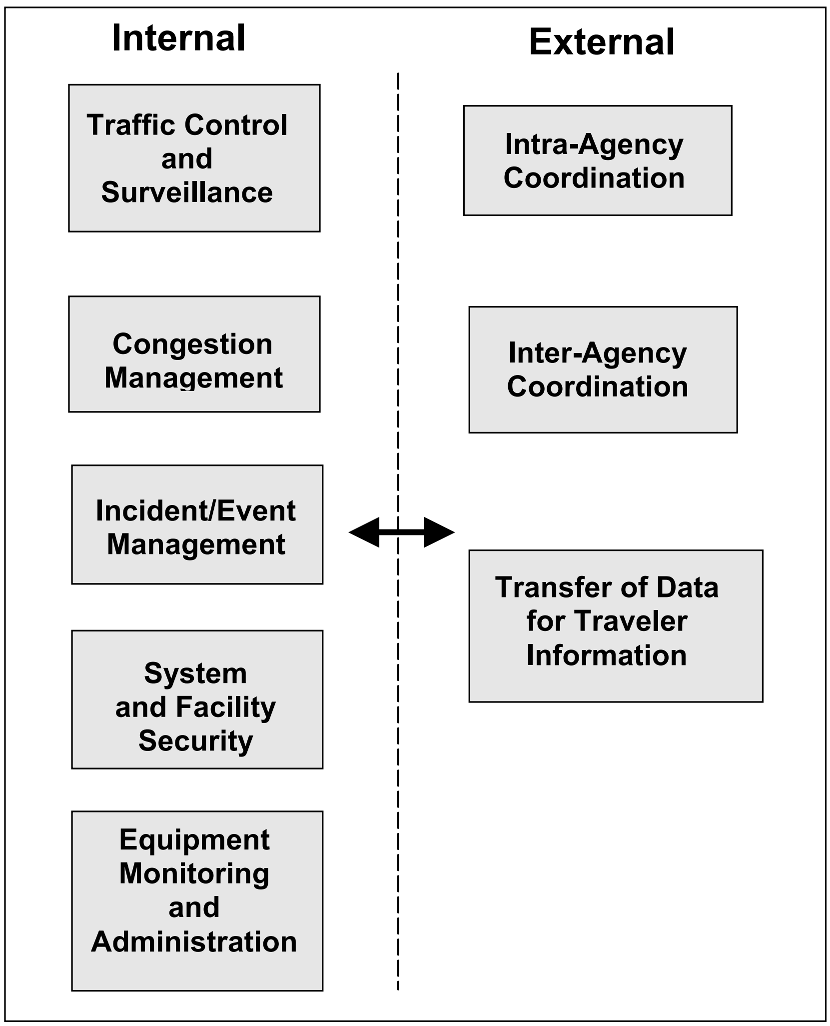



**Figure 3.1: ATMS Functions**

## 3.3 Internal TMC Functions

### 3.3.1 Traffic Surveillance

This involves the real time monitoring of traffic parameters such as volume, occupancy, and speed collected by system detectors and closed circuit television cameras. Monitoring of the system detectors is typically done as an automated process, with alarms being activated to notify traffic-engineering staff of unusual conditions at an intersection or along a segment of roadway. In some cases, the system detector information may be used to automatically implement a system response, with or without operator intervention per the policies of the agency (traffic responsive operation). Collected data is aggregated and stored for later analysis. This data may be exported to off-line programs used in the generation and optimization or traffic signal timing plans.

Closed circuit television allows operators at the Local TCC to verify traffic patterns at intersections, roadway segments, or other critical locations, primarily to verify conditions or assess the impacts of implementing a system response. Facilities at the Local TCC for providing CCTV monitoring may include dedicated television monitors, a large screen projection TV, or windowed video on a computer workstation.

### 3.3.2 Congestion Management

This is an operational activity designed to enhance traffic responsive operation to address traffic congestion. Recurring congestion patterns are detected in real time and can generally be predicted based on historical experience. Tools are provided to allow the development and implementation of traffic control strategies to reduce and disperse congestion. Such strategies can run counter to free-flow, traffic responsive type operation.

### 3.3.3 Incident/Event Management

This refers to traffic response plans that are implemented to manage traffic during an accident, incident (e.g. hazardous material spill, natural flood or earthquake), planned lane closure, or special event such as parade or stadium event. These events occur irregularly, and may create non-recurring congestion. Some are predictable and can be prepared for by creating a custom response plan. Others occur without warning, and may require use of the closest suitable existing plan, or dynamic creation of a new plan.

### 3.3.4 System Monitoring and Administration

The Local TCC typically provides central (automated) monitoring of the status of all field devices that communicate with a central computer. Status information is used to confirm that a device is working correctly (e.g. a detector loop is on line, a changeable message sign is showing the correct message), and to detect system faults and alarms. Maintenance and performance logs are generated, and maintenance staff may be dispatched in response to a system problem (manually or automatically). Tools may be provided for the on-line analysis of signal timings (split, cycle and offset).

Normal system administration functions such as central computer maintenance and software updates, changes in security and access, etc. are also performed through workstations at the Local TCC. For centrally controlled signal systems, new timing parameters or plans are generated at the Local TCC and downloaded to the field. Software updates for field devices may also be downloaded from the Local TCC, but more typically they require field PROM changes or direct connection with a laptop computer.

### 3.3.5 Security

There are two types of security relevant to the system and its environment:

1. **System security** that establishes access privileges for operational staff, and detects any system breaches. There are different options for providing system security ranging from individual levels of password access for different users, through establishing "roles" for categories of users such as the "system administrator", "operator", etc. In the latter case, passwords are used to identify a specific user, but each user has similar privileges as others in that category.

2. **Facility security** controls who has access to the Local TCC building/rooms, and detects physical breaches, intrusion, or vandalism. A Local TCC typically has a number of critical spaces including a control room, communications room, and computer room. Access to each is sometimes individually controlled.

## 3.4 External TMC Functions

### 3.4.1 Intra-Agency Coordination

The traffic-engineering department of an agency typically works closely with other internal departments such as public works, planning, maintenance and emergency services. Public works may provide input on planned roadway construction activity, unplanned events such as a water main break, and other information related to the street and utility infrastructure. Operations staff uses this information to update or create new response plans. In return, the public works department may be advised of infrastructure-related problems detected by the LCC.

System detector data provides a valuable source of traffic information for planning departments. Long term changes in urban development, and the street network, etc. impacts response plans and potentially the configuration/operation of field devices.

Maintenance staff may or may not be co-located at the LCC (more typically they are off-site at a maintenance yard or other location). An important function of the control site is to advise maintenance staff of field device malfunctions or routine maintenance functions. This may be pre-scheduled and/or the control site may have a direct dispatch facility.

Subject to the policies of the agency, there are typically links to local police, fire and other emergency services for the purpose of detecting and responding to incidents or events. Incidents detected by the system can be reported to emergency services, and they (particularly the police) may report accidents or other problems that impact traffic to the LCC.

For smaller agencies, the link with emergency services is usually by telephone or intercom. Larger TMC's (e.g. Caltrans District 7) may include an officer co-located in their Local TMC facility.

### 3.4.2 Inter-Agency Coordination

A key function of the IEN is to facilitate coordination with other agencies through the exchange of data and information. Data will flow between LCC's, Sub-Regional TMC's and the County TMC. Rules for the sharing of data and information may be created on a bi-party basis, or through group agreement, depending on the organizational structure and policies of the participating agencies. The following illustrates the kind of information that may be shared between agencies, but is not intended as a recommendation or as a statement of policy. Specific rules and permissions for information sharing will need to be developed by the participating agencies as the Project progresses.

Possible types of information sharing include:

- Exchange of signal timing and other response plans to facilitate coordination at jurisdictional boundaries, or along major arterials that cross multiple jurisdictions.
- Real-time exchange of system detector data to allow one agency to implement local timing and response plans in response to changing traffic conditions in an adjacent jurisdiction.
- Sharing of CCTV video images, potentially with access control to manage who has access to what images and under what conditions.

Inter-agency coordination also extends into the area of control, under which agencies can coordinate operations to ensure that signal timings best meet the current traffic conditions, this can be:

- On a planned basis, to cope with events as diverse as sporting venues and road closures. As the timing of the event is known, the impact can be anticipated and so mitigation plans can be drawn-up and programmed into the system to be implemented at the correct time.
- Automatically, on a real-time basis, using, for example, traffic responsive plan selection over a multi-jurisdictional area. This allows an ATMS to use traffic data from another agency for plan selection.
- Manually, so that an operator can request a plan for an intersection/section of an adjacent ATMS to address a particular traffic situation identified by the operator.

A specific example of this is coordinated response to freeway incidents. Freeway incident information will be received at the Sub-Regional TMC where it is evaluated. Should a match be found with pre-defined scenarios, and should a multi-agency response be required (e.g. the changing of arterial signal timings or displaying a dynamic message sign), then the request will be sent to the relevant systems to implement the response. The responses will be pre-defined and agreed between the agencies.

The incident information will also be passed on to the ATMS's for analysis and response. This is necessary for the event that a coordinated, multi-agency response is not required but the local agency has decided that under such conditions a response by that agency is necessary.

It should also be noted that the incident information is made available at the IEN workstations located in the agency facilities. Individual and multi-agency responses can be initiated from these workstations given the necessary access privilege.

Finally, there exists the opportunity to share control of field devices within a sub-region covered by two or more agencies for the purpose of implementing regional responses, or to allow agencies to share staffing resources, or simply to permit one agency to view the CCTV images of another and control the other agency's camera.

Specific agreements may be required for all the above types of information and control sharing, and may be subject to various operational restrictions such as time of day/hours of operation.

### 3.4.3 Transfer of Data for Traveler Information

The Local ATMS collects traffic data such as volume and occupancy from field devices, aggregates the data and deduces congestion parameters such as travel times and speeds. These parameters provide a measure of mobility status on roadways that can be a useful part of an Advanced Traveler Information System (ATIS). An ATIS is a means to distribute real-time information on road and traffic conditions to travelers for pre-trip planning and en-route guidance. The effectiveness of an ATIS system increases with area of coverage both geographically and functionally (across different modes). For this reason the traveler information function is typically performed at the Sub-Regional TMC or Regional TMC level where data from LCC's is aggregated. Hence, the local systems provide the data to the Sub-Regional and/or Regional TMC.

# 4 ATMS FUNCTIONALITY

## 4.1 Requirements Definition

From the definition of user objectives and needs, previous work identified the functionality required of the ATMS in the form of use cases. These use cases were then defined in more detail in the form of functional requirements. In order to define the content of the ATMS, which will be supporting each of the LCC's, it is necessary to understand the base functionality which is required to be present.

Appendix A presents the use cases and allocates them to the individual agencies according to the information derived from the operational objectives and analysis and needs definition. A simple analysis of these requirements has identified three potential components of the ATMS at an agency: a traffic control system, a CCTV system and a changeable message sign system (see Figure 4.1).

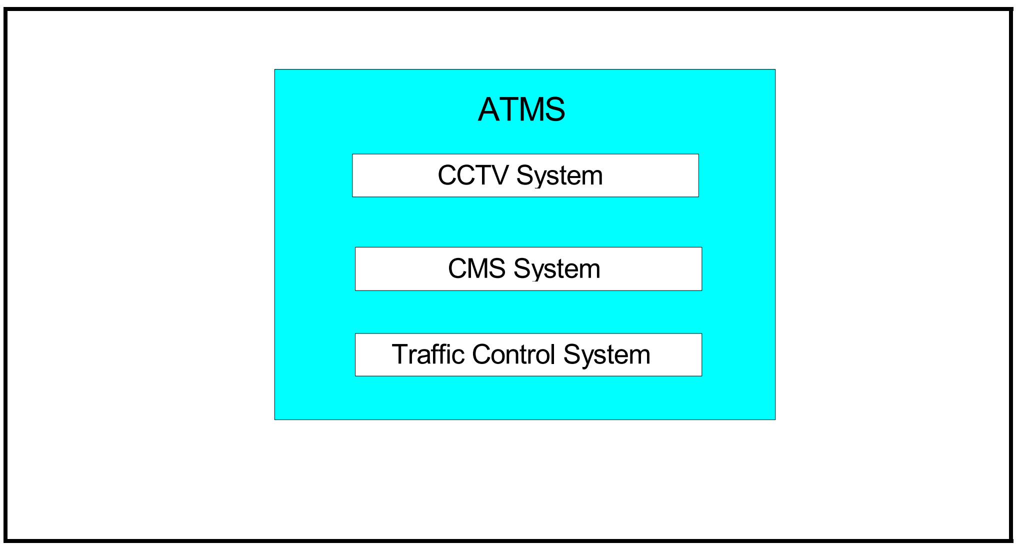



**Figure 4.1: Basic ATMS Components**

## 4.2 Allocating Functionality

Table 4.2 takes the ATMS definition and allocates the functionality according to the use case analysis presented in Appendix A. This identifies which functionality needs to be present in the ATMS to support the relevant LCC.

| | Traffic Control | CCTV Viewing Only | CCTV | CMS |
|---|---|---|---|---|
| Commerce | X | | X | |
| Downey | X | | X | |
| La Mirada | X | X | | |
| Montebello | X | X | | |
| Pico Rivera | X | X | | |
| Santa Fe Springs | X | | X | X |
| LA County DPW | X | | X | |
| Caltrans D7 | X | | X | |

**Table 4.2: Allocation of Functionality to LCC**

### 4.3 System Architecture Considerations

Section 4.2 illustrates that further differentiation needs to be made regarding the individual systems. While it is a requirement that it shall be possible to view/control CCTV images at all LCC's, it may not be the case that all agencies will have CCTV cameras on their facilities. At this stage of the system design, without a formal definition of the CCTV system, it is considered worthwhile to separate viewing/control of CCTV (CCTV manager) from CCTV image collection and distribution (which will be considered a sub-system including cameras). The CMS system can be considered as a manager with a CMS subsystem comprising signs. CMS control is considered analogous to traffic signal control and so resides solely with the local/operating agency. The Project scope has already identified the traffic control system as having a vehicle detection subsystem and a controller sub-system. This leads to the definition of the LCC architecture as shown in Figure 4.2.

In Figure 4.2, the ATMS components and the subsystems have been augmented with the interface to the IEN and on to the inter-systems communications network via a communications firewall for security purposes. The local IEN and ATMS workstations complete the local architecture components. This configuration complies with the requirements defined for the Integration System component of the Project (specifically that all inter-system communications go through the IEN) while still complying with the I-105 Corridor relationship as detailed in Section 2.2.2.

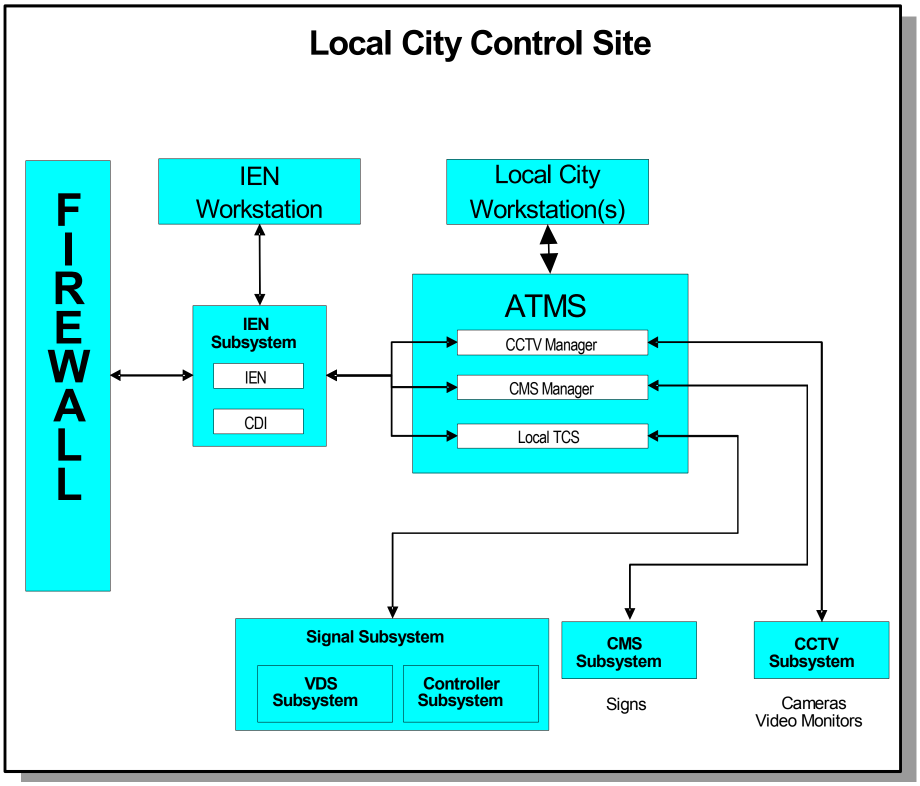



**Figure 4.2: LCC Architecture**

The resultant design introduces a change in the overall Gateway Cities Forum architecture as presented in the I-105 Corridor TMC High Level Design which did not pass all inter-system communications through the IEN. In addition, the I-105 Corridor architecture assumed the use of a specific solution (a video matrix switch) for video distribution. This component will be defined during the alternatives analysis and so should be represented simply as the CCTV sub-system at this point in the design process. The resulting revised corridor architecture is presented in Figure 4.3.

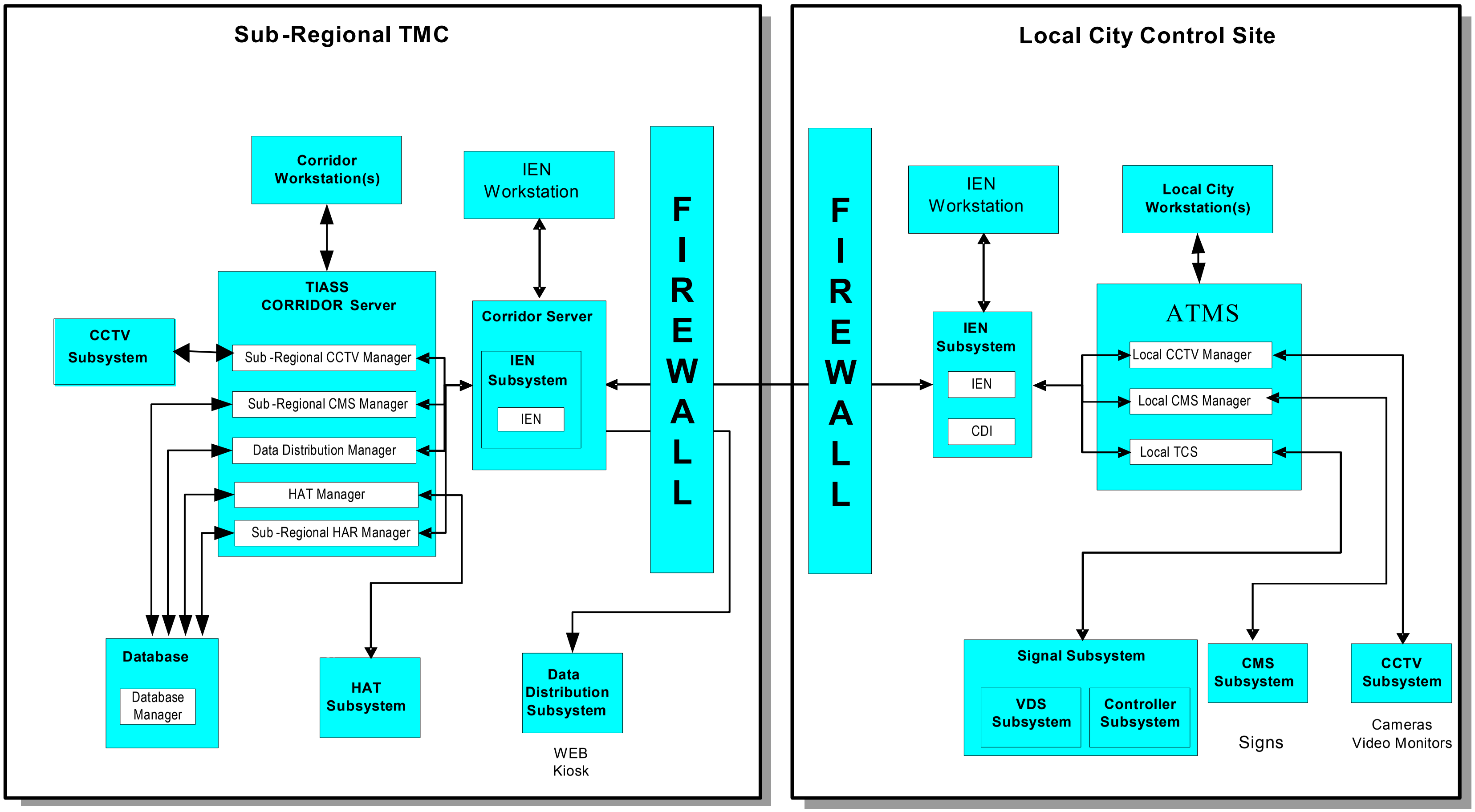



**Figure 4.3: Revised Corridor Architecture**

# 5 SYSTEM ARCHITECTURE

## 5.1 System Allocation

The operational objectives analysis, presented in the Project report "Stakeholder's Operational Objectives and Individual City Reports", made the following recommendations:

Caltrans

Intersections should be connected to Caltrans' future CTNET system at the District 7 TMC.

Commerce

The Project should result in a fully functional traffic control system located in the City of Commerce. This can be achieved either by upgrading the existing Bi Tran system or replacement with a new system. Controller firmware should be upgraded/replaced to support AB3418E protocol and controllers should be upgraded/replaced if NTCIP communications needs to be supported.

The upgrade of the current Bi Tran system to support the interface to the County's IEN should be investigated.

Montebello

The Project should result in a fully functional traffic control system located in the City of Montebello. Controllers should be upgraded in line with the County's policy for controller upgrades.

Downey

The Project should result in a fully functional traffic control system located in the City of Downey. AB3418E should be used as the communications protocol with the capability to upgrade to NTCIP in the future to accommodate the City's desire to secure future funding for adding ITS system components.

Pico Rivera

The Project should result in project intersections being connected to a fully functional traffic control system. Options are:

- Location of the system in the City of Pico Rivera, should the City agree to support the maintenance of the equipment.
- Connection of the City intersections in the Project area to the Downey system.
- Connection of the City intersections in the Project area to the County system.

Santa Fe Springs

The City desires to maintain Econolite as its supplier of traffic control equipment. The selection of the traffic control system should take into account and emphasize support for Econolite equipment.

La Mirada

The intersections in the City of La Mirada should be connected to the County's traffic control system.

County

Intersections should be connected to County's future traffic control system at the County TMC.

The only modification made to these recommendations since the writing of the Stakeholder's Operational Objectives and Individual City Reports would be to recommend that the City of Montebello not house its own system due to staff resource limitations. In addition, the close relationship between the Cities of Pico Rivera and Downey in traffic signal operations and maintenance would suggest that connection of the City of Pico Rivera's intersections in the Project area to the Downey system.

### 5.2 Overall Corridor Architecture

Given the recommendations presented above the following conclusions can be drawn regarding the placement of ATMS in the Project area:

(1) The City of Commerce and City of Santa Fe Springs will host their ATMS functions and IEN access in a dedicated LCC,

(2) The City of Downey will host the ATMS server functions and IEN access for the Cities of Montebello and Pico Rivera in its LCC, and

(3) The County DPW will host the ATMS server functions and IEN access for the City of La Mirada in the County TMC as well as the County's ATMS.

This allocation results in the Corridor architecture as presented in Figure 5.1.

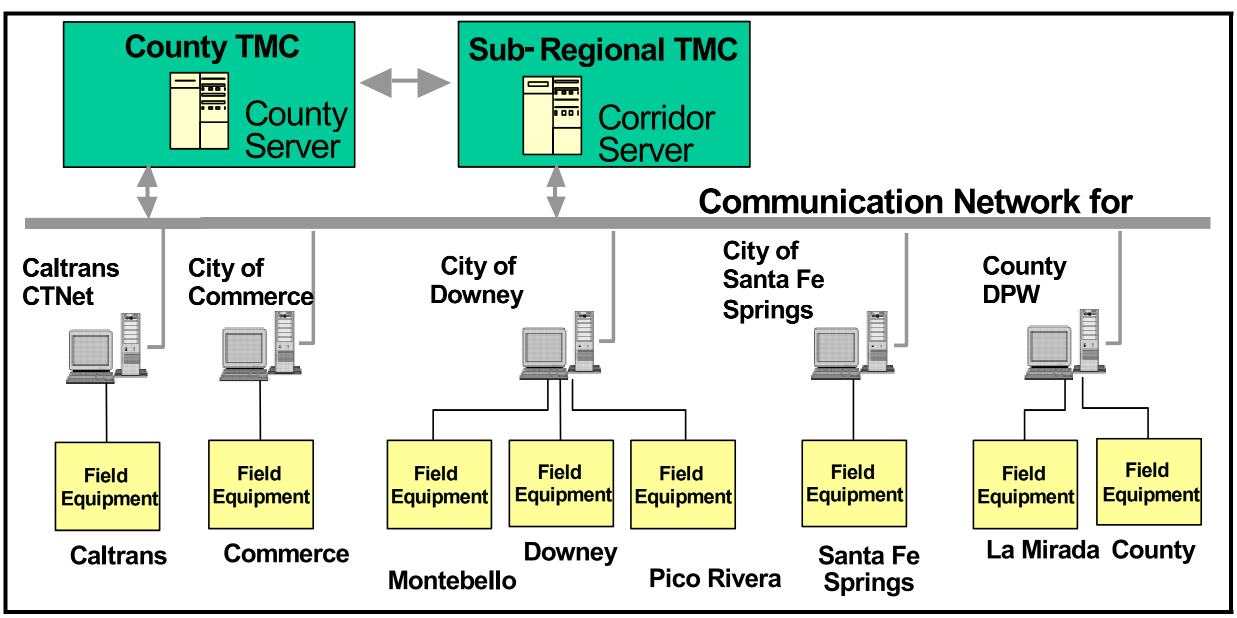



**Figure 5.1: I-5 Corridor System Architecture**

With this architecture, there are three types of LCC sites in the I-5/Telegraph Road Corridor:

(1) Sites with an ATMS client workstation(s) and IEN access:

   a. City of Montebello

   b. City of Pico Rivera

   c. City of La Mirada

(2) Sites with ATMS client workstation(s), ATMS server functions, and IEN access:

   a. City of Commerce

   b. City of Santa Fe Springs

(3) Sites with ATMS client workstation(s), ATMS server functions, IEN access, and hosting for field device communications for partner cities:

   a. City of Downey

   b. LA County TMC

The next Section of this document identifies the typical recommended configuration for the LCC in each of these cases. Design of the County TMC will not be addressed since it is outside the scope of this Project. It is recommended that a workstation within the TMC be used as a LCC for the City of La Mirada.

# 6 LOCAL CITY CONTROL SITES

The logical architectures and notional physical layouts of the three types of LCC's identified in Section 5.2 are described in this Section. These should be considered to represent only example, or "typical" configurations; actual LCC's will vary dependent upon the local conditions and individual agency requirements.

## 6.1 Stand-Alone LCC

The "stand-alone" LCC is a site with field communications, ATMS servers, ATMS workstations, IEN workstation, and access to the IEN all in one location and dedicated for the field equipment (TSMACS, CMS, CCTV, etc.) under control of a single city alone. Given the limited size of the systems supported in stand-alone fashion, large-format video projection is specified as an optional feature in the logical diagram, and probably not warranted. Figure 6-1 illustrates the logical architecture of a stand-alone LCC.

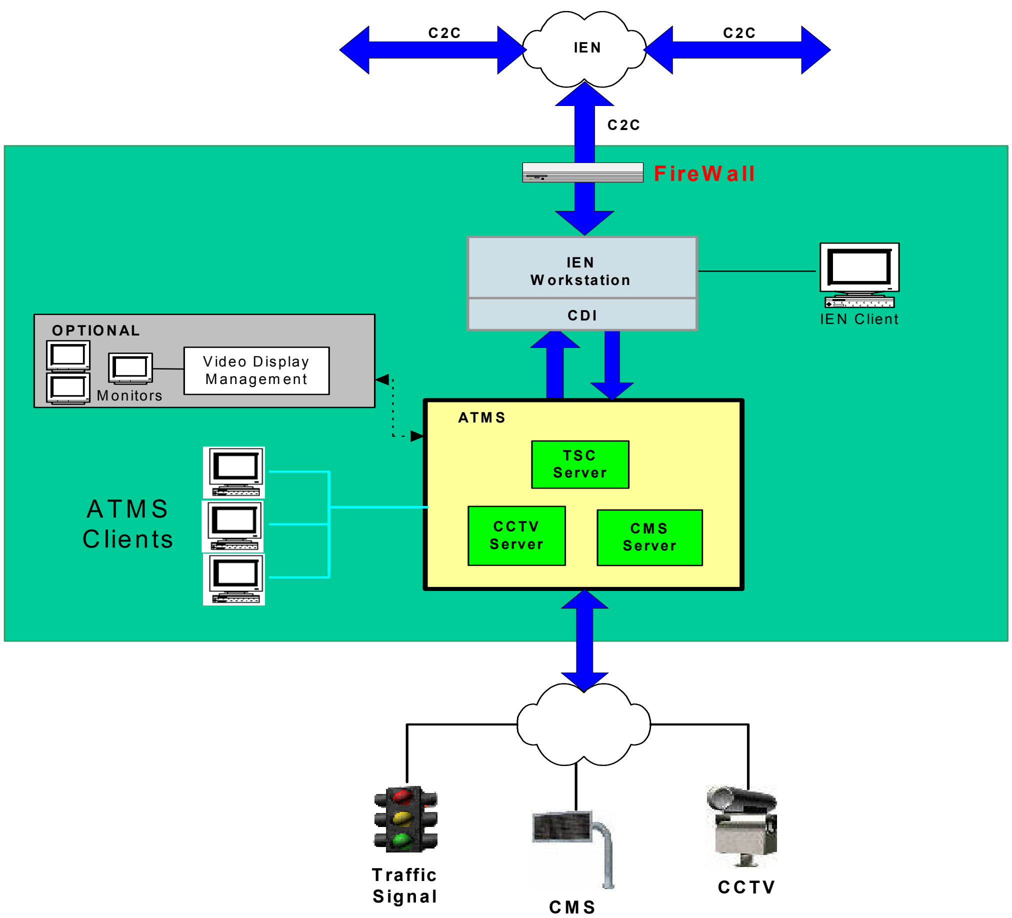



**Figure 6-1: LCC Logical Architecture**

The ATMS server functions include CMS, CCTV, and TCS. These features are typically provided with most COTS ATMS packages in an integrated fashion. If the elements are provided as separate applications, they can still be logically treated in the architecture as a component of the ATMS. Video feeds to the optional large-format video display system are shown with dotted lines because the logical connection between video feeds and the video management equipment is dependent on the video distribution scheme chosen (e.g. multicasting versus unicasting). HAR/HAT is listed as an optional service of the ATMS. ATMS clients connect directly to the ATMS servers via a LAN installed in the LCC. It is recommended that this LAN be dedicated to the LCC. The ATMS servers communicate with the CDI of the IEN workstation via the same LAN. Communications from ATMS servers to the field devices is dependent on the selection of the communications architecture (via WAN, serial, wireless, etc.).

The IEN client communicates directly with the IEN workstation via a separate LAN than the LCC LAN (or internal connections if the workstation and client are the same machine). and provides “view only” display of the Corridor conditions together with scenario response plan management. The IEN workstation allows the operators in the LCC to determine which data to publish from the ATMS, which data to subscribe to from the IEN, priority of field device control, user access configuration, and so on, according to the functional specifications of the IEN.

It is recommended that the IEN workstation and client are hosted on separate machines than those hosting the ATMS functions, foe the following reasons:

- This reduces the risk of loss of IEN access in the event of problems with the LCC LAN or ATMS.
- Hosting the IEN functions on the ATMS servers may introduce performance problems.
- The ATMS client workstations are already tasked with displaying a large amount of information as a result of which many systems support dual monitored workstations. Adding the IEN corridor displays would further aggravate this problem.

These logical functions are allocated to physical devices and equipment as shown in the physical architecture diagram of Figure 6-2. As can be seen, the anticipated equipment required for a Stand-Alone LCC is:

- ATMS Client PCs (2)
- IEN PC
- ATMS Applications server PC
- ATMS Database server PC
- CCTV Video display (server PC is shown but may also be a matrix switch)
- Communications server PC
- Field Communications equipment (i.e. modems, codecs, switches)
- Firewall device

Notes:

1. Two ATMS workstations are recommended, even if the LCC is intended to be staffed with a single operator. This is suggested primarily for the requirements of the LCC to view CCTV video images from the local city and other cities within the Project area. One ATMS client workstation can use its processor resources for CCTV and the other ATMS client can use its processor resources for TCS, CMS,

incident management, and other functions. The two workstations can also enhance the public relations appeal of the LCC by allowing more impressive displays of traffic management functions simultaneously without overlapping windows, etc. The second workstation may also be invaluable in incident situations where two operators could be required, or when police access to the incident management system is required.

2. Smaller systems may permit various combinations of applications/data base and communications server functionality. This is a performance issue determined by the size of the system and the capabilities of the specific ATMS.

All of the server and client PCs are connected via the same LAN. A firewall device is connected to the IEN PC to isolate the LCC LAN from the IEN communication network. It is also suggested that the LCC LAN be isolated from the general office LAN communications, if possible. A video projection control server PC is shown in Figure 6-2 as an optional item. These elements, as well as additional equipment, are shown in a notional LCC as illustrated in Figure 6-3.

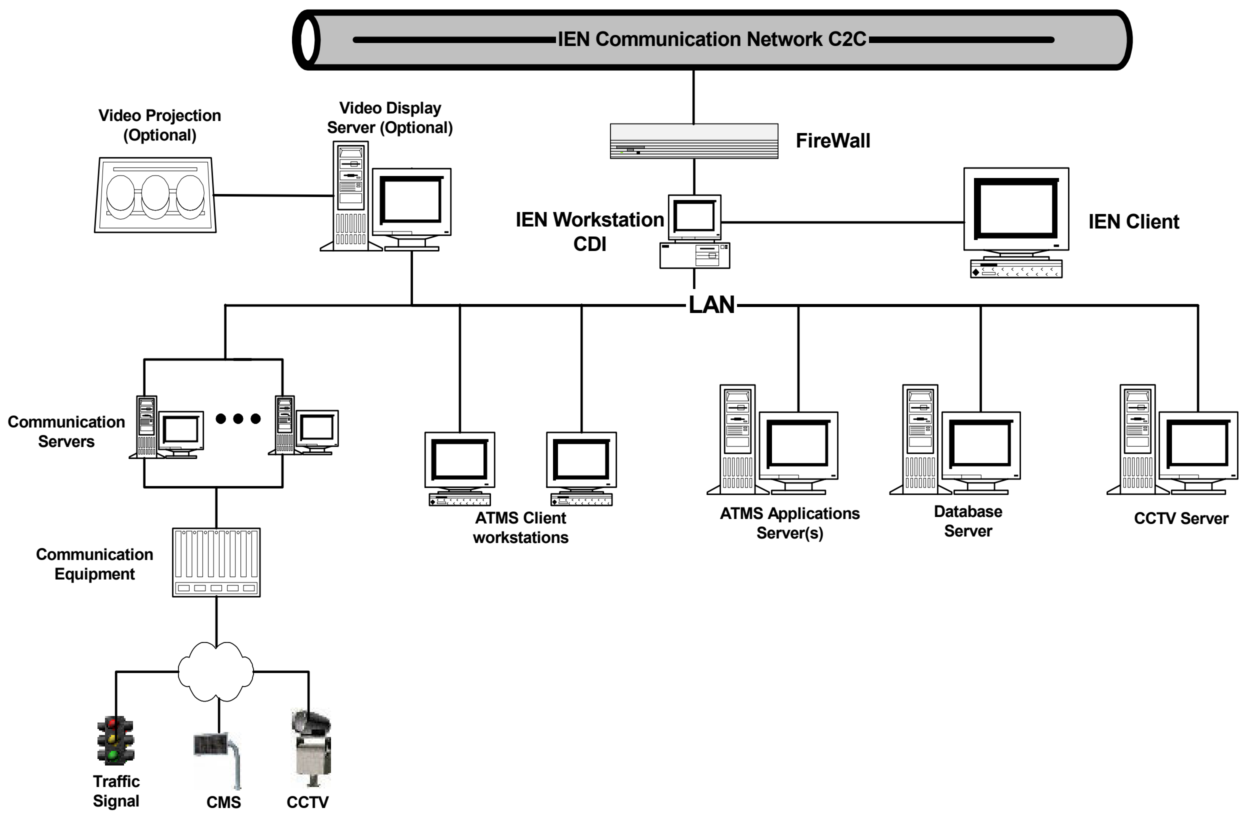



**Figure 6-2: Stand-Alone LCC Physical Architecture**

As shown in Figure 6-3, the LCC is comprised of two rooms. One room is used for the operator control functions and one room is used to house the communications and “back end” equipment. Example sizes for these rooms would be 14” by 16” for the operations area and 14” by 7’ for the equipment room. This operation room would be too small to justify a video projection unit.

### 6.1.1 Operator Control Room

The operator control room contains:

(1) Two ATMS workstations with dual flat screen displays

(2) Two phone lines

(3) Fax machine

(4) Printer

(5) IEN client workstation

(6) Storage area, credenza – for reference materials, manuals, etc.

(7) Sufficient LAN access points for all workstations

(8) Combination punch lock access (for security)

(9) Ambient overhead lighting (not shown)

(10) Task lighting (not shown)

(11) Sufficient power receptacles (not shown)

(12) Dedicated climate control (not shown)

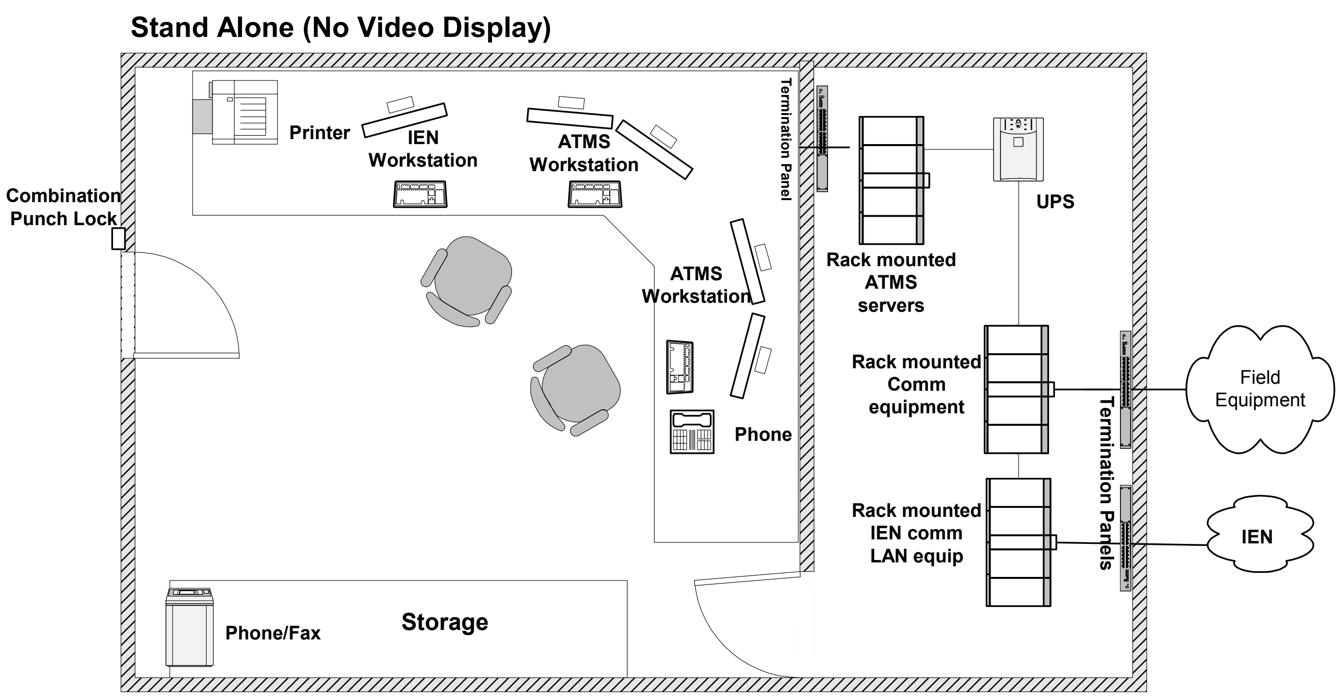



**Figure 6-3: Stand Alone LCC Physical Layout**

### 6.1.2 Equipment Room

The equipment room contains:

(1) ATMS server equipment

(2) IEN workstation server equipment

(3) LAN/WAN communications equipment, including, at minimum:

  i. Firewall,

  ii. LAN switch with full wire-speed back-plane

(4) Field device communications equipment

(5) IEN communications equipment

(6) Associated cabling

(7) Termination panels

(8) UPS unit(s)

(9) Sufficient WAN access point(s)

(10) Ambient overhead lighting (not shown)

(11) Sufficient power receptacles (not shown)

(12) Dedicated climate control (not shown)

The equipment room is accessible directly from the operator control room with a closeable door. With the limited number of operators, this room is probably not required to be accessible without entering the operator control room (i.e. another door on the opposite side of the room). An alternative design would require operators to enter the control room through the equipment room, but this alternative is less desirable from a public relations standpoint. The notional equipment room layout groups the back-end equipment into racks by the type of equipment. Three racks are probably required, at minimum. Location of termination panels in the diagram is not intended to be physically accurate but only indicative of the presence of individual independent access points to: (a) field equipment, (b) WAN to ATMS clients, (c) the IEN. Dedicated climate controls in the equipment room are required because of the differences in the significant HVAC needs between the equipment room and the control room.

## 6.2 LCC Hosting Additional City's Field Communications

A hosting LCC is a site with field communications, ATMS servers, ATMS workstations, IEN workstation, and access to the IEN all in one location with support for the field equipment (TSMACS, CMS, CCTV, etc.) of the host city as well as the field equipment of other hosted cities. For the I-5/Telegraph Road Project, this arrangement applies to the City of Downey and, to some extent, the County, although its hosting responsibilities are likely to be more demanding due to the larger number of agencies involved. Large-format video projection is specified as an optional feature in the logical diagram, but is included in the physical layout to illustrate the layout of the equipment and control rooms if large-format video display is included in the final design. Figure 6-4 illustrates the logical architecture of a host LCC.

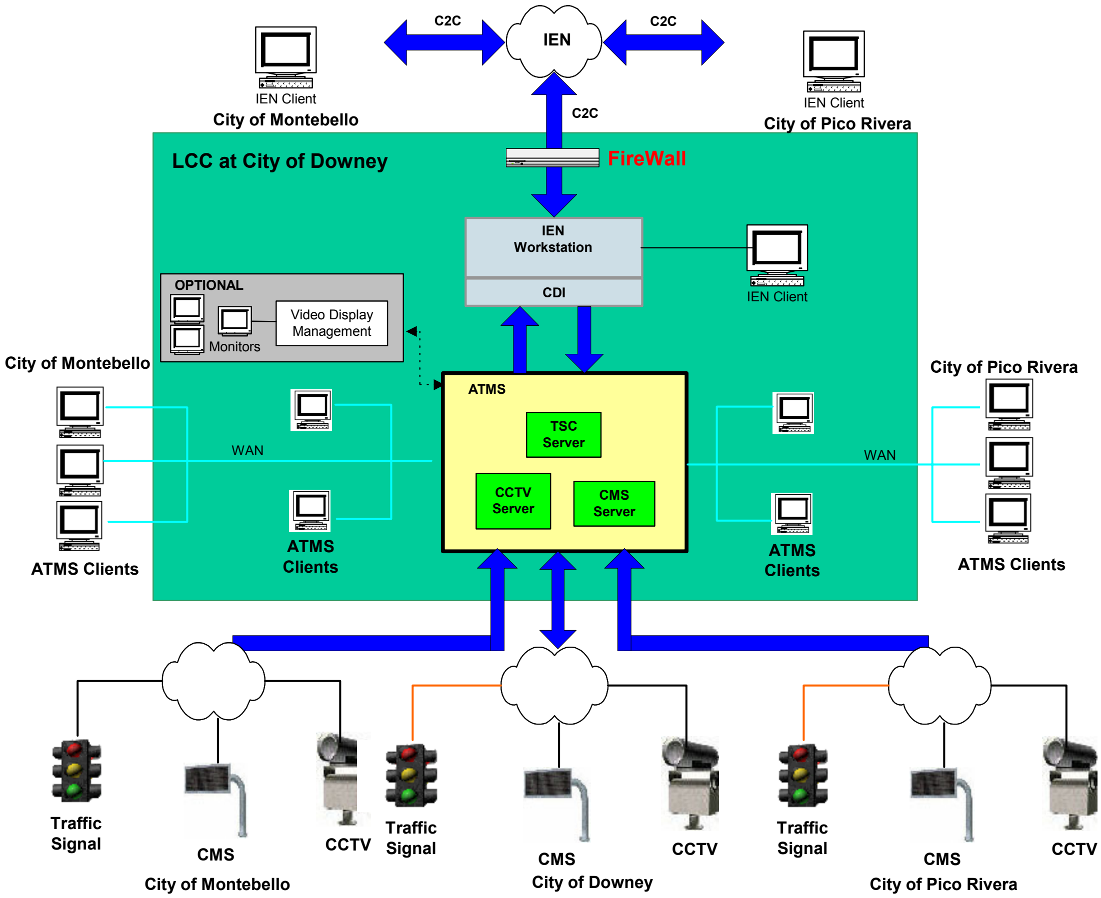



**Figure 6-4: LCC with Hosting - Logical Architecture**

The ATMS server functions include CMS, CCTV, and TCS. These features are typically provided with most COTS ATMS packages in an integrated fashion. If the elements are provided as separate applications, they can still be logically treated in the architecture as a component of the ATMS. Video feeds to the optional large-format video display system are shown with dotted lines because the logical connection between video feeds and the video management equipment is dependent on the video distribution scheme chosen (e.g. multicasting versus unicasting). HAR/HAT is listed as an optional service of the ATMS. ATMS clients within the control room connect directly to the ATMS servers via a LAN installed in the LCC. Additional ATMS clients located in the hosted cities (and other locations on the LAN or intranet within the City of Downey) connect to the ATMS servers via the WAN or dial-up connections, as appropriate.

It is recommended that the LAN in the LCC be dedicated to the LCC and operate at 100Mb full-duplex speed or better (i.e. the ATMS servers and associated equipment should not share LAN resources with general office email traffic, file transfers, internet browsing, etc.). The ATMS servers communicate with the CDI of the IEN workstation via the same LAN. Communications from ATMS servers to the field devices is dependent on the selection of the communications architecture (via WAN, serial, wireless, etc.). The IEN workstation client communicates directly with the IEN server via LAN (or internal connections if the server and client workstation are the same machine). Additional IEN clients in the City of Montebello and City of Pico Rivera communicate to the IEN workstation via the IEN. The workstation client provides "view only" display of the Corridor conditions. The IEN configuration client allows the operators in the LCC to determine which data to publish from the ATMS, which data to subscribe to from the IEN, priority of field device control, user access configuration, approval of scenario response plans, and so on, according to the functional specifications of the IEN.

These logical functions are allocated to physical devices and equipment as shown in the hardware architecture diagram of Figure 6-5.

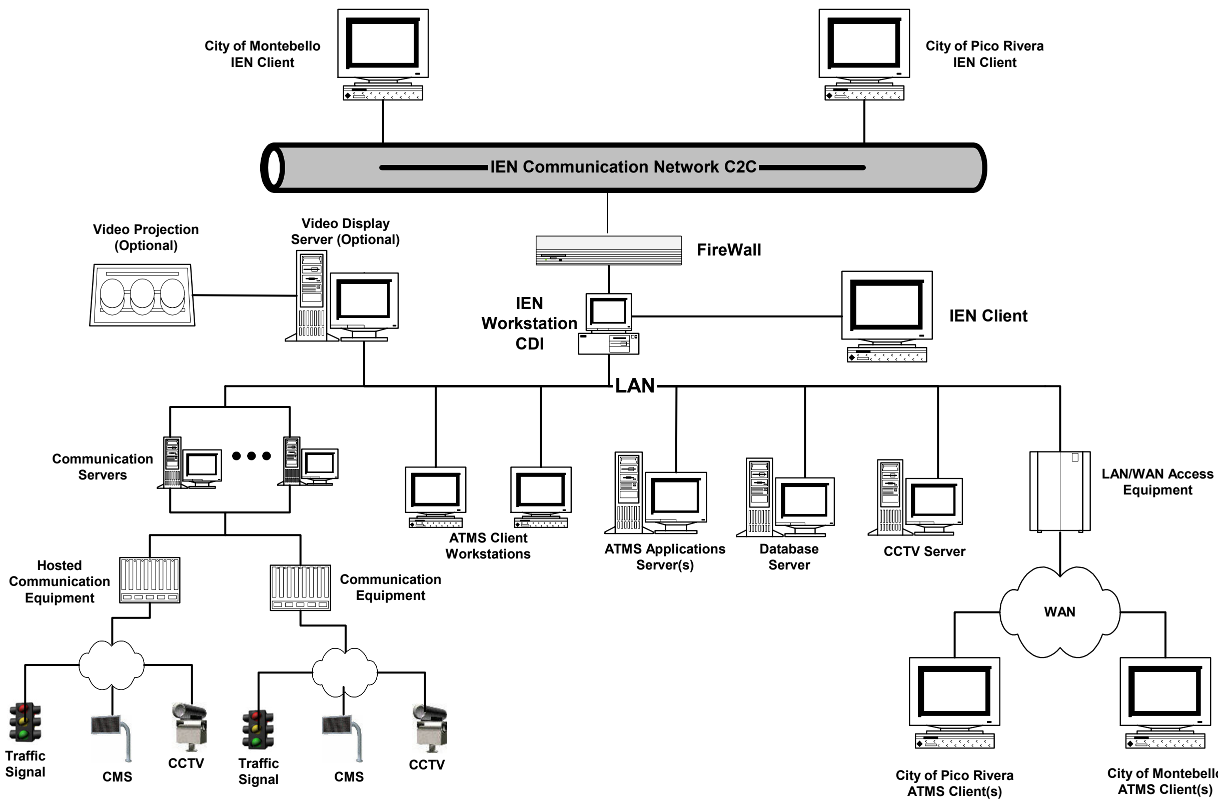



**Figure 6-5: LCC With Hosting - Physical Architecture**

As shown in Figure 6-5, the anticipated equipment required for the hosting LCC are:

- ATMS Client PCs (3)
- IEN PC
- ATMS Applications server PC
- ATMS Database server PC
- CCTV Video display (server PC is shown but may also be a matrix switch)
- Communications server PCs (3)
- Field Communications equipment (i.e. modems, codecs, switches)
- Firewall device
- WAN access equipment

Notes:

1. An additional TMS workstation is recommended over and above the previous LCC design (Section 6.1.1) as more than one City is being accommodated, increasing the likelihood of multiple operators needing to be accommodated. Also this is suggested for the requirements of the LCC to view CCTV video images from the local city and other cities within the Project area. Three workstations allow an ATMS client to be "zoomed in" on to the Project area for a specific city for all three cities simultaneously. Again, this is desirable from a public relations standpoint as well.

2. Smaller systems may permit various combinations of applications/data base and communications server functionality. This is a performance issue determined by the size of the system and the capabilities of the specific ATMS.

All of the server and client PCs are connected via the same LAN, except for those clients in Pico Rivera and Montebello connected via the WAN. A star configuration LAN with 100MBps capacity full-duplex connections to each server PC and a wire-speed, non-blocking backplane central switch for inter-PC communications is suggested. A firewall device is connected to the IEN PC to isolate the LCC LAN from the IEN communication network. It is also suggested that the LCC LAN be isolated from the general office LAN communications, if possible. A Video projection control server PC is shown in Figure 6-5 as an optional item. In addition, there may be a need for an additional CCTV video server as the system grows. These elements, as well as additional equipment are shown in a notional LCC with hosting as illustrated in Figure 6-6.

As shown in Figure 6-6, the LCC is comprised of two rooms. One room is used for the operator control functions and one room is used to house the communications and "back end" equipment. Example sizes for these rooms would be 20" by 20" for the operations area and 20" by 12' for the equipment room. Depending on the design of the control room, there may not be a significant space saving if no video projection unit is present.

### 6.2.1 Operator Control Room

The operator control room contains:

(1) Three ATMS workstations with dual flat screen displays

(2) Three phone lines

(3) Fax machine, or fax/phone service

(4) Printer

(5) IEN workstation

(6) Storage area, credenza – for reference materials, manuals, etc.

(7) Sufficient LAN access points for all client workstations

(8) Combination punch lock access (for security)

(9) Ambient overhead lighting (not shown)

(10) Task lighting (not shown)

(11) Sufficient power receptacles (not shown)

(12) Dedicated climate control (not shown)

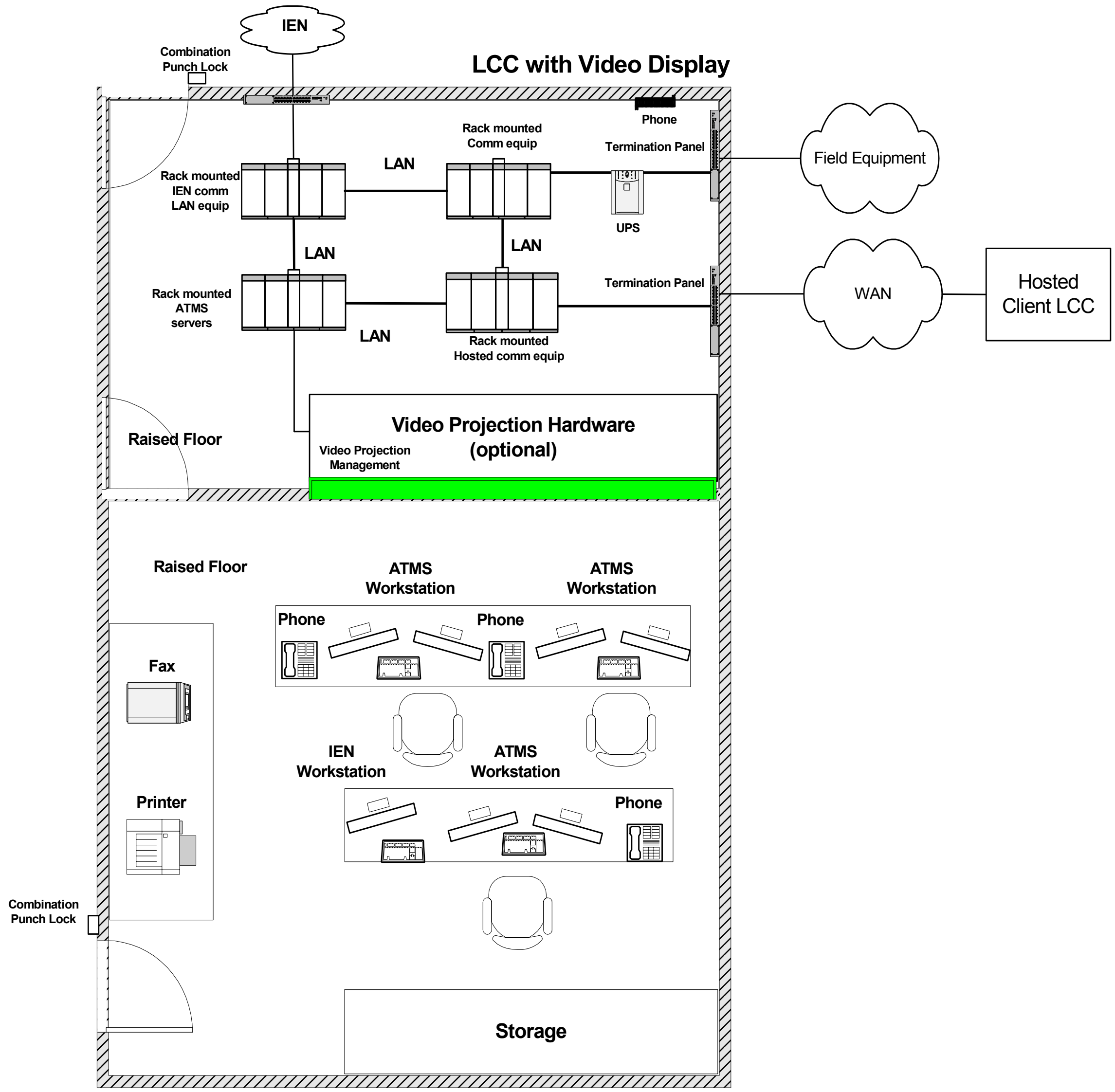



Figure 6-6: Hosting LCC Physical Layout

The notional hosting LCC is shown with large-format video projection capability, although the decision may not be consistent with the final design. If the large-format video display is not required or constrained by limited funding, the final LCC design for the hosting facility would appear more like the LCC design for the stand-alone LCC, with:

(1) Additional racks of communications equipment and termination panels for the hosted city's equipment.

(2) Redesigned operator workstation room layout for three workstations (minimum) – i.e. visibility to the video wall is not required, so the desks do not need to be arranged with common view in the same direction (it may be more desirable for the workstations to be in a semicircle).

### 6.2.2 Equipment Room

The equipment room contains:

(1) ATMS server equipment

(2) IEN workstation server equipment

(3) Host city LAN/WAN communications equipment, including:

   i. firewall

   ii. LAN switch with full wire-speed back-plane

(4) Host city field device communications equipment

(5) Hosted city (cities) field device communications equipment

(6) IEN communications equipment

(7) Video projection equipment

(8) Video display management equipment

(9) Telephone

(10) Associated cabling

(11) Termination panels

(12) UPS unit(s)

(13) Sufficient WAN access point(s)

(14) Ambient overhead lighting (not shown)

(15) Sufficient power receptacles (not shown)

(16) Dedicated climate control (not shown)

The equipment room is accessible directly from the operator control room with a closeable door. In addition, because of the increased amount of field and video projection equipment, the equipment room is accessible from the outside via combination lock without entering the operator control room. The intent is to limit the disruptions to operator tasks by maintenance personnel. If only one door can be allocated for the LCC, operators would enter the control room through the equipment room. This alternative is less desirable from a public relations standpoint, however.

The notional equipment room layout groups the back-end equipment into racks by the type of equipment. Location of termination panels in the diagram is not intended to be physically accurate but only indicative of the presence of individual independent access points to: (a) field equipment, (b) WAN to off-site ATMS clients, (c) the IEN. Dedicated climate controls in the equipment room are required because of the differences in the significant HVAC needs between the equipment room and the control room.

## 6.3 Client-Only LCC

A Client-Only LCC is a site at a city with an only an ATMS workstation and IEN client, as it's ATMS is hosted at another agency. The communications for the city's field devices are also hosted at the LCC of the host city. This applies in the I-5/Telegraph Road Project to the City of Montebello (hosted by Downey), City of Pico Rivera (hosted by Downey), and City of La Mirada (hosted by the County).

Refer to Figure 6-3 for the logical connection of the ATMS/IEN clients to the hosted LCC. ATMS clients connect to the ATMS servers via a WAN. IEN clients connect to the IEN workstation servers via the IEN. It is recommended that the WAN connection from the LCC to the hosted ATMS servers be at least T1 or better, and if possible, not share LAN resources with general office email traffic, file transfers, internet browsing, and so on. The ATMS workstation allows operators to manage field devices in their jurisdiction and view the status of field devices of the host city and other cities that are hosted at the host LCC in the common ATMS interface. The IEN workstation client provides "view only" display of the Corridor conditions and scenario response plan management.

These logical functions are allocated to physical devices and equipment as shown in the physical architecture diagram of Figure 6-7.

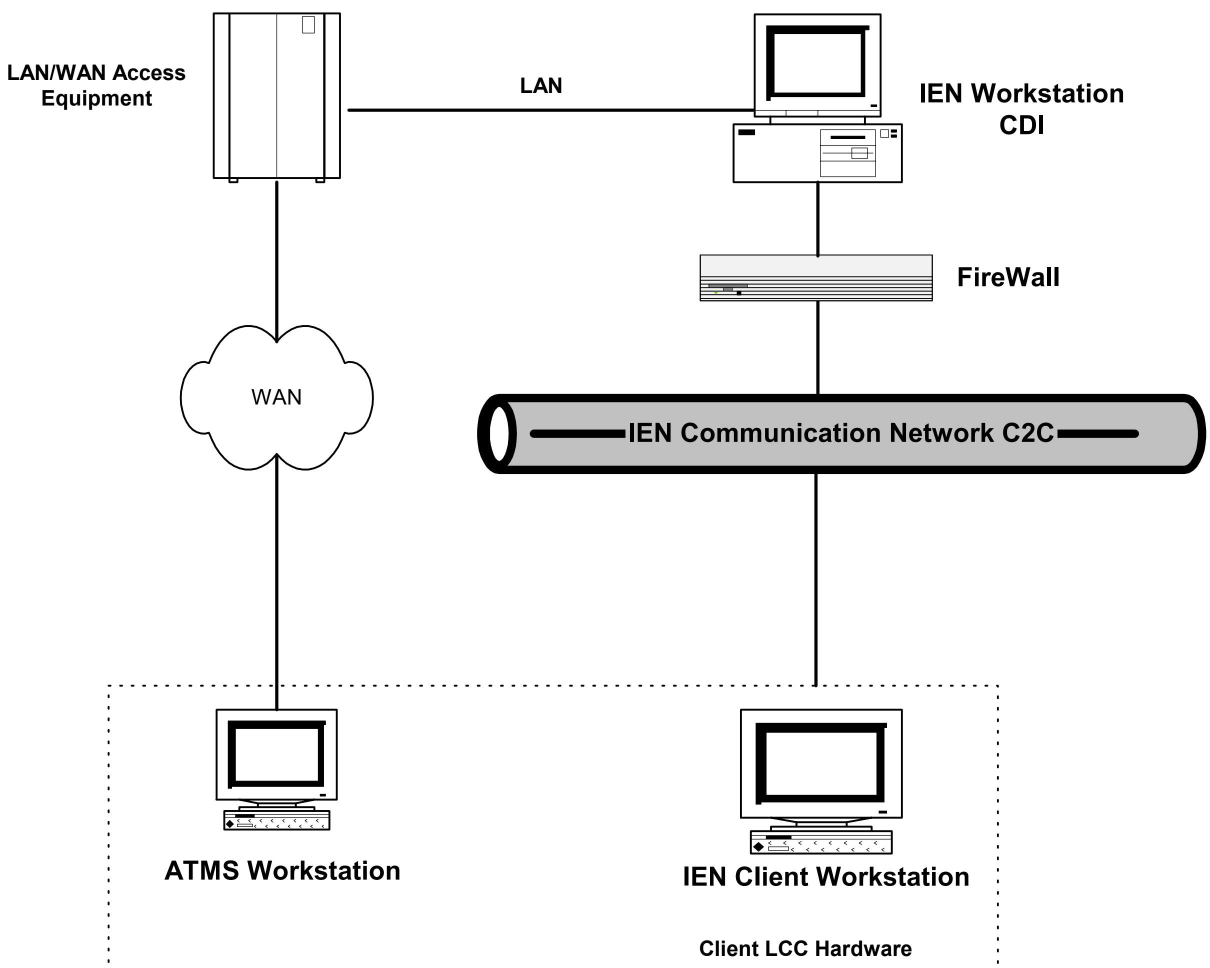



**Figure 6-7: Client-Only LCC Physical Architecture**

As shown in Figure 6-7, the anticipated equipment required for the Client-Only LCC are:

- ATMS Client PC
- IEN PC
- IEN access equipment
- WAN access equipment

The ATMS client PC and IEN PC should not be nor should the ATMS client software and IEN client software can run on a single machine. The IEN access equipment and WAN access equipment are also probably the same device, although there is no requirement that this is the case.

These logical functions are allocated to physical devices and equipment in a notional control room as illustrated in Figure 6-8.

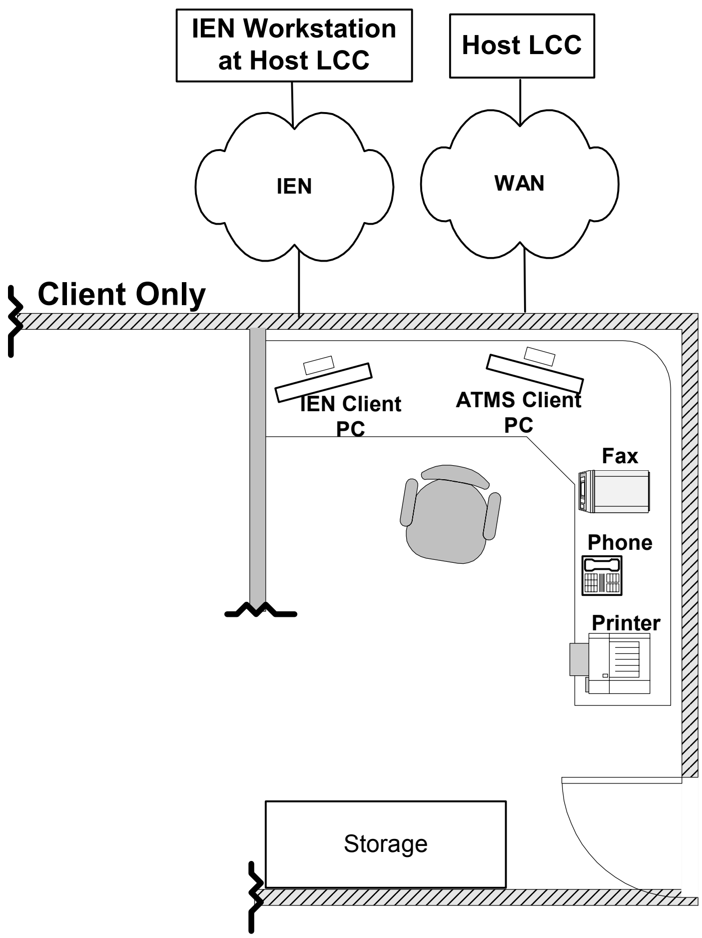



**Figure 6-8: Client-Only LCC Physical Layout**

As shown in Figure 6-5, the LCC is comprised of a single room or possibly a cubicle in a larger multi-purpose work area, since there is no requirement to house the ATMS, IEN, and communications servers in the Client-Only LCC. There are no compelling reasons for the

Client-Only LCC to have dedicated climate controls, combination locks, or even be located in a dedicated office. Security can be provided by software applications for the IEN and ATMS workstations. Privacy and environmental controls are no more stressing than a normal office environment. All that is required in the cubicle is connectivity to the IEN and WAN.

### 6.3.1 LCC Room

The LCC room contains:

(1) One ATMS workstation with flat screen display (dual flat screens are an option)

(2) One phone line

(3) Fax machine (or fax service on ATMS workstation)

(4) Printer

(5) IEN client workstation with flat screen display

(6) Storage area, credenza – for reference materials, manuals, etc.

(7) Sufficient LAN/WAN access point(s)

(8) Ambient overhead lighting (not shown)

(9) Task lighting (not shown)

(10) Sufficient power receptacles (not shown)

(11) Dedicated climate control (not shown)

Only one ATMS workstation is recommended, since the LCC is intended to be staffed only "part-time" by a single operator.

# 7 VEHICLE DETECTION SYSTEM

## 7.1 Background

In the Gateway Cities, there exists a need to capture traffic data for both real-time traffic signal operations and to support transportation planning efforts, and to be able to detect incidents in the corridor. Further, this information must be shared between the jurisdictions and agencies in the corridor. It is from the vehicle detection system that these needs and requirements are met.

Detectors are used as sensors to collect data for a number of system functions. They are in essence the surveillance subsystem that provides necessary data to the signal system for such functions as, timing plan selection, critical intersection control, information for planning purposes, and incident detection.

### 7.1.1 Characterizing Detection

Detector type and location requirements within a signal system are dependent upon the control strategy being employed. To better understand how detection requirements relate to the control strategy, one has to understand the different detector functions (as opposed to technologies).

- *Local Detection:* Detection located at the intersection for the purpose of calling or extending a phase. These detectors are connected directly to the local controller and their data affect the local controller's timing only. Detection at the intersection also provides information about incidents in the measurements of detector occupancy and volumes.

- *Advanced Detection:* Detection located close to the intersection, usually between 250 and 300 feet. These types of detectors are used to extend the phase. Advanced detection can be used as system detectors aslong as the DLC cables coming back to the cabinets are not joined together. Individual lane information can be gathered from the advanced detectors and detector are set in passage mode.

- *System Detection:* Detection typically located between intersections to provide the central system or master controller with information (typically volume & occupancy) to control and coordinate multiple interconnected signals. System detection, too, provides the function of incident detection through the same means as local detection. Further, the system detection supplies the advanced traffic management system with real-time traffic condition information.

Figure 7-1 is a schematic that illustrates these three types of detectors. Each collects data that can be used to optimize traffic flow through an advanced traffic management system (ATMS). Within an ATMS the detectors are used to support different control strategies. Time-of-day control doesn't require system detection since its timing plans change based upon a time clock. Local detection, though, is necessary for protected phasing actuation, side road actuation, and extensions. Traffic responsive and traffic adaptive control require system detection to provide timely information on current traffic conditions and trends so that the timing plans can be changed automatically as conditions warrant. For example, as it lies parallel to the I-5 Freeway, Telegraph Road has a function as a freeway alternate. It is necessary to know the traffic conditions on this arterial either before assigning this as an alternate or in order to know which signal timing plan would be the most appropriate for accommodating the additional traffic.

A separate program is being implemented by the County DPW to address the design and provision of local detection. The I-5/Telegraph Road Project is focusing on system detection,-to be accommodated either by dedicated system detectors or suitable advanced detectors, or both.

#### 7.1.2 User Needs for System Detection

Within the Gateway Cities (Project) area, agencies originally identified a number of traffic management needs requiring vehicle detection including:

- Improved mobility through improved traffic signal timings.
- Improved traffic signal operations.
- Information sharing.
- Traffic condition monitoring.
- Automated notification of congestion and incidents.
- Video surveillance.
- Automated data collection and timing plan generation.

In addition, a desire was expressed to replace Inductive loops with a technology not susceptible to failure with pavement deterioration, while one city preferred to continue with its use of loops.

Later an additional need was identified, that of security, in the form of identifying stopped vehicles. This is contributory to enhancing the security of the transportation network as well as an early response to the cause of non-recurring congestion on the arterial incident.

These identified needs have corresponding requirements for ATMS functionality which require system detectors to provide information. System detector stations collect real time data on highway traffic flow. The data is used for traffic management functions such as detecting incidents, traffic flow information, and archiving for planning and historical analysis. System detection provides the capability to monitor and manage both recurring and non-recurring congestion. For example, the latter would trigger the congestion alarm; the former may be used in conjunction with traffic responsive plan selection.

Requirements have been identified for the following data to be on a lane-by-lane basis:

- Volume
- Occupancy
- Speed

At present, the system detection in I/5 Telegraph Road Project area consists of advanced detection on some major approaches. Previous studies, along with this effort, have demonstrated the benefits to be derived from upgrading the traffic management systems in the Project area. It is clear that system detection covering all major approaches must also be provided in the Project area.

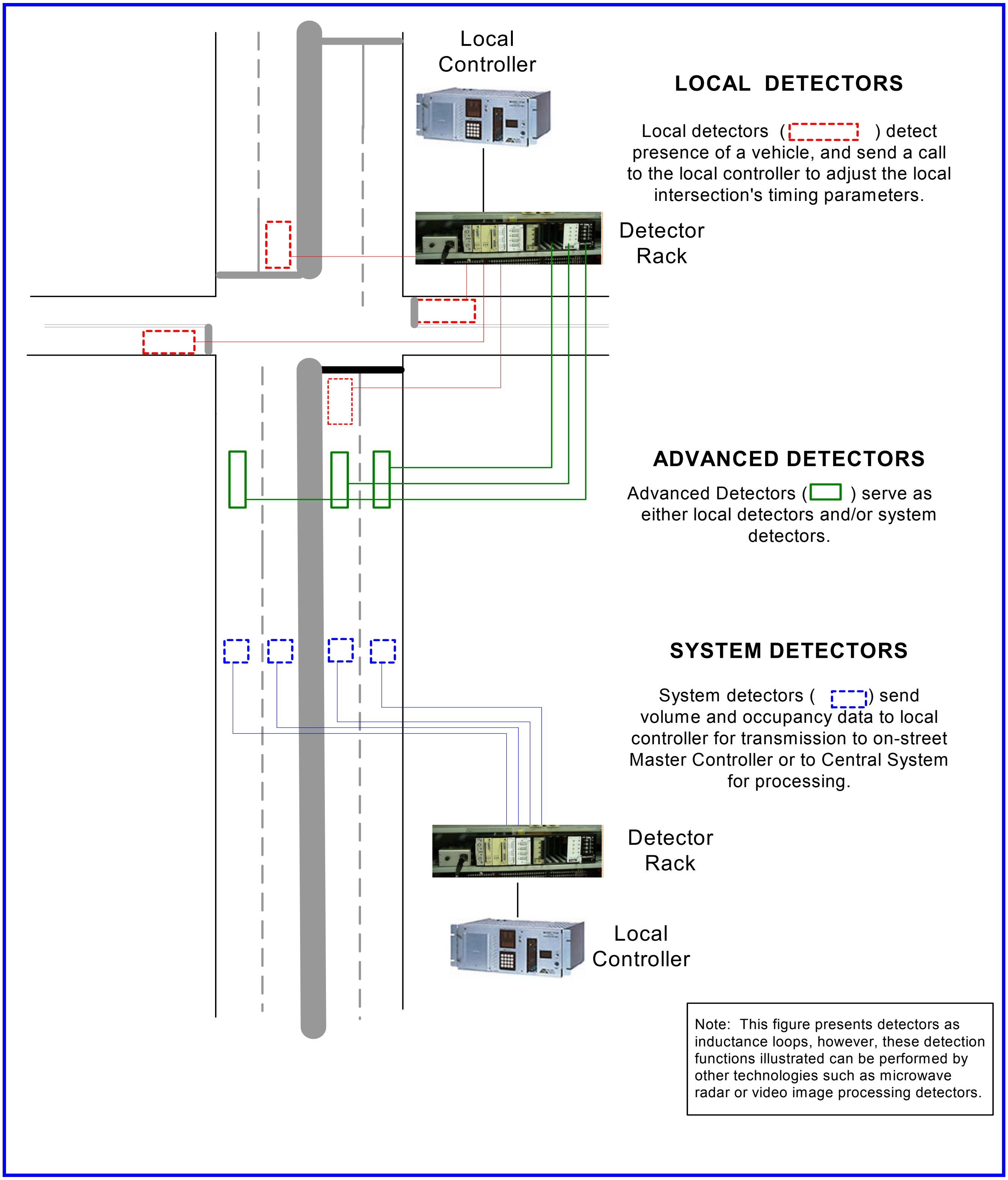



**Figure 7-1: Detector Functional Type**

### 7.1.3 Candidate Detection Technologies

An analysis of current detection technologies was conducted previously in this Project and presented in the report*: Deliverable 3.2.1; ATMS Functional And Local Traffic Control Center Requirements*". That analysis led to a recommendation of three detector technologies: Inductive loops (in-pavement), microwave radar (above-pavement), and video image detection systems (VIDS, above-pavement). The recommendations were based upon compliance to the functional specifications, requirements of Gateway Cities' agencies, technological maturity, reliability, ease of implementation, and cost. These candidate detection technologies are the focus of the analysis, which follows in this report.

### 7.1.4 Detector Placement

Paramount to successful system detection is the placement of the detection. Basic guidelines that apply include:

- Detection should be placed outside of any "weaving" areas along the arterial.
- For non-intersection areas, detectors should be placed away from lane-drops, acceleration/deceleration lane introductions, and other similar features.
- Placement of side-fire microwave detectors and VIDS (on poles) must be outside of the clear zone if breakaway pedestal bases are not used, and is good practice even with breakaway bases.
- Placement of side-fire microwave detectors and VIDS (on poles) should be accessible for maintenance vehicles (e.g., bucket trucks).

Based on these guidelines, the following is recommended for placement locations of the system detection in the I-5 Telegraph Road Project area:

- The system detectors should be placed 250ft to 300ft upstream of intersections except in cases:
  1) Where the distance between the intersection is greater than half a mile
  2) Where the traffic volumes are high enough that the queues are expected to back-up past the system detectors.

## 7.2 Configuration and Detector Layout

### 7.2.1 Inductive Loop Detectors

*System Detector Configuration / Layout*

Inductive loops are installed in the pavement as single loops to collect volume and occupancy data (Figure 7-2). If speed data is necessary, the loops need to be configured in a "trap" configuration; two loops spaced at a consistent distance apart (typically 16-ft) leading edge to leading edge to collect speed data (Figure 7-3).

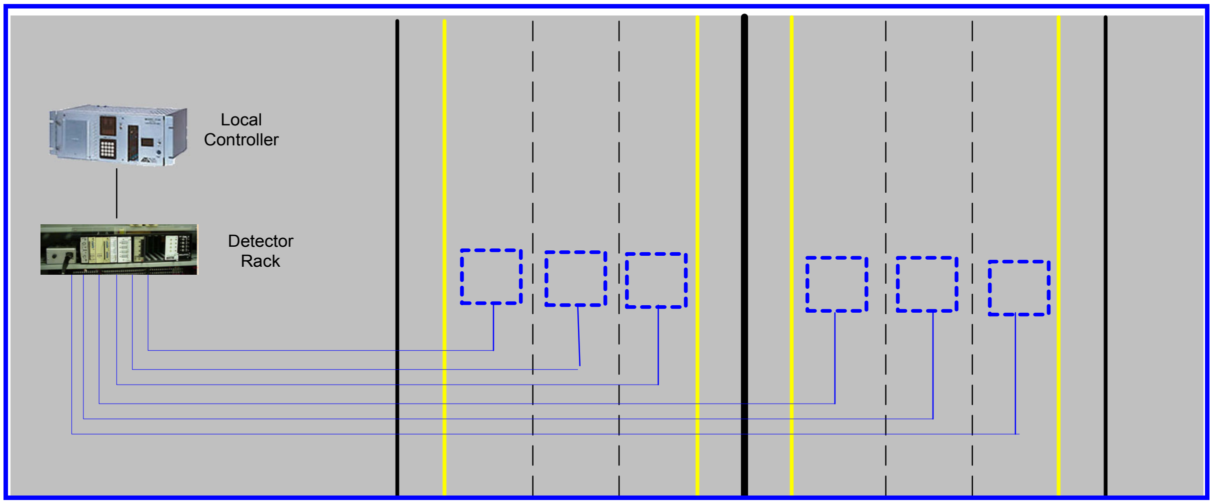



**Figure 7-2: Loop Configurations for Volume and Occupancy**

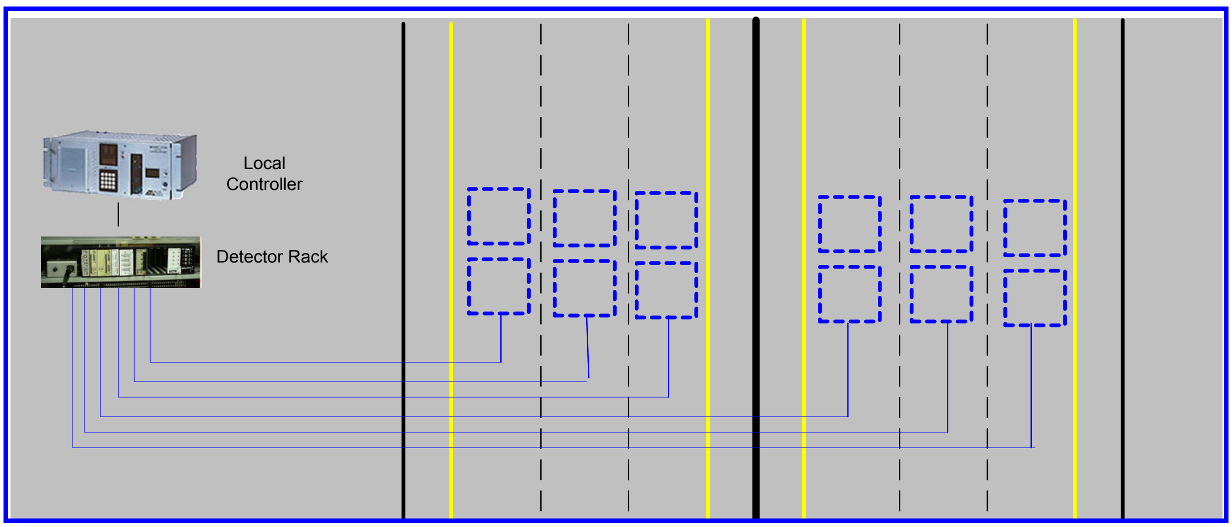



**Figure 7-3: Loop Configurations for Speed Data**

Each loop is connected to a detector unit housed in a controller cabinet via a lead-in cable between the loop and the cabinet. Typically, a maximum of 24 loops can be housed in a 170 controller cabinet. Advanced developments with 2070 controllers are capable of handling 64 detectors in a controller cabinet. Loop amplifiers are required for each loop pair as well in the cabinet.

The detector unit makes presence and passage data available to the controller unit which processes the data and makes it available to the central system upon request. This processing is typically calculation of vehicle counts (volumes) and loop occupancy, but may also include speed calculation.

*Miscellaneous Issues*

As Inductive loops are in the pavement, their installation and maintenance are the most disruptive to the traffic stream of any devices currently being used. This is a major weakness, along with their high failure rate (about 10% per year) generally caused by poor installation techniques or installation in poor quality pavement. In the event of failure of the loop, the only remedy is replacement of the whole loop. In addition, when the road system “footprint” changes the investment into cutting the loops is lost.

### 7.2.2 Microwave Detector

Microwave detectors are above-ground units mounted either over a traffic lane (e.g., on a bridge overpass or sign structure), or along the side of the arterial mounted on a pole in a “side-fire” (see Figure 7-4) configuration approximately 15 feet high. For microwave detectors mounted over a traffic lane, speed can be measured, whereas via side-fire configuration, the speed parameter is calculated.

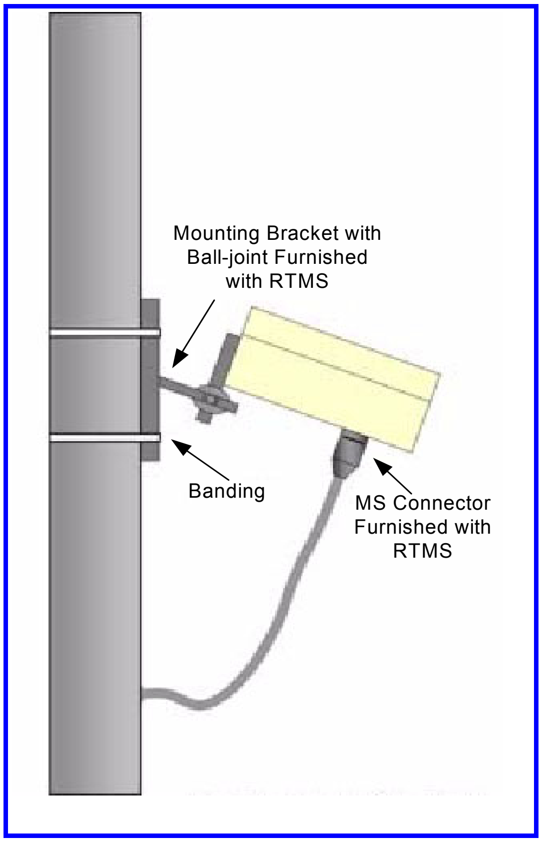



**Figure 7-4: Typical RTMS Mounting Configuration**

The RTMS unit (Remote Traffic Microwave Sensor) from EIS Systems Inc. is a general-purpose, all-weather traffic sensor, which detects presence, and measures traffic parameters in multiple independent lanes. The RTMS is a traffic detector providing presence, volume, occupancy, and speed and classification information in up to 8 discrete user-defined detection zones up to 60 m (200 ft.) away (see Figure 7-5). It is possible to provide the output information from a RTMS unit either to the controller or directly to the traffic control system. Output information is provided to existing controllers via contact pairs and to central systems via a RS-232 serial communications port. The RTMS is designed for side-fired operation. It is usually mounted on existing side-of-the-road poles for ease of installation and is programmable to support a variety of applications. The manufacturer claims that the RTMS unit and that the detector is unaffected by any type of weather.

*System Detector Configuration / Layout*

The RTMS Microwave detectors utilize 12-pair cable between the detection unit and the controller cabinet. One microwave detector cable is required for each unit. A 170 controller cabinet can accept 24 detector inputs, where each input corresponds to a detection "zone". In a side-fire configuration collecting data for 3 lanes, the single microwave detector unit captures three zones, and thereby requires three inputs in the 170 controller cabinet. For bi-directional detection, two units can be used for 6 total lanes, thereby requiring 2 microwave detector units, 2 microwave detector cables (1 per unit), and 6 inputs in the controller cabinet. The microwave detector units should be placed within 800 feet of the controller cabinet.

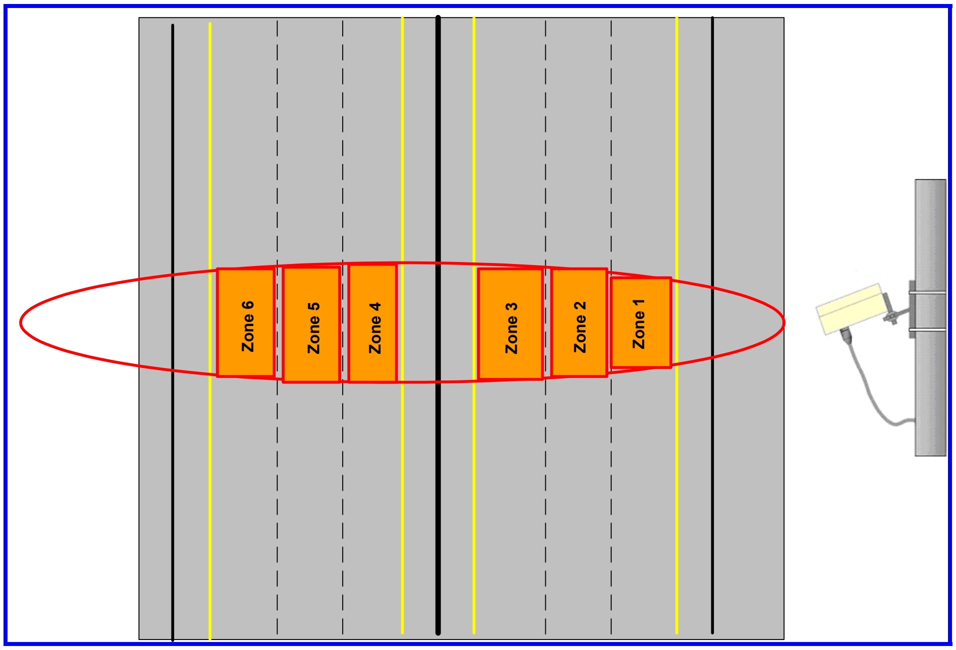



**Figure 7-5: Typical RTMS Configuration for a Three-Lane Roadway**

It is possible to connect the RTMS unit directly to a wireless communication device (e.g., CDPD modem) and transmit Vehicle Speed, Occupancy and Volume data back to a central location. The field RTMS unit would communicate directly with a CDPD modem. On the TMC side, the traffic volume, occupancy and speed data can be retrieved via an Internet connection or via another CDPD modem.

*Miscellaneous Issues*

The RTMS speed accuracy in sidefire mode is approximately ± 10 percent, but its accuracy mounted over a lane and facing approaching traffic is claimed by the manufacturer to be much better. Concrete median barriers sometimes limit RTMS performance on the far side of a highway. Each RTMS unit can handle up to eight lanes. The manufacturer claims that maintenance on the RTMS is minimal once the detector is set and calibrated. RTMS unit needs 12-24V AC/DC power. CDPD modem needs 12VDC.

RELIABILITY: Mean Time between Failures 10 years

WARRANTY: 2 years

### 7.2.3 Video Image Detection System (VIDS)

Video Image Detection System (VIDS) are above-ground units mounted over (Figure 7-6) or along side (Figure 7-7) the arterial to collect volume, occupancy and speed data. Representative information about the VIDS systems is provided here. The features and specifications of individual VIDS systems may vary. Traditional VIDS, such as Autoscope, Vantage and Trafficon are configured with the cameras in the field and control receivers located in the controller cabinet. This typically requires more space in the controller cabinets than loop detectors or RTMS Interface Units.

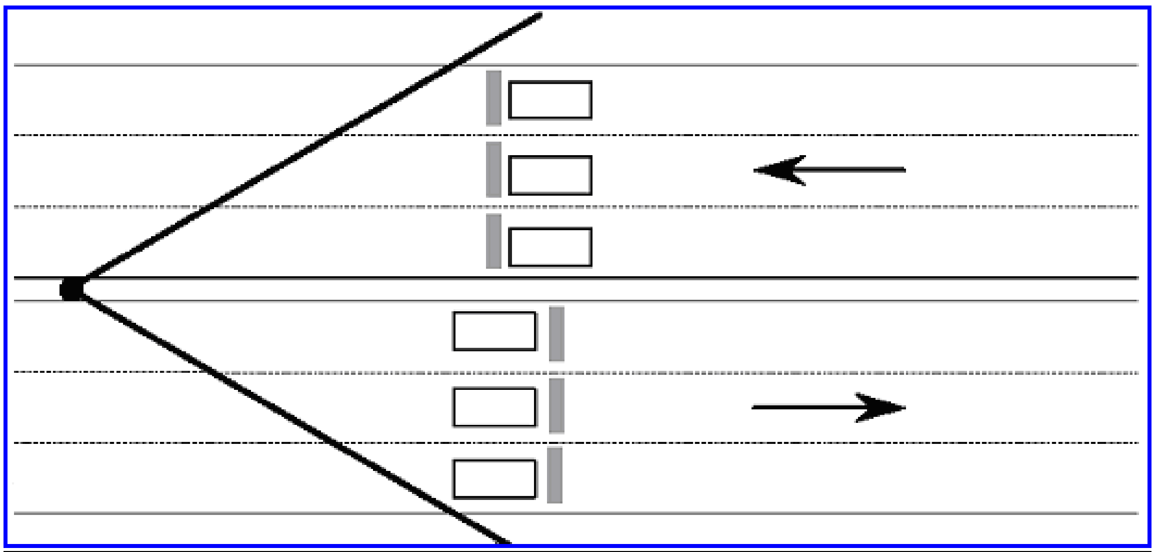


**Figure 7-6: Video Image Detection System - Median Mounted**

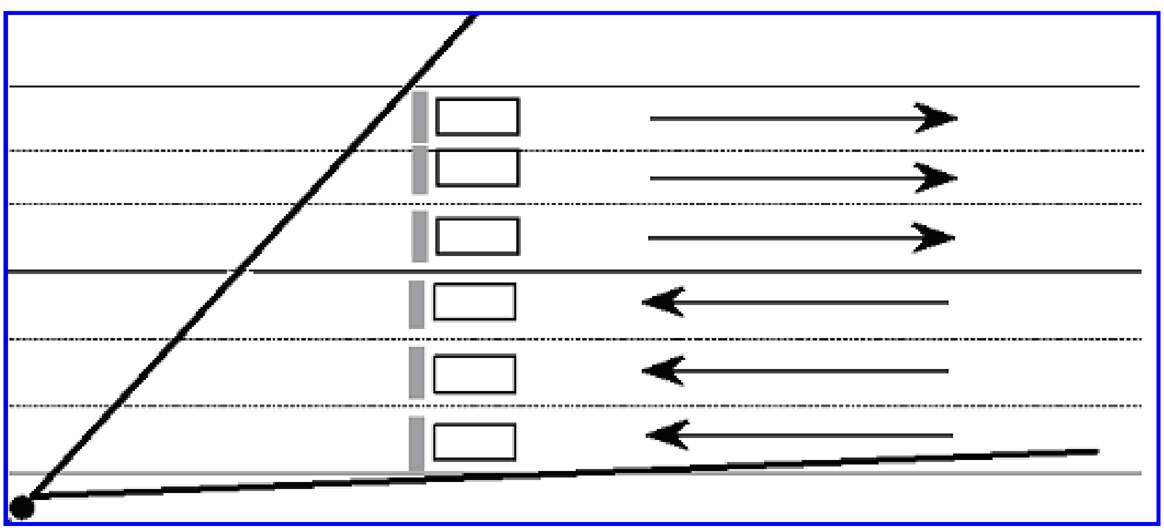


**Figure 7-7: Video Image Detection System - Side-Fire Mounted**

*System Detector Configuration / Layout*

VIDS cameras are mounted on street lighting mast arms or poles. Video and power cables are run from the cabinet to each camera. The VIDS Processor connects directly to coax cabling from each camera, or in some cases can receive the video signal through a wireless system. Isolation amplification is included in the VIDS Processor, eliminating the need to buy extra equipment to protect against transients or compensate for coax cable losses.

Typically, programming of the VIDS unit requires a separate PC/laptop. The Vantage unit (Iteris Inc) VIDS processor includes full programming capability and eliminates the need for a separate PC. Usually a programming menu is displayed as an overlay on the video image from each camera. Detectors are drawn on the camera video image using a mouse. Once vehicle detectors are saved in memory the detection starts immediately.

Newer versions of VIDS such as Econolite's SoloPro have intelligent cameras where all the processing is done at the pole, requiring no additional equipment in the cabinet.

*Miscellaneous Issues*

Manufacturers claim the VIDS system will accurately measure individual vehicle speed with more than 95% accuracy under all operating conditions for vehicles approaching the sensor (viewing the front end of vehicles), and 90% accuracy for vehicles receding from the sensor (viewing the rear end of vehicles). Attached to a CDPD modem, the traffic data can be polled every 20 seconds and video snapshot every 2-3 minutes. Maximum data rate of between 9600bps and 19200bps can be achieved with a CDPD modem. At the central TMC location a high-speed Internet service can be used to connect to CDPD modem in field.

RELIABILITY: Mean Time between Failures 10 years

WARRANTY: 2 years

### 7.2.4 System Upgrade Considerations

In order to upgrade the detection to support system detection, additional equipment both in the road and at the roadside is necessary, as well as additional equipment in the existing cabinets and services. Upgrades (or modifications) necessary regardless of the technology used include:

*New Cabinet / Placement*

The placement of a new controller cabinet may be needed, and is influenced by:

- Visibility of the detectors from the controller cabinet.
- Distance between the controller cabinet and the detectors. Due to the necessary loop to lead-in Inductive ratio, the distance between the cabinet and loop detectors is an important factor.
- Accessibility for maintenance vehicles, whenever possible.
- Safety of the cabinet location (do not place the cabinet on the outside of a curve).
- Grades.
- Drainage.

*Electrical Service*

In the case of microwave and VIDS, electrical service is necessary for the detector units themselves. For the purposes of this analysis it is assumed that the electrical service exists to the pole on which these devices would be mounted.

*Communication*

Some form of communications is necessary to communicate from the detectors to the controller. Examples are: twisted pair copper, coaxial cable, optical fiber, and wireless.

Communication interface units are required as well. (see Section 7.3 below)

*Underground Infrastructure*

This comprises:

- Conduit - used for detector station raceways.
- Trenching and / or sawing for conduit.
- Pull Boxes - the number is dependent upon the spacing. Typically, they should be spaced no greater than 200 feet. If a conduit run contains only one or two lightweight cables (e.g., loop lead-ins), this distance can be stretched to approximately 300 feet.

*Roadside Infrastructure*

In instances where structures are not available for installing microwave or VIDS detectors, poles and mast arms may be necessary.

## 7.3 Communications to Central

### 7.3.1 Communication Infrastructure

There are two ways of bringing the field traffic data back to a central TMC location:

- Via a controller (see Figure 7-8).
- Directly from the detection unit (see Figure 7-9).

Not all detector technologies support both methods. For Inductive loop installations, controllers in the field are needed to accumulate the speed, volume and occupancy data and transfer the data to the central system when polled.

RTMS and VIDS installations support both methods. In addition to the method used by loop detectors, they also permit a configuration whereby the data can be sent directly to the Central TMC location. The RTMS and the VIDS units have a serial interface and data can be retrieved directly via this interface. The data can be sent either over the existing communication infrastructure or over a wireless link.

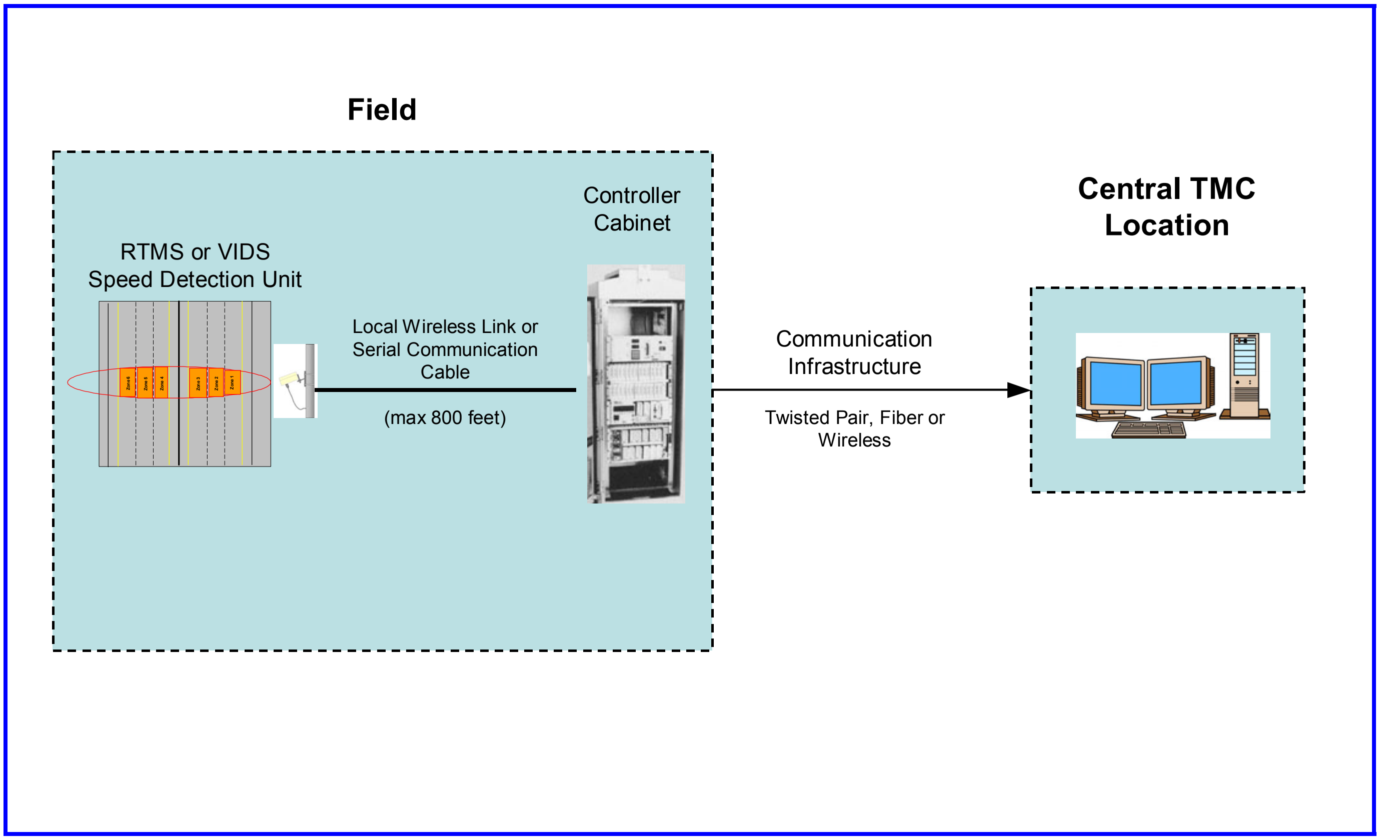



**Figure 7-8: Field to Central Communication Via Traffic Signal Controller**

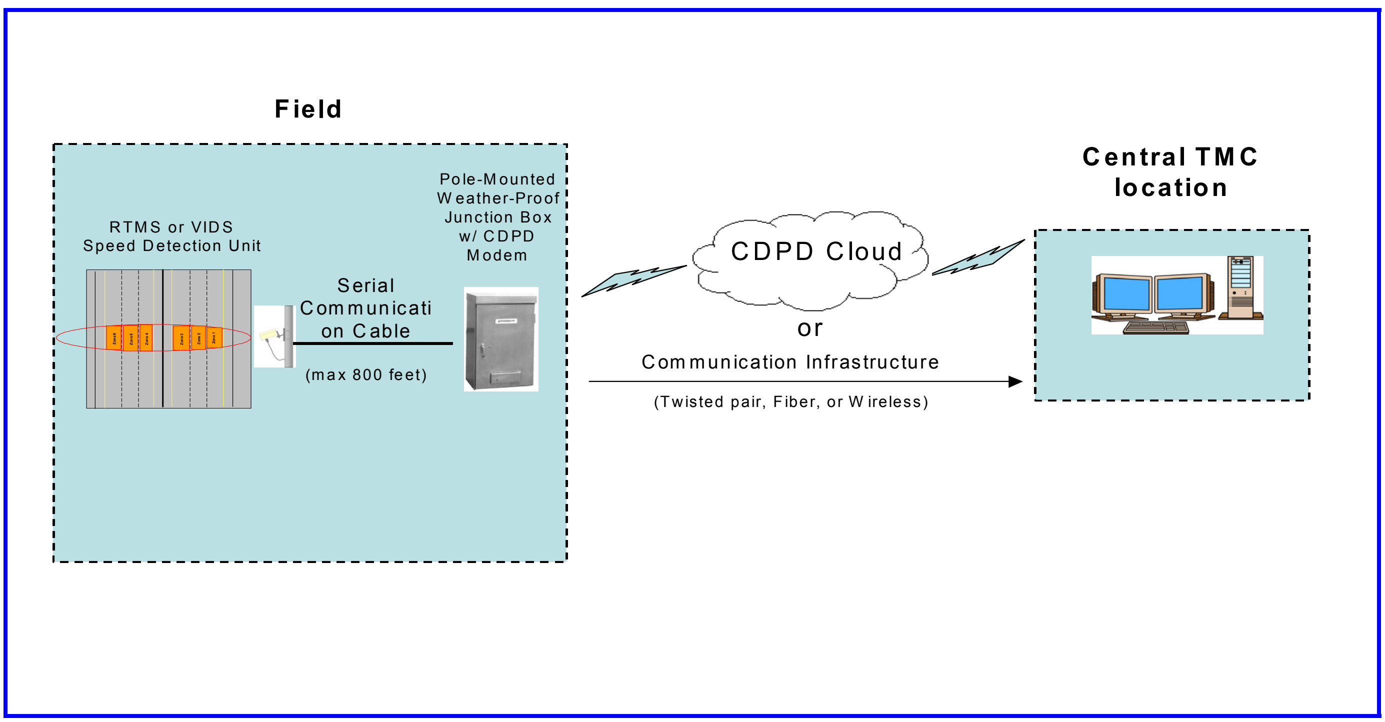



**Figure 7-9: Direct Detection Unit to Central Communication**

### 7.3.2 Communication Media

Applicable communications media are twisted pair, fiber modems or wireless. Each offers an agency-owned or leased option. Brief details are presented here; a more comprehensive analysis to identify the field to central communications is presented elsewhere in this Project.

- TWISTED PAIR - Copper twisted pair is the predominant media existing in older traffic communication infrastructures. Serial modems and repeaters (depending on distance) can be used to transmit data that is collected at the field location. On the field side the serial modem is attached to the data collecting unit, usually a controller. On the central TMC side there is another serial modem that will connect up to a PC or other equipment that will receive and store the traffic data.

- FIBER - An increasingly used alternative to TWP is fiber optics. Communications infrastructures have single-mode or multi-mode fiber installed in the field. One advantage of fiber is that for VIDS locations it is possible to bring back full motion video to the TMC for viewing or distribution.

- WIRELESS – This medium is viable not only for field to central, but also for local detector-to-controller communications links. The wireless options include, Spread Spectrum Radio and CDPD (Cellular Digital Packet Data) communications.

## 7.4 Comparison of Candidate Detection Technologies

### 7.4.1 Candidate Technology Characteristics

Table 7-1 presents a summary of the relative merits of the candidate detector technologies. Factors such as installation, parameters measured, performance in inclement weather and variable lighting conditions, and suitability for wireless operation are considered.

For example, the RTMS and VIDS units have overhead sensors that are compact and not roadway invasive, making installation and maintenance relatively easy. On the other hand the Inductive loop installation and maintenance may require the closing of the roadway to normal traffic to ensure the safety of the installer and motorist. All the detector technologies discussed here operate under day and night conditions.

The strengths and weaknesses were compiled from various sources, and are representative of the technology in general; they may not be directly relevant to a specific vendor and product. A representative product from each of the detection technologies has been used here for comparison purposes only. For Microwave technology, a RTMS system manufactured by EIS Systems was used, and for Video (VIDS) an AUTOSCOPE unit manufactured by Econolite was used for comparison purposes.

**Table 7-1: Comparison of Detection Technologies**

| | STRENGTHS | WEAKNESS |
|---|---|---|
| Inductive Loops | ▪ Flexible design to satisfy large variety of applications.<br>▪ Mature, well understood technology.<br>▪ Generally insensitive to inclement weather.<br>▪ Provides range of traffic parameters(e.g., volume, presence, occupancy, speed, headway, and gap).<br>▪ Stopped vehicle detection.<br>▪ High accuracy if well maintained. | ▪ Installation requires pavement cut.<br>▪ Decreases pavement life.<br>▪ Installation and maintenance require lane closure.<br>▪ Wire loops subject to stresses of traffic and temperature.<br>▪ Multiple detectors usually required to instrument a location and additional detection needed to obtain speed.<br>▪ Requires traffic signal controller for local processing. |
| Microwave | ▪ Generally insensitive to inclement weather.<br>▪ Direct measurement of speed.<br>▪ Multiple lane operation available at no extra cost over single lane operation.<br>▪ Does not need traffic signal controller for local processing. | ▪ Doppler sensors cannot detect stopped vehicles.<br>▪ Lost counts due to occlusion. |
| Video | ▪ Monitors multiple lanes and multiple zones/lane.<br>▪ Multiple lane operation available at no extra cost over single lane operation.<br>▪ Easy to add and modify detection zones.<br>▪ Rich array of data available.<br>▪ Provides wide-area detection when information gathered at one camera location can be linked to another.<br>▪ Does not need traffic signal controller for local processing.<br>▪ Stopped vehicle detection.<br>▪ Video can be brought back to the central for surveillance purposes. | ▪ Inclement weather, shadows, vehicle projection into adjacent lanes, occlusion, day-to-night transition, vehicle/road contrast, and water, salt grime, icicles, and cobwebs on camera lens can affect performance.<br>▪ Requires 50-to 60-ft camera mounting height (in a side-mounting configuration) for optimum presence detection and speed measurement.<br>▪ Susceptible to camera motion caused by strong winds.<br>▪ Lost counts due to occlusion. |

## 7.5 Equipment Cost Comparison

This Section contains the costs associated with the deployment of the three candidate technologies. Cost components taken into account in addition to the basic equipment supply costs include local communications, installation, maintenance and operational costs.

### 7.5.1 Assumptions

The following assumptions were made in developing the cost estimates:

1. Six Lane highway facility with three lanes in each direction.
2. Existence of communications between controllers and the Central TMC.
3. It is possible to use the existing cabinet and controller. If a new cabinet is required, assume an additional cost of $ 10,000 per cabinet for a new 332 cabinet with controller and detector racks.
4. The detector units are placed 250 feet from the stop bar.
5. It is assumed that a convenient pole exists for the RTMS and the VIDS units to be mounted. If a new pole is needed, assume an additional cost of installing a new pole to be in the range of $ 6,000 to $ 10,000.
6. It is further assumed that Electrical supply is available at the RTMS or VIDS mounting pole. A worst case scenario would increase installation cost by approximately $ 8,750.
7. For RTMS and VIDS, it is assumed that one unit will be required at each location.
8. It is assumed that the approximate cost of installing new conduit is $35 per foot.
9. Inductive loops failure rate is assumed to be 10% per year.

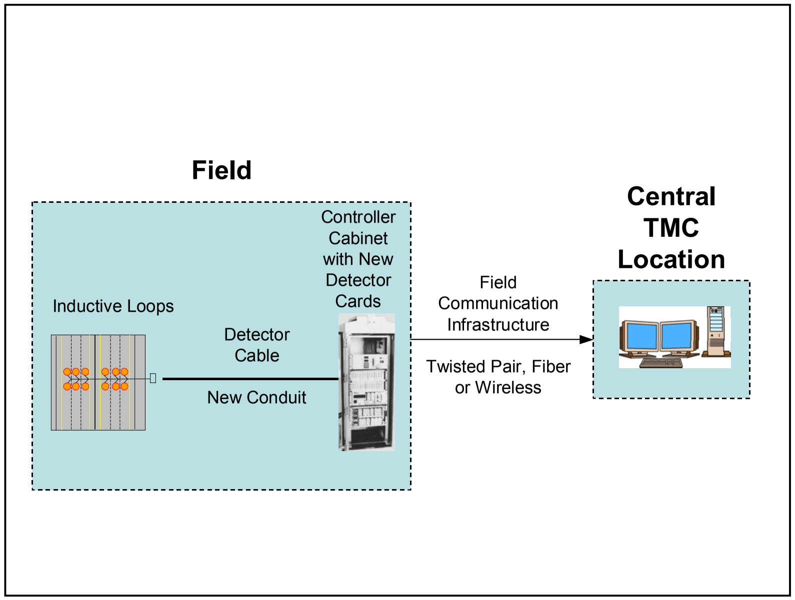
### 7.5.2 Deployment Costs

In order to develop deployment costs, for each technology, different options for communicating data back to the central are considered.

Figure 7-10 presents the equipment layout for deploying inductive loop technology and Table 7-2 presents associated costs for deploying this option.

Figures 7-11 through 7-14 present equipment layouts for deploying RTMS technology for four different options and Table 7-3 presents associated costs for deploying these options.

Figures 7-15 through 7-18 present equipment layouts for deploying VIDS technology for four different options and Table 7-4 presents associated costs for deploying these options.

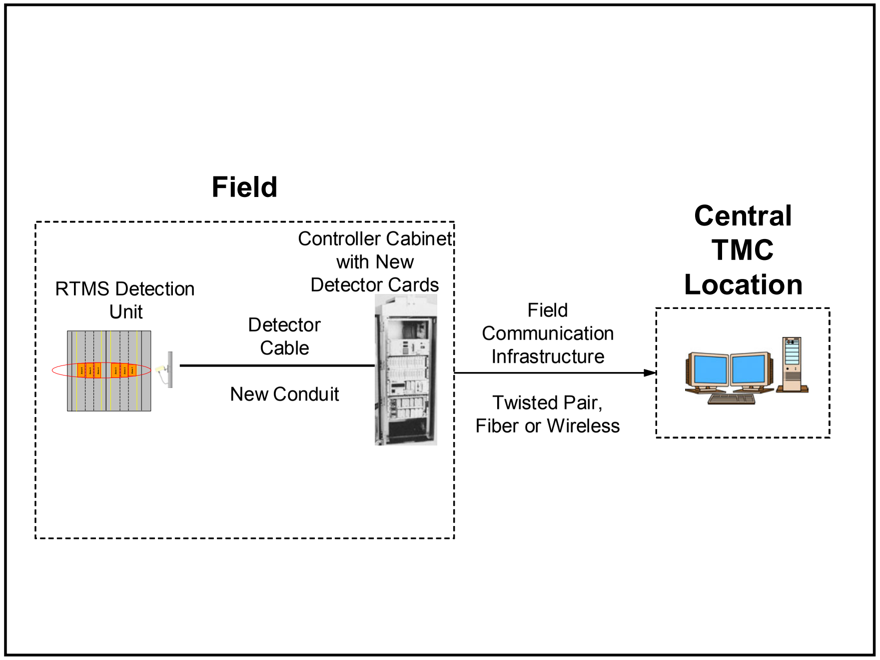



- The detector data is brought to a Central TMC via a controller using field communication infrastructure.
- Inductive loops cut in the roadway about 250 ft upstream of the stop bar.
- New conduit installation between the pull box adjacent to the loops and the controller.
- It is assumed that there is enough space in the existing detector rack to accommodate new detector cards.
- New detector cards will be installed.
- Detection processing is performed in the controller.

**Figure 7-10: Inductive Loop Equipment Configuration**

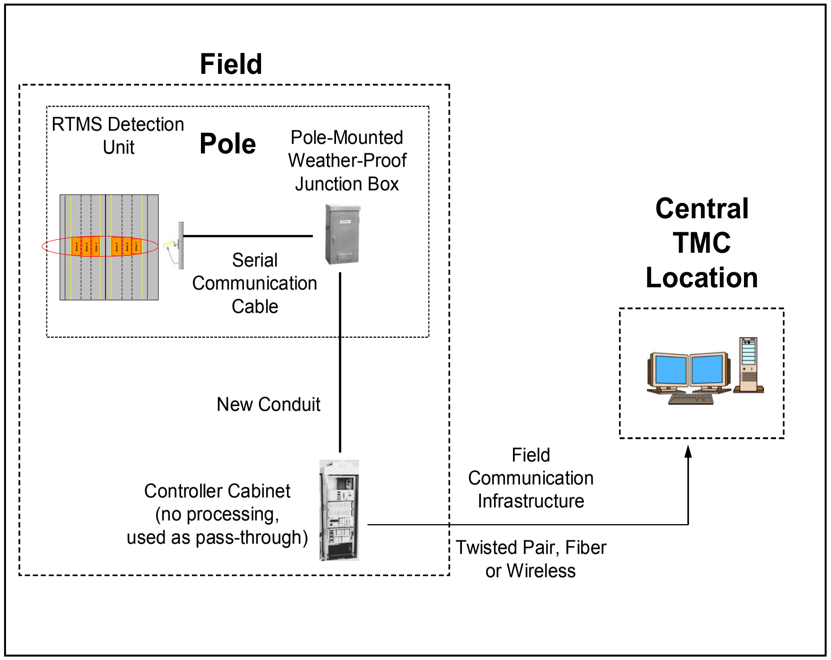
**Table 7-2: Capital Cost for Deploying Inductive Loops Technology**

| Component | Cost | Unit | Total Cost |
|---|---|---|---|
| **Inductive Loops Installation** | $ 450 | 12 | $ 5,400 |
| **Dual Channel Detector Cards** | $ 200 | 6 | $ 1,200 |
| **Conduit – Pull detector lead cables to Controller Box** | $35 / foot | 250 feet | $ 8,750 |
| | | Total | $ 15,350 |



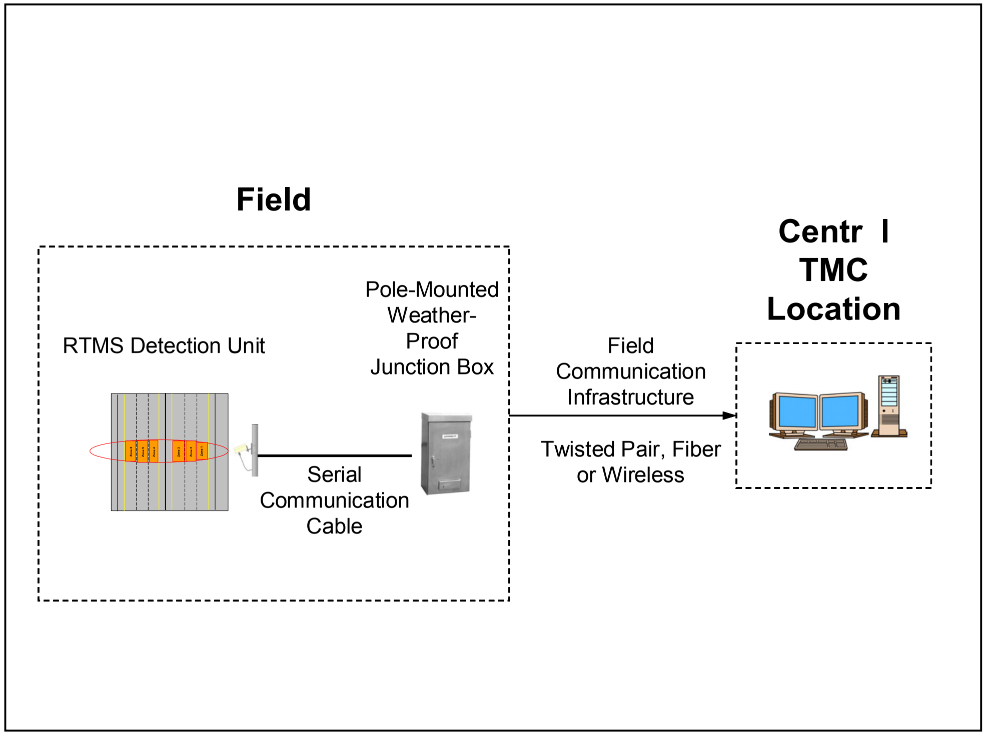

- The detector data is brought to a Central TMC via a controller using the field communication infrastructure.
- RTMS units installed on an existing pole on the side of the roadway about 250 ft upstream of the stop bar.
- New conduit installation between the pull box adjacent to the pole and the controller.
- It is assumed that there is enough space in the existing detector rack to accommodate new detector cards.
- New detector cards will be installed.
- Detection processing is performed in the controller.

**Figure 7-11: RTMS Equipment Configuration – OPTION A**



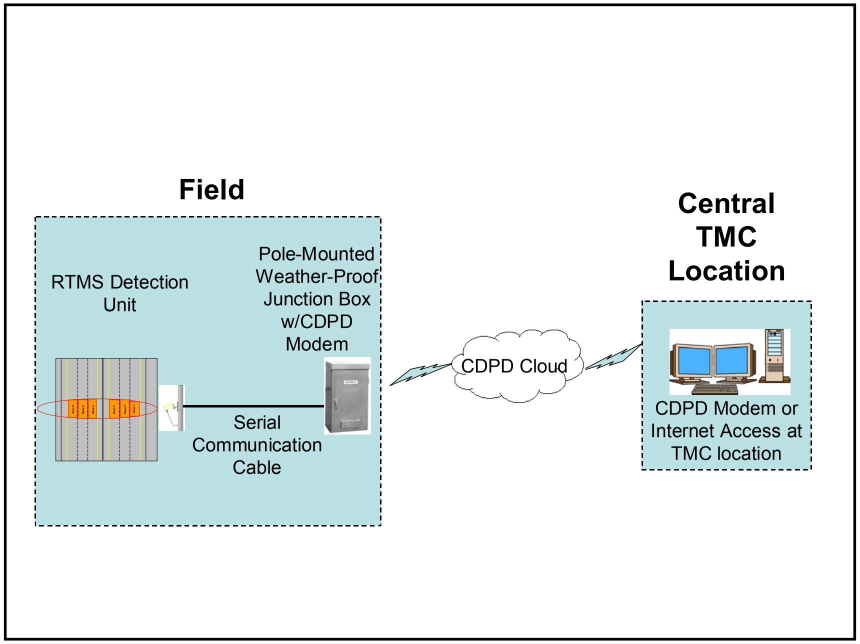

- Assumes field communication infrastructure is not available at the pole.
- New conduit installation between the pull box adjacent to the pole and the controller.
- The detector data is brought directly to the Central TMC using field communication infrastructure.
- RTMS units installed on an existing pole on the side of the road about 250 ft upstream of the stop bar.
- A junction box in installed on the pole to house communications equipment.
- Detector processing is performed at the RTMS Unit in the field.

**Figure 7-12: RTMS Equipment Configuration – OPTION B**




- Assumes field communication infrastructure is available at the pole.
- The detector data is brought directly to the Central TMC using field communication infrastructure.
- RTMS units installed on an existing pole on the side of the road about 250 ft upstream of the stop bar.
- A junction box is installed on the pole to house communications equipment.
- Detector processing is performed at the RTMS Unit in the field.

**Figure 7-13: RTMS Equipment Configuration – OPTION C**

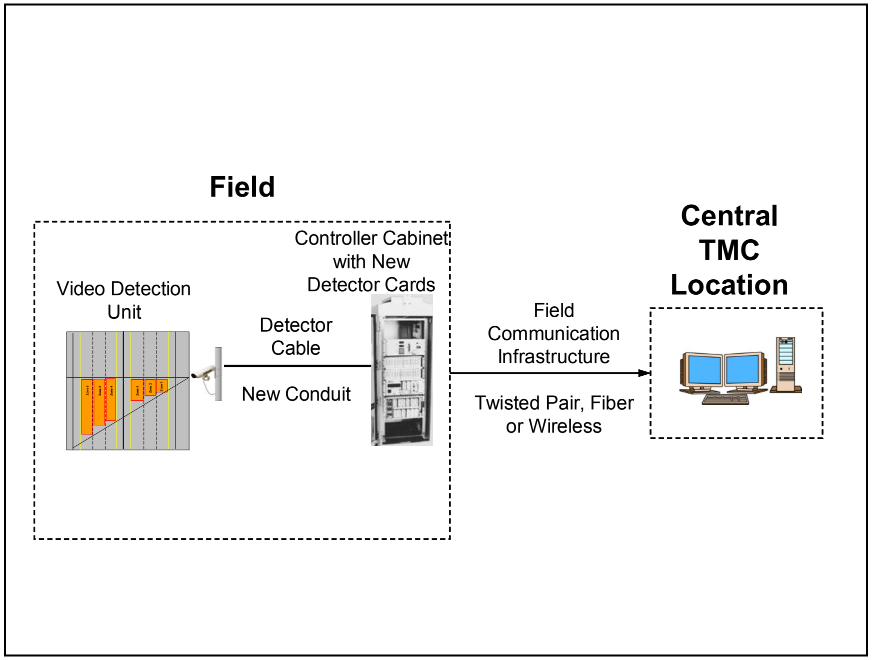



- The detector data is brought directly to the Central TMC using wireless CDPD communication.
- RTMS units installed on an existing pole on the side of the road.
- A junction box is installed on the pole to house communications equipment.
- CDPD Wireless modem with unlimited wireless access plan installed in junction box.
- Communications needs to be established between the pull box on the side of the road and the junction box on the pole.
- Recurring cost of $50/month for CDPD unlimited access plan.
- Assumes that electrical supply exists on the mounting pole.
- Detector processing is performed at the RTMS Unit in the field.

**Figure 7-14: RTMS Equipment Configuration – OPTION D**

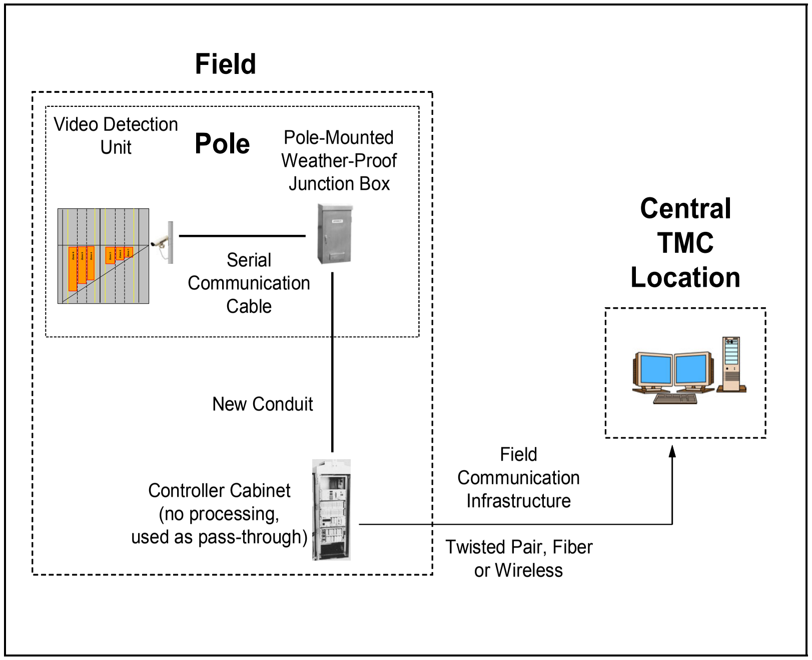
**Table 7-3: Capital Cost for Deploying Microwave Technology (RTMS by EIS Systems)**

| Component | Cost | Unit | Total Cost | Option A | Option B | Option C | Option D |
|---|---|---|---|---|---|---|---|
| **Detection Processing** | | | | Controller | RTMS unit | RTMS Unit | RTMS Unit |
| **Communcation Infrastructure** | | | | New conduit to cabinet | New conduit to cabinet | Existing communication to RTMS Unit | Wireless |
| **RTMS Unit with mounting bracket and cable connector** | $ 4000 | 1 | $ 4000 | X | X | X | X |
| **Installation and Mounting** | $ 400 | 1 | $ 400 | X | X | X | X |
| **Weather-proof Junction Box** | $300 | 1 | $ 300 | | X | X | X |
| **Cable - RTMS to Junction Box** | $2 / foot | 20 feet | $ 40 | | X | X | X |
| **Cable - RTMS to Controller Cabinet** | $2 / foot | 270 feet | $ 540 | X | | | |
| **New Conduit - Pull box to Controller Cabinet (RTMS Serial Cable)** | $35 / foot | 250 feet | $ 8,750 | X | | | |
| **New Conduit – Existing communication (Fiber / twisted pair) pulled to Junction Box** | $35 / foot | 250 feet | $ 8,750 | | X | | |
| **Dual Channel Detector Cards** | $ 380 | 6 lanes | $ 2,280 | X | | | |
| **CDPD Wireless Modem** | $ 1,000 | 1 | $ 1,000 | | | | X |
| **Fiber or Twisted Pair modems** | $ 500 | 2 | $ 1000 | | X | X | |
| | | | Total | $ 15,970 | $ 14,490 | $ 5,740 | $ 5,740 |



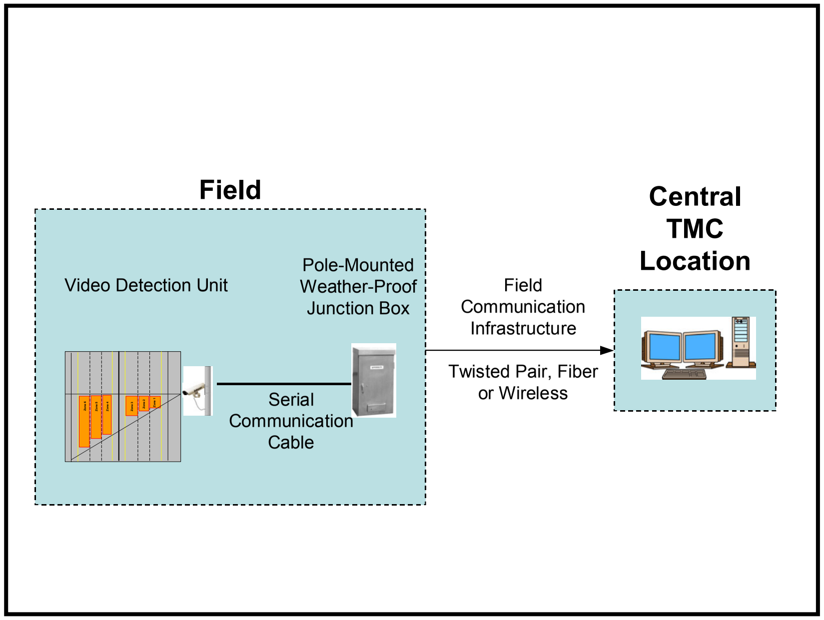

- The detector data is brought to a Central TMC via a controller using field communication infrastructure.
- VIDS units installed on an existing pole on the side of the roadway about 250 ft upstream of the stop bar.
- New conduit installation between the pull box adjacent to the pole and the controller.
- It is assumed that there is enough space in the existing detector rack to accommodate new detector cards.
- New detector cards will be installed.
- Detector processing is performed in the controller.

**Figure 7-15: VIDS Equipment Configuration – OPTION A**



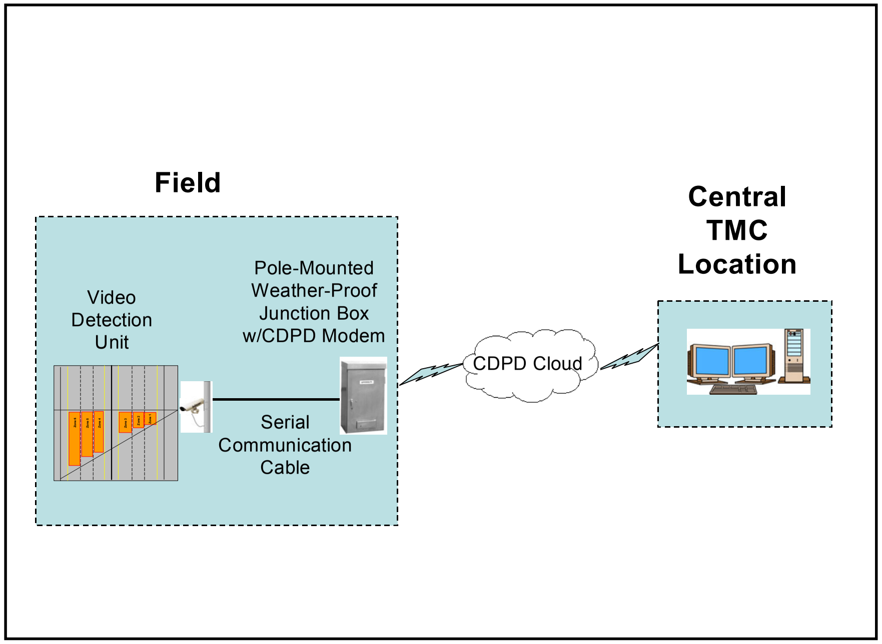

- Assumes field communication infrastructure is not available at the pole.
- New conduit installation between the pull box adjacent to the pole and the controller.
- The detector data is brought directly to the Central TMC using field communication infrastructure.
- VIDS units installed on an existing pole on the side of the road about 250 ft upstream of the stop bar.
- A junction box in installed on the pole to house communications equipment.
- Streaming video can be brought back using fiber or snapshot images can be brought back using twisted pair.
- Detector processing is performed at the VIDS Unit in the field.

**Figure 7-16: VIDS Equipment Configuration – OPTION B**




- Assumes field communication infrastructure is available at the pole.
- The detector data is brought directly to the Central TMC using field communication infrastructure.
- VIDS units installed on an existing pole on the side of the road about 250 ft upstream of the stop bar.
- A junction box is installed on the pole to house communications equipment.
- Streaming video can be brought back using fiber or snapshot images can be brought back using twisted pair.
- Detector processing is performed at the VIDS Unit in the field.

**Figure 7-17: VIDS Equipment Configuration – OPTION C**




- The detector data is brought directly to the Central TMC using wireless CDPD communication.
- VIDS units installed on an existing pole on the side of the road.
- A junction box is installed on the pole to house communications equipment.
- CDPD Wireless modem with unlimited wireless access plan installed in junction box.
- Recurring cost of $50/month for CDPD unlimited access plan.
- Assumes that electrical supply exists on the mounting pole.
- Snapshot (2-3 minutes) video from the VIDS unit.
- Detector processing is performed at the VIDS Unit in the field.

**Figure 7-18: VIDS Equipment Configuration – OPTION D**

**Table 7-4: Capital Cost for Deploying Video Image Detection Systems (VIDS)**

| Component | Cost | Unit | Total Cost | Option A | Option B | Option C | Option D |
|---|---|---|---|---|---|---|---|
| **Detection Processing** | | | | Controller | VIDS Unit | VIDS Unit | VIDS Unit |
| **Communication Infrastructure** | | | | New Conduit to Cabinet | New Conduit To Cabinet | Existing communication to VIDS Unit | Wireless |
| **VIDS Camera and Processor** | $ 4,600 | 1 | $ 4,600 | X | X | X | X |
| **Mounting Bracket and Strap** | $ 130 | 1 | $ 130 | X | X | X | X |
| **Installation and Mounting** | $ 200 | 1 | $ 200 | X | X | X | X |
| **Interface Panel** | $ 625 | 2 | $ 1,250 | X | X | X | X |
| **Weather-proof Junction Box** | $ 300 | 1 | $300 | | X | X | X |
| **Cable – VIDS to Junction Box (6-Pair 20 foot Cable)** | $150 | 1 | $ 150 | | X | X | X |
| **Cable - VIDS to Controller Cabinet (6-Pair 300 foot Cable)** | $ 450 | 1 | $ 450 | X | | | |
| **New Conduit - Pull box to Controller Cabinet** | $35 / foot | 250 feet | $ 8,750 | X | | | |
| **New Conduit – Existing communication (Fiber / Twisted pair) pulled to Junction Box** | $35 / foot | 250 feet | $ 8,750 | | X | | |
| **Mini Hub 2 Detector cards** | $ 700 | 1 | $ 700 | X | | | |
| **Licensed Software and Doc. For polling data and viewing images** | $ 500 | 1 | $ 500 | X | X | X | X |
| **CDPD Wireless Modem** | $ 1,000 | 1 | $ 1,000 | | | | X |
| **Fiber or Twisted Pair modems** | $ 1,000 | 1 | $ 1,000 | | X | X | |
| | | | Total | $ 16,580 | $ 16,880 | $ 8,130 | $ 8,130 |

### 7.5.3 Cost Summary

Table 7-5 presents a comparison of the 10-year cost analysis for the candidate technologies. The following observations can be made:

- The cost comparison shows that there are no significant difference between the capital costs for installing the three technologies in cases where the detector data is brought back to the central TMC using existing infrastructure via the controller, or directly to the central.
- Since the loops have a higher failure rate, and require more maintenance, the loops have the highest life-cycle cost over a period of 10 years. VIDS and RTMS units have lower life-cycle costs than loops with VIDS having slightly higher life cycle costs than RTMS units.
- The RTMS and VIDS technologies cost estimates have assumed the existence of poles and power to the pole at the deployment location, this may not be true. In such cases where poles must be installed and service provided, the cost of deploying these technologies may be higher than deploying loops, but the life-cycle cost is still less. In addition, in certain cases more than one unit may be required to cover the entire detection zone which will also increase these costs.
- The installation costs reduce by as much as 50% for RTMS and VIDS technologies for options where the data is brought back directly to the central using wireless communications or if it is assumed that the existing interconnect is available at the pole, mainly due to elimination of installing conduit between the detector and the controller cabinet. However, if VIDS and RTMS units are deployed using CDPD, the operational costs are higher due to recurring CDPD charges.

In conclusion, over a ten year life cycle:

1. The lowest cost option is RTMS using the field communications option.
2. VIDS is between 5% and 40% more expensive than RTMS depending on the communication configuration.
3. Loops are the most expensive detection option.

**Table 7-5: 10-Year Cost Analysis Summary Table**

| | **LOOPS Option *** | **RTMS Option A** | **RTMS Option B** | **RTMS Option C** | **RTMS Option D** | **VIDS Option A** | **VIDS Option B** | **VIDS Option C** | **VIDS Option D** |
|---|---|---|---|---|---|---|---|---|---|
| Capital Cost | $15,350 | $15,970 | $14,490 | $5,740 | $5,740 | $16,580 | $16,880 | $8,130 | $8,130 |
| 10-year Operational Cost | $ 540/Year $5,400 | 2 year warranty + maintenance ($200 / year for 8 years)= $1,600 | 2 year warranty + maintenance ($200 / year for 8 years)= $1,600 | 2 year warranty + maintenance ($200 / year for 8 years)= $1,600 | 2 year warranty + maintenance ($200 / year for 8 years) + CDPD Fees ($50*120)= $7,600 | 2 year warranty + maintenance ($250 / year for 8 years)= $2,000 | 2 year warranty + maintenance ($250 / year for 8 years)= $2,000 | 2 year warranty + maintenance ($250 / year for 8 years)= $2,000 | 2 year warranty + maintenance ($250 / year for 8 years) + CDPD Fees ($50*120)= $8,000 |
| Total Cost for 10 years | $20,750 | $17,570 | $16,090 | $7,340 | $13,340 | $18,580 | $18,880 | $10,130 | $16,130 |
| **Cost Per Year** | **$2,075** | **$1,757** | **$1,609** | **$734** | **$1,334** | **$1,858** | **$1,888** | **$1,013** | **$1,613** |
| Provision of Pole | | $6,000 | $6,000 | $6,000 | $6,000 | $6,000 | $6,000 | $6,000 | $6,000 |
| Provision of Power | | | | $8,750 | $8,750 | | | $8,750 | $8,750 |
| Capital Cost With Provision of Power and Pole | $15,350 | $21,970 | $20,490 | $11,740 | $11,740 | $22,580 | $22,880 | $14,130 | $14,130 |
| **Cost Per Year With Provision of Power and Pole** | **$2,075** | **$2,357** | **$2,209** | **$1,334** | **$1,934** | **$2,458** | **$2,488** | **$1,613** | **$3,026** |

*

For loops it is assumed that there is a 10% maintenance cost per year.
For Inductive loops, the only option of fixing failed loops is replacing the entire loop.

### 7.6 Analysis

This report analyzed the functionality and costs of three detection technologies (Loops, RTMS, VIDS) against the Project requirements. As far as functionality is concerned, loops provide the most accurate measurements of volume and occupancy. RTMS units have the additional advantage that they provide direct speed measurements if mounted over the road. However, this method is not preferred due to potential disruption to the traffic during mounting and maintenance activities. If mounted sideways, speed is calculated which has a measurement error of ± 10%.

The VIDS provide a good measurement of volume and occupancy and offer an added advantage that the video can be brought back to the TMC for viewing. VIDS over a fiber network will provide streaming video while VIDS using a CDPD or twisted-pair modem will bring back snapshot images from the field.

RTMS units and VIDS also provide the ability to bring the data back to central directly from the detection unit. This feature makes the two options cost competitive if wireless media is used to bring the data back to the central. This provides added advantage in cases where the detectors need to be placed further away (more than 250 feet) from the stop bar.

If stopped vehicle detection and verification over an area is required, then VIDS solution is needed.

If cost is an overwhelming factor, then RTMS provides the best solution using CDPD, if no field communication exists at the detection site or with direct communication to the central TMC location if the field communication infrastructure is available.

Table 7-6 summarizes the recommended choices of detection technologies and communication medium depending upon the local requirements.

**Table 7-6: Summary of Recommended Choices**

**Communication at Site**

| | **Technology** | **Communication Medium** |
|---|---|---|
| Accuracy | Loops | Twisted Pair or Fiber |
| Stopped Vehicle | VIDS | Twisted Pair or Fiber |
| Video (Still) | VIDS | Twisted Pair or Fiber |
| Video (Motion) | VIDS | Fiber |
| Cost | RTMS | Twisted Pair or Fiber |

**No Communication at Site**

| | **Technology** | **Communication Medium** |
|---|---|---|
| Stopped vehicle | VIDS | CDPD |
| Video (Still) | VIDS | CDPD |
| Cost | RTMS | CDPD |

## Appendix A: LCC Functionality Matrix

| | USE CASES | Commerce | Downey | La Mirada | Montebello | Pico Rivera | Santa Fe Springs | Los Angeles County | Caltrans District 7 |
|---|---|---|---|---|---|---|---|---|---|
| 4.2.1 | Control Traffic | x | x | x | x | x | x | x | x |
| 4.2.2 | Operate Signals | x | x | x | x | x | x | x | x |
| 4.2.3 | Monitor Signals | x | x | x | x | x | x | x | x |
| 4.2.4 | Maintain Signals | x | x | x | x | x | x | x | x |
| 4.2.5 | Synchronize Clocks | x | x | x | x | x | x | x | x |
| 4.2.6 | Generate Timing Plans | x | x | x | x | x | x | x | x |
| 4.2.7 | Manage Timing Plans | x | x | x | x | x | x | x | x |
| 4.2.8 | Schedule Operations | x | x | x | x | x | x | x | x |
| 4.2.9 | Exchange Coordination Data | x | x | x | x | x | x | x | x |
| 4.2.10 | Data Archiving | x | x | x | x | x | x | x | x |
| 4.2.11 | Monitor Congestion | x | x | x | x | x | x | x | x |
| 4.2.12 | Analyze Data | x | x | x | x | x | x | x | x |
| 4.2.13 | Measure Traffic | x | x | x | x | x | x | x | x |
| 4.2.14 | Monitor Events and Alarms | x | x | x | x | x | x | x | x |
| 4.2.15 | Generate Maintenance Log Reports | x | x | x | x | x | x | x | x |
| 4.2.16 | Log Event Details | x | x | x | x | x | x | x | x |
| 4.2.17 | Repair Equipment | x | x | x | x | x | x | x | x |
| 4.2.18 | Configure Operations | x | x | x | x | x | x | x | x |
| 4.2.19 | Configure System | x | x | x | x | x | x | x | x |
| 4.2.20 | Manage Network | x | x | x | x | x | x | x | x |
| 4.2.21 | Manage Resources | x | x | x | x | x | x | x | x |
| 4.2.22 | Manage Users | x | x | x | x | x | x | x | x |
| 4.3.1 | View CCTV Image | x | x | x | x | x | x | x | x |
| 4.3.2 | Control City Camera | x | x | | | | x | x | |
| 4.3.3 | Select Caltrans Camera | x | | | | | | | |
| 4.3.4 | Manage Signs | | | | | | | | |
| 4.3.5 | Control Signs | | | | | | x | | |
| 4.3.6 | Respond to Incidents | | | | | | x | | |
| 4.3.7 | Priority to Transit | | | | | | x | | |
| 4.3.8 | Pre-emption for Emergency Vehicles | | | | | | x | x | |
| 4.3.9 | Manage Incidents | | x | | | | | | |