SIEMENS

Deliverable For:

Gateway Cities Traffic Signal Synchronization and Bus Speed Improvement Project

Atlantic Boulevard/I-710 Corridor

Deliverable 2.3.1.1

ATMS and Communications User and System Requirements Report

DRAFT

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TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

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 Atlantic Blvd./I-710 Corridor is one such project which will result in arterial infrastructure improvements on north-south and east-west arterials along I-710 freeway in the South-East LA County (Gateway Cities) Forum.

As shown in Figure 1-1, the Atlantic Blvd./I-710 project area consists of 642 intersections in the following 15 different jurisdictions, comprising 13 cities, the County and Caltrans.

- Los Angeles County
- Caltrans
- City of Bell
- City of Bell Gardens
- City of Commerce
- City of Compton
- City of Cudahy
- City of Huntington Park
- City of Long Beach
- City of Lynwood
- City of Maywood
- City of Paramount
- City of Signal Hill
- City of South Gate
- City of Vernon

The objective of this project is to design, develop and deploy Advanced Traffic Control system(s) (ATMS) in the corridor so that the signals in the Project area can be synchronized across the jurisdictional boundaries. This project concentrates on the needs of the agencies in this corridor with respect to signal synchronization 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 Atlantic Blvd./I-710 Corridor will have full access to a 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-time. 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.

1.2 Requirements Process Overview

The requirements for the Atlantic Blvd./I-710 Corridor are based on the user and functional requirements developed as part of I-5/Telegraph Road Corridor Project. The I-5/Telegraph Road Corridor requirements were based on the East San Gabriel Valley Project and incorporated requirements from the I-105 Corridor Project. Based on the data collected on the operational objectives of the operating agencies in the Corridor, the requirements developed as part of I-5/Telegraph Road Corridor Project are reviewed, and modified as needed.

The User Requirements specify the capabilities of the system in terms a user can understand. This generates a common understanding of the systems for both the users as well as developers.

The Functional Requirements identify the elements of the system that are required to implement the User Requirements. This procedure enables a systematic approach to the first level of system architecture.

Use Case Diagrams depict the Functional Requirements. At the highest level, Use Case Diagrams help capture the externally required functionality for a given aspect of a system. These diagrams are intended to allow user and technical audiences to gain mutual understanding of a system’s operational characteristics.

Use Case Diagrams are composed of actors (stick figures), use cases, as well as links (connecting lines/arrows). The Use Case Diagram provides a mechanism to graphically show how actors play out their role in relationship to the use cases. The actors/users in the Use Case Diagram represent the external interactions with the system, and the use cases represent the transactions that occur within the system.

The Functional Requirements presented in this report comprise a combination of the requirements for the agencies in the Project area. Preparing the requirements for a specific system would comprise the selection of the relevant requirements based upon the information contained in the User Requirements detailing agency specific features.

1.3 Purpose of Document

This document is being presented for the purpose of compiling the ATMS software, Detection Systems, Local Traffic Control Center, and Communications User and Functional Requirements for the Atlantic Blvd. / I-710 Corridor Project. These Requirements are for Advanced Traffic Management Systems to be used by the signal operating agencies for traffic signal control and monitoring.

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 IEN architecture and the relationship between this and other projects.

Section 3: Concept of Operations

Describes the enhancements to operations within the corridor to be brought about by the project and examines how the systems will support intra and inter agency operations, traveler information and system security.

Section 4: National Standards

Identifies applicable national standards and examines consistency with the National ITS Architecture.

Section 5: Use Case Analysis

Provides the Use Cases, which the Functional Requirements address.

Section 6: ATMS User and Functional Requirements

Presents the Use cases, User Requirements and Functional Requirements. The Functional Requirements and the User Requirements are categorized by Use Case.

Section 7: Detection Technologies

Examines currently available detection technologies and identifies technologies applicable to the Project area.

Section 8: Local Traffic Control Center Considerations

Identifies requirements for the individual city's control centers and identifies typical equipment and its attributes.

Section 9: Communications Requirements

Presents the requirements for the communications system derived from the above User and Functional Requirements for field-to-center and center-to-center communications system requirements.

Section 10: Requirements Traceability

Describes the requirements tracking process and the foundations of the Traceability Matrix. Functional Requirements are traced to User Requirements and Use Cases. – To be provided later.

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
    - Deliverable 3.6: Final Requirements Analysis
    - Deliverable 3.2.1 ATMS Functional and Local Traffic Control Center Requirements
    - Deliverable 3.3.2 Integration System User and Functional Requirements
    - Deliverable 3.5.1: Communications System Requirements

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 architecture (IEN) represented in Figure 2.1. This is the architecture that will be followed in the design of the Atlantic Blvd./I-710 Corridor Project.

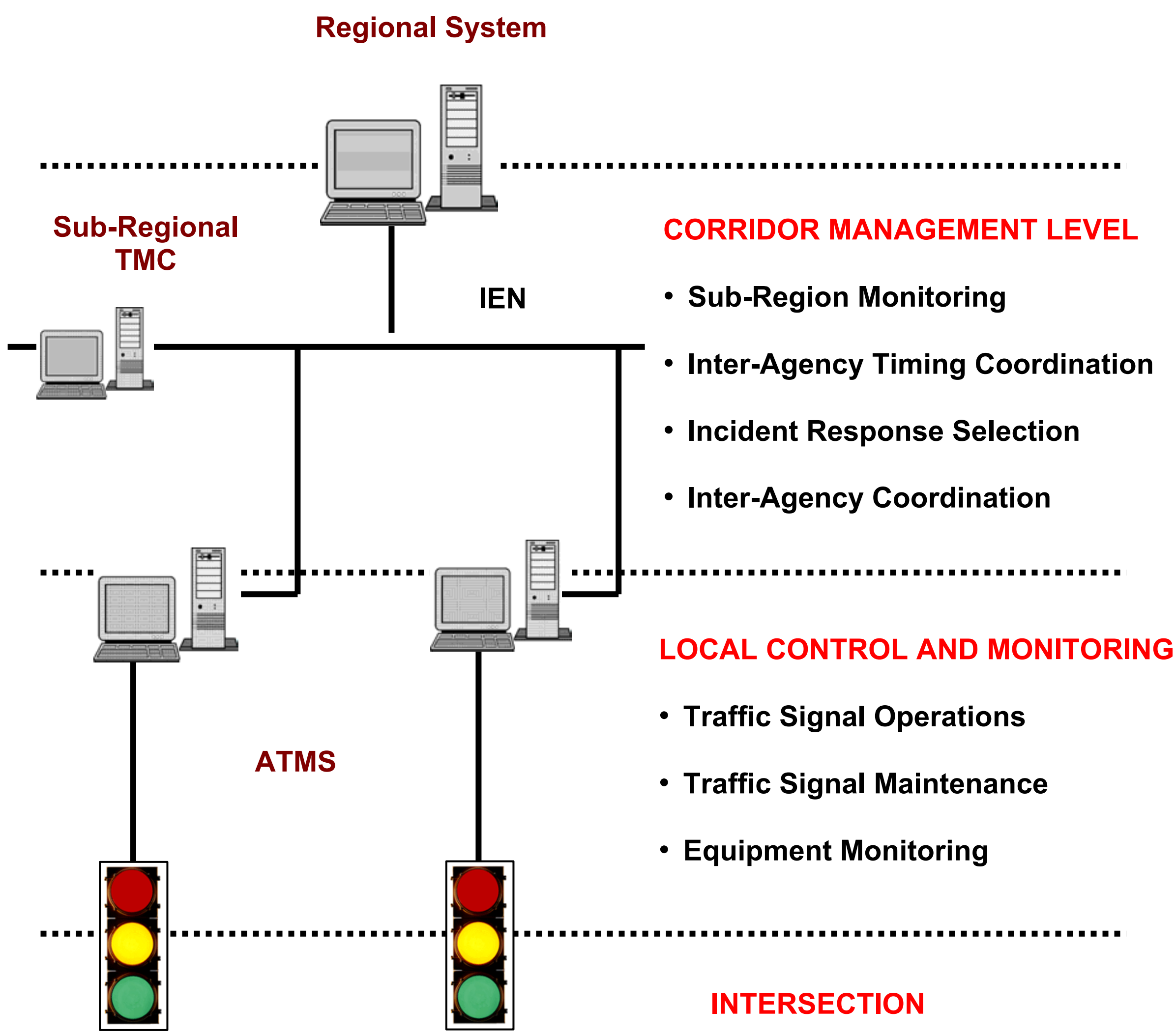


Figure 2.1: The Information Exchange Network Architecture (IEN)

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. These components are connected via a communications network known as the Information Exchange Network (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 Atlantic Boulevard/I-710 Corridor 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 (see Figure 2.2):

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

From the aspect of the Atlantic Boulevard/I-710 Corridor, these 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 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

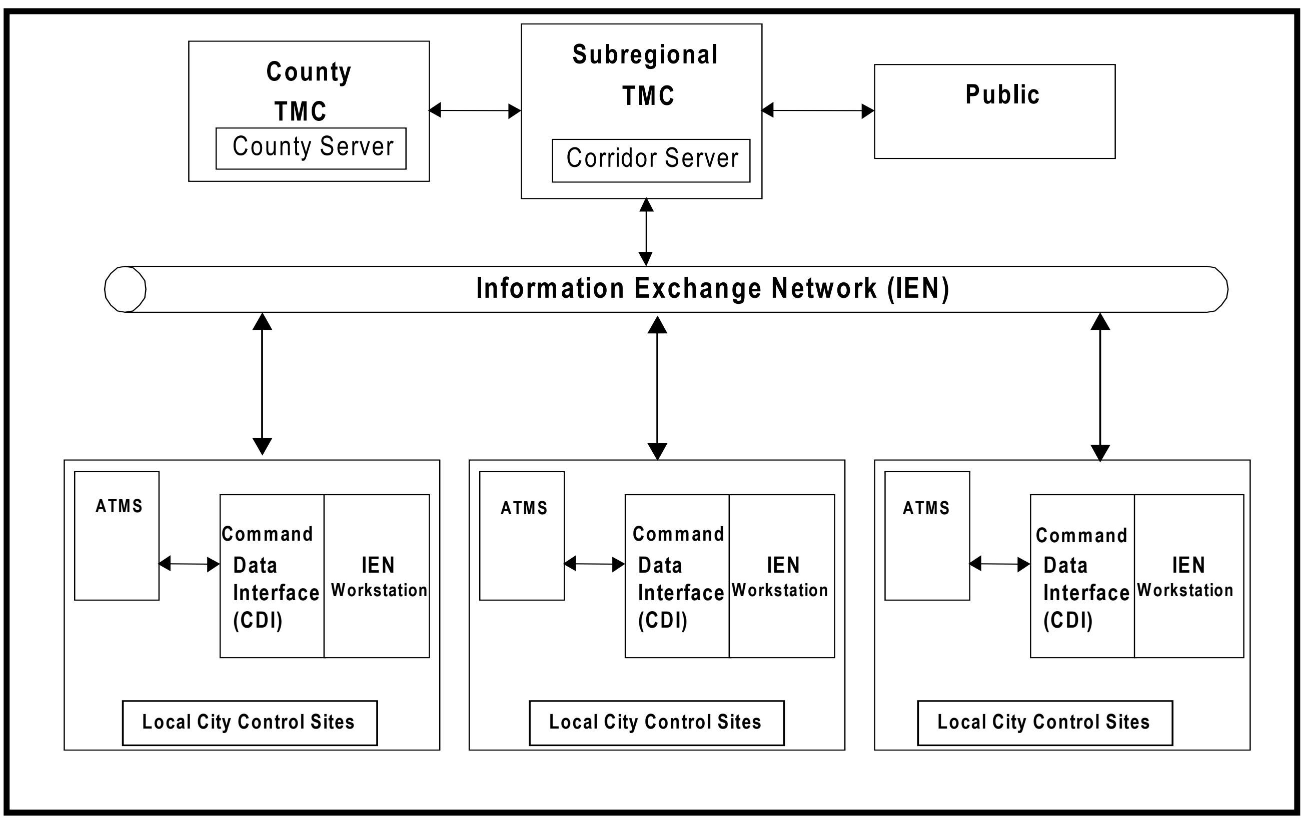


Figure 2.2: I-105 Corridor System Relations

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 that the Corridor clock is not available.

2.2.3 Atlantic Boulevard./ I-710 Corridor Project

The Atlantic Boulevard/I-710 Corridor Project assumes the availability of the IEN at the Corridor and Regional levels as provided by the I-105 Corridor Project. Atlantic Boulevard/I-710 Corridor focuses upon the selection and integration of multiple ATMSs (for the Cities included in Atlantic Boulevard/I-710 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 System Integration Functional Requirements for the Atlantic Boulevard/I-710 Corridor Project takes into account the interface of the ATMS to the IEN (i.e. the CDI) and Video Distribution system at the local level (see Figure 2.3)

The IEN will provide the exchange of traffic signal data. For exchange of camera images, a video distribution system would be implemented which would allow

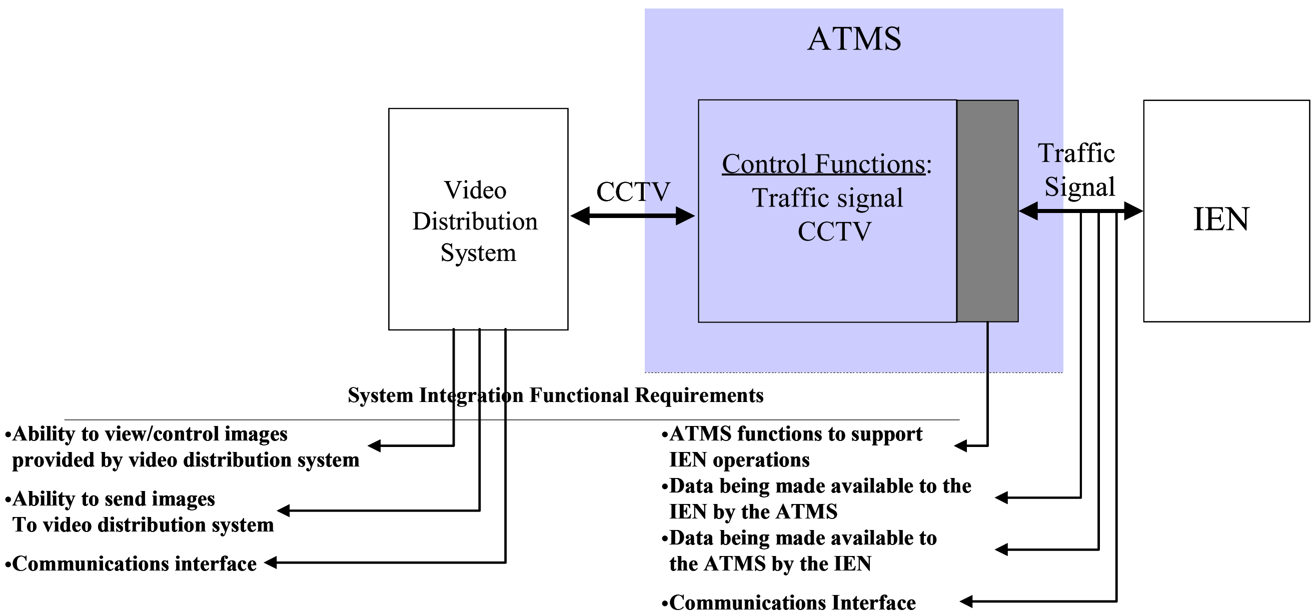


Figure 2.3: ATMS to IEN Interface

3 CONCEPT OF OPERATIONS

3.1 Operational Enhancements

The Atlantic Blvd./I-710 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

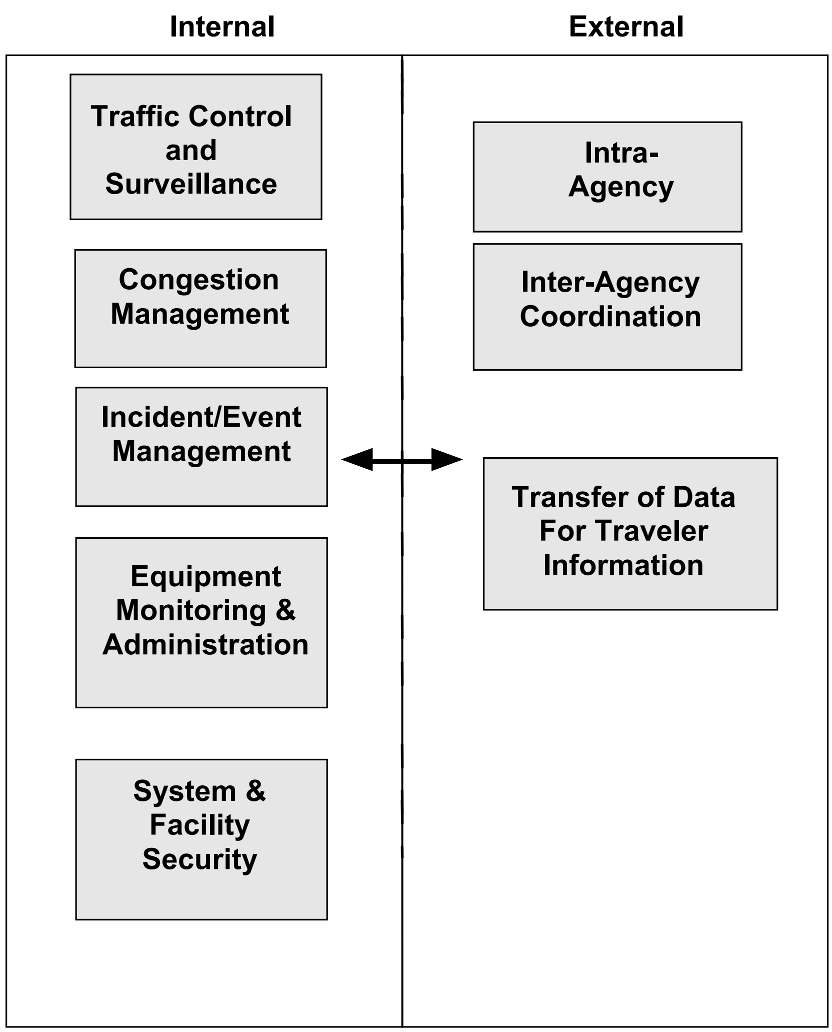
The multi-city and agency participation in the IEN, dictate the consideration of two types of operations centers; a local city control center (LCC) and a Sub-Regional TMC. At this stage of the project, final decision of the configuration of the Sub-Regional TMC has not been reached. For the purpose of the Atlantic Boulevard/I-710 Corridor, the focus is on the LCC.

The potential functions that could be provided by 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 and so form the focus of the Integration Systems Requirements Definition. They are described in the following subsection.



3.3 External TMC Functions

3.3.1 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.

3.3.2 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. 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 in 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.

3.3.3 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.

3.3.4 Security

The multi-jurisdictional nature of the overall system requires that additional security measures be put in place. These go beyond the common ATMS access requirements, and extend to remote users. The local agencies will maintain the ability to define access to their own systems by remote users. This access will be definable by function, by equipment and by time of day.

4 NATIONAL STANDARDS

4.1 Conformance with the National ITS Architecture

To satisfy the ITS rulemaking policy issued by the FHWA on January 8, 2001, (23 CFR 940) the project must meet two requirements. The first is that the County's regional architecture based on the Information Exchange Network (IEN) must conform to the national ITS architecture. The second is that the Project must be based on a systems engineering analysis.

The IEN architecture is in conformance with the National ITS Architecture because it meets the following criteria:

- Describes planned ITS services/functions.
- Includes the subsystems and organizations relevant to the area.
- Describes information exchanges planned between regional subsystems/organizations.
- Provides a regional framework for ITS integration.
- Guides Project definition.

Furthermore, the IEN is specifically identified in the Regional ITS Architecture as defined in the Los Angeles/Ventura County ITS Strategic Deployment Plan. By following the precepts of the IEN architecture, the project's design will be in accordance with that architecture.

The project development consulting contract specifically requires use of systems engineering, including identification of participating regional ITS architecture components, identification of the roles and responsibilities of participating agencies, requirements definition, alternatives analysis, consideration of applicable standards, and identification of procedures and resources needed for on-going operation and maintenance.

The relevant sections of the rule making policy for both the IEN and this Project are Project Requirements and Major ITS Project Requirements. The Project can be considered a Major ITS project because it involves Traffic Management Centers and is part of the deployment of a major new integrated traffic signal system.

4.2 Applicable ITS Standards

During the process of development of the requirements, applicable ITS Standards were identified. The following table summarizes the major groups of ITS standards used in the United States.

Group Name (unofficial)	Sample Standards *	Standards Development Organizations **	Scope ***
NTCIP **	NTCIP 1103 – Transportation Management Protocol. NTCIP 1201 – Global Object Definitions. NTCIP 1202 – Object Definitions for Traffic Signal Controllers. NTCIP 1203 – Object Definitions for Dynamic Message Signs. NTCIP 2304 – DATEX-ASN. NTCIP 2305 – CORBA. NTCIP 2306 - XML .	ITE, NEMA, AASHTO (Joint Committee for NTCIP)	Center-to-field protocols and messages for field devices, and center-to-center protocols
TMDD	Traffic Management Data Dictionary. Message Sets for External Traffic Management Center Communication	ITE	Center-to-center messages for traffic management
Incident Management	IEEE 1512 series – Message Sets for Transportation Incident Management	IEEE	Center-to-center messages for incident management
ATIS	J2354 – Message Sets for Advanced Traveler Information Systems J2266 – Location Referencing Message Specification	SAE	Center-to-center messages for traveler information dissemination
TCIP	Transit Communications Interface Profiles, version 2.5	APTA	Center-to-center and center-to-field messages and protocols for

Group Name (unofficial)	Sample Standards *	Standards Development Organizations **	Scope ***
			transit management
ADUS	E2259-03 – Standard Guide for Archiving and Retrieving ITS-Generated Data	ASTM	Archived data practices and metadata
ATC	ITE – Advanced Transportation Controller ITE – ITS Cabinet ITE – ATC Application Program Interface	ITE, NEMA, AASHTO (Joint Committee for ATC)	Hardware, and software interface, for the controller component of field devices
DSRC	IEEE 1609 – Dedicated Short Range Communications at 5.9 GHz IEEE 1556 – DSRC Security and Privacy (5.9 GHz) ASTM E2158-01 – DSRC at 915 MHz	IEEE (5.9 GHz protocol), SAE (data and messages), ASTM (915 MHz protocol)	Roadside-to-vehicle communications
ITE	ST-017B – Equipment and Material Standards	ITE	Traffic signal displays and other equipment
NEMA	TS 1 – Traffic Control Systems TS 2 - Traffic Controller Assemblies	NEMA (Transportation Management Systems and Associated Control Devices Section)	In-cabinet equipment for traffic signals.

* The above table does not show all standards within each group, there being too many to list here. Also, the names of sample standards are abbreviated. Standards may be in various stages of completion or revision. For details of standards in each group see www.ntcip.org/library/documents/, www.ite.org/tmdd/, www.tmdd.org, standards.ieee.org,

grouper.ieee.org/groups/scc32/imwg/, www.arincxchange.com/exchange/login.cfm (enter apta guest as user name and password), www.sae.org/its/standards/, http://www.astm.org/cgi-bin/SoftCart.exe/DATABASE.CART/REDLINE_PAGES/E2259.htm?L+mystore+bola8912+1064613121, www.ite.org/standards/atc/,

** Acronyms not defined in the table are as follows:
AASHTO = American Association of State Highway Officials
ADUS = Archived Data User Service
APTA = American Public Transportation Association
ASTM = American Society for Testing and Materials
IEEE = Institute of Electrical and Electronics Engineers
ITE = Institute of Transportation Engineers
NEMA = National Electrical Manufacturers Association
NTCIP = National Transportation Communications for ITS Protocol
SAE = Society of Automotive Engineers

*** The term "center-to-center" refers to computer-to-computer communications, and implies balanced, peer-to-peer communications, used for information exchange and requests. A computer may be located in a traditional transportation management or incident management center, or may be in the field (e.g., handheld, in a vehicle, or anywhere else) and may or may not be attended by a human user. The term "center-to-field" refers to computer-to-field device communications, and implies unbalanced, supervisory communications, also known as supervisory control and data acquisition (SCADA). The supervisory computer monitors, and issues instructions to, unattended field devices.

A brief discussion of each standards group and its potential applicability is included below based upon the ATMS requirements definition. The observations are reflected in the relevant sections of the Integration System Requirements.

4.2.1 NTCIP Protocols

The National Transportation Communications for ITS Protocol (NTCIP) is a suite of standards covering both center-to-field and center-to-center communications.

Center-fo-Field Communications

California Assembly Bill 3418 requires that newly installed traffic signal controllers support a standard center-to-field communications protocol. The standard protocol has to be available, but need not be used. Since no standard protocol existed at the time this law was enacted in 1996, Caltrans worked with local agencies to define a protocol commonly referred to as AB3418. Today, NTCIP provides an alternative to AB3418 for this purpose. See Appendix A for further details on these two protocols. The AB3418 protocol uses a similar message structure to NTCIP, but supports only a few fixed messages.

Most modern traffic signal controllers and software support AB3418, NTCIP, or both. In general, controllers are not being replaced in this project, but new ATMS software should support these standard protocols, in addition to agency or vendor-specific protocols needed in each jurisdiction. If the ATMS software owned and operated by one agency is to manage traffic signals operated by another agency, the protocol requirements of that other agency's signals will also need to be considered.

Center-to-Center Communications

The Regional ITS Architecture as defined in the Los Angeles/Ventura County ITS Strategic Deployment Plan, and the Atlantic Boulevard/I-710 Corridor Project, have adopted the Information Exchange Network (IEN) as the center-to-center communication mechanism for traffic signals. New ATMS software should include an IEN interface.

The IEN uses CORBA (Common Object Request Broker Architecture), one of three protocols adopted by the NTCIP for center-to-center communications. However, it is not necessary for local ATMS software to support the full NTCIP CORBA standard. Instead, the IEN defines a simplified one-to-one protocol that an agency's ATMS software can use to communicate with an IEN corridor server. Support for this simplified protocol is the minimum requirement for new ATMS software on this project.

Center-to-center communication, such as that performed by the IEN, precludes the need for an agency's ATMS software to communicate directly with signal controllers managed by another agency's ATMS. Each traffic signal communicates with only one ATMS.

4.2.2 TMDD

The Traffic Management Data Dictionary (TMDD) group of standards defines data elements and messages for center-to-center communication for traffic management. The messages used by the IEN are based on the version of the TMDD available at the time the IEN was developed. It is not necessary for new ATMS software in this project to support the TMDD message sets directly, but support is needed for the messages defined by the IEN.

4.2.3 Incident Management

Though arterial incident management has not been identified as a requirement by any of the agencies in the Atlantic Boulevard/I-710 Corridor project, it is an important issue the project should address for future operations. In addition, the ATMS must be capable of being part of the detection and management of incidents on a corridor and regional basis, as this is supported by the IEN.

Incident management is accomplished though the interaction of the IEN Workstations, IEN Command Data Interface (CDI), IEN Corridor Server and the Caltrans ATMS. IEN incident information can originate from two sources: user defined and Caltrans ATMS. User defined incident information is entered through a user interface located on the IEN Workstation which is communicating with the IEN Corridor Server. The Corridor Server will also receive incident information from the Caltrans ATMS through CORBA communications with the Caltrans intertie server. The Corridor Server distributes the information to the IEN Workstations for display.

The Corridor Server evaluates the incident information and recommends modifications to the traffic signal timing plans to mitigate the affects of the incident with its Scenario Management functionality. The requested change in timing plans are generated by the Corridor Server and communicated to the ATMS through the Command Data Interface. The ATMS should support the IEN Scenario Management functionality.

4.2.4 There are two Incident definition standards that are used in the IEN. The first standard is the CORBA event definitions that are used to receive incident information from Caltrans. The second standard has been developed by the IEN and is used to exchange event information between the Corridor server and the IEN Workstations.

4.2.4 ATIS

The Society of Automotive Engineers SAE J2374 – Location Referencing Message Specification Information Report, also known as LRMS, defines a standard mechanism for the exchange of geographic location. These include:

- Address
- Cross Streets
- LinkID
- Longitude, Latitude
- Linear Reference (e.g. Milepost)

The IEN has adopted the message profiles as specified by the SAE's Location Referencing Message Specification Information Report, so this should be specified for use on the Atlantic Blvd./I-710 Corridor Project, at least as part of the ATMS-IEN interface, if not internally to ATMS software.

The project will not directly support traveler information dissemination. ATMS software therefore need not support the ATIS standard messages. The IEN could provide an ATIS interface in the future without modification of its interface with local ATMS software.

4.2.5 TCIP

The project does not involve transit fleet management, and the ATMS does not need to support the Transit Communications Interface Profiles (TCIP) standards. Any priority service for transit vehicles at traffic signals needs to be compatible with the countywide approach adopted by LACMTA.

4.2.6 ADUS

The ATMS software to be used by local agencies will have the ability to archive data such as traffic volumes and equipment fault alarms. However, there are no plans to exchange archived data. The ATMS therefore need not support the Archived Data User Service (ADUS) standards, but they should be recommended as good practice.

4.2.7 ATC

The project may upgrade selected traffic signal controller assemblies (controllers and cabinets), but such upgrades need to be compatible with existing controllers rather than the Advanced Transportation Controller (ATC) standards. Where an agency is in a position to change to a new standard, they should consider the ATC standards.

4.2.8 DSRC

The project does not involve roadside-to-vehicle communications and the Dedicated Short Range Communications (DSRC) standards are not applicable.

4.2.9 ITE

The project is unlikely to involve installation of new traffic signal heads, but if it does, the those components will need to adhere to the Institute of Transportation Engineers (ITE) standard.

4.2.10 NEMA

Existing in-cabinet traffic signal equipment operated by local agencies adhere to either the National Electrical Manufacturers Association (NEMA) or Caltrans standards. Any upgrades or new installations need to be compatible with the standard currently used by each agency.

5 USE CASE ANALYSIS

As described in Section 3, the User Requirements specify the capabilities of the system in terms that a user can understand. The Use Case analysis, on the other hand, captures users' expectations of the functionality of the system and expresses them clearly in terms that system developers can follow. The User Case model, which expresses top-level Functional Requirements, is the central part of a Requirements Document for the object-oriented development approach[1].

The Use Case model emphasizes interfaces and end-to-end functionality within the "system" by systematically identifying all "system users" and actions they might take. Each "User Case" describes how a "System User" or an "actor" would use the system in each particular "Case". That is, each Use Case describes a particular and observable system behavior. These "behaviors" can be traced back to each identified User Requirement in Section 3. These statements must be easily understood by end users (Atlantic Blvd./I-710 Corridor agencies) and system developers.

The following initial Use Cases are intended to be informal, and will become better defined and more complete through an iterative review process. This document does not intend to explore the Use Case model and analysis in great details.

5.1 System Users

Use Cases are guaranteed to be observable by the fact that they must be connected to one or more "actors". In the Atlantic Blvd./I-710Corridor System, actors (system users) are the ones who operate various levels of traffic control systems; contribute, access and manipulate traffic data; and disseminate relevant traffic information to other agencies or public motorists. Multiple agencies will be able to coordinate their traffic signals, share real-time traffic information, respond to the Caltrans Freeway Management System and ultimately improve travel speeds along the arterial.

System User/ Use Case Actor	**Description**
Caltrans Freeway System	Caltrans computer system that manages freeway data. It provides selected data to outside agencies through a defined interface.
Sub-Regional Operator	A System Operator who is responsible for managing the Sub-Region. The Sub-Regional Operator function is normally performed at the Sub-Regional TMC, but operators at other locations may also assume this role.

"Developing Object-Oriented Software - An Experience-Based Approach", By Kenneth S. Rubin, IBM Object-Oriented Technology Center, 1997.

System User/ Use Case Actor	Description
County Operator	An Operator who is responsible for monitoring congestion and traffic signal operations across the entire County (the entire system). The County operator function is normally performed at the County TMC, but operators at other locations may also assume this role.
External ATMS	An ATMS (Traffic Signal Management And Control System) which is not part of nor directly compatible with the Atlantic Blvd./I-710 Corridor System.
Field Technician	Technical person within signals group who can make physical repairs to the signals and network hardware.
Intersection Controller	The Intersection Controller is the interface from the overall system to the vehicles on the street.
Local Operator	The Local Operator function is normally performed at a local agency TMC, but Operators at other locations can assume this role if they have the correct security access privileges. Note County also acts as a Local Operator for its own signals.
Maintenance Operator	An Operator responsible for monitoring the system for equipment problems.
Off-line Operator	The Off-line Operator function is usually performed by a Traffic Engineer and can be performed from any workstation on the network.
System Operator	The System Operator manages the system for other's use. This Operator sets up users accounts, equipment configuration, and so forth.
Vehicle Detector	The Vehicle Detector is the system's primary input from the street. Vehicle Detectors include, but not limited to, inductive loops or video detectors.
WWV Clock	The WWV Clock object is the system's interface to a WWV time reference. It provides accurate time information to permit time-based traffic signal coordination between geographically separated intersections within the system.

5.2 Use Cases

The following "cases" intend to capture every type of interaction that the system will have with the "outside" world, based on the User Requirements. These "cases" do not represent the design of the Atlantic Blvd./I-710 Corridor ATMS system. They only describe the interfaces to the system and are used to verify that all requirements for the system have been identified, and all identified requirements have been addressed. The objects identified in the Use Case analysis will be carried forward to subsequence steps of the object-oriented design process.

5.2.1 Control Traffic

Controlling traffic consists of determining what plan to run, what mode to run the controller in, implementing it via communications, and verifying its correct operation via communications.

5.2.2 Operate Signals

The Local Operator is responsible for operating all traffic signals within the local agency's jurisdiction, such as manually changing timing plans on control modes.

5.2.3 Monitor Signals

The Local Operator monitors signal operation and congestion within the local agency's jurisdiction using status screens, maps and alarms.

5.2.4 Maintain Signals

The Local Operator receives maintenance events and alarms for signals within the local agency's jurisdiction, for purposes of maintaining correct operation of the signals. The Local Operator may make database adjustments or dispatch field technicians in order to correct the problems detected.

5.2.5 Synchronize Clocks

The computers in the system synchronize all their clocks to one or more WWV Clocks.

5.2.6 Generate Timing Plans

Off-line Operator creates and edits timing plans and schedules in order to optimize traffic flow through the system.

5.2.7 Manage Timing Plans

The Local or Off-line Operator can edit signal timing plans and schedules for controllers in the local agency's jurisdiction in order to optimize flow.

5.2.8 Schedule Operations

The off-line Operator sets up scheduled plan changes and other time-of-day operations.

5.2.9 Exchange Coordination Data

External ATMS system exchanges coordinated information with the system through a Control/Data Interface (CDI). Data exchanged includes equipment status, operating modes, traffic levels, events, and plan implementation commands.

5.2.10 Data Archiving

The System stores data regularly for off-line analysis including documenting system performance.

5.2.11 Monitor Congestion

The System monitors congestion and reports it to the Local, Sub-Regional or County Operator via status screens, maps and alarms.

5.2.12 Analyze Data

The Operator can record, review and analyze signal timings and traffic data.

5.2.13 Measure Traffic

Vehicle detectors provide data (e.g. volume and occupancy) to the system. Other parameters or MOEs (e.g. vehicle speed, stops, delays, queue length) are calculated by the system based on the collected data.

5.2.14 Monitor Events and Alarms

The Maintenance Operator receives maintenance events and alarms for the system or signals within the local agency's jurisdiction for purposes of maintaining correct operation of the signals. The Maintenance Operator dispatches Field Technicians or contacts a System Operator in order to correct the detected problem.

5.2.15 Generate Maintenance Log Reports

The Maintenance Operator can generate reports of historical data from the logs of events and alarms.

5.2.16 Log Event Details

The system logs events. The Maintenance Operator may enter additional details of field events into the event log database, which will appear when system maintenance reports are printed.

5.2.17 Repair Equipment

The Field Technician is responsible for correcting or repairing problems that occur with field hardware. When the repair is complete the technician notifies the System or a Local Operator that the equipment is operational. If a controller was replaced in the field, then the technician may request a download of timing sheet data to the controller.

5.2.18 Configure Operations

The Off-line Operator configures all traffic control aspects of the system, such as intersection, detector, and group geometry, traffic responsive operation, and connections to traffic data from other jurisdictions.

5.2.19 Configure System

The System Operator manages hardware and software configuration issues, such as file and directory location, database backup and replication and jurisdictional partitioning.

5.2.20 Manage Network

The System Operator performs overall network management on the local area network (LANs) in the system using COTS software packages. Different System Operators may have responsibilities for different paths of the physical network.

5.2.21 Manage Resources

The System Operator manages access to system resources. This includes setting the rights or privileges necessary to access a resource, and resolving dynamic conflicts involving resource locking.

5.2.22 Manage Users

The System Operator adds, modifies, and deletes authorized users and the privileges assigned to each of them.

5.3 The Use Case Diagram

Having defined the actors and the use cases, it is now possible to relate them together. This is illustrated in Figure 5.1, the Common ATMS Use Case Diagram, which depicts those use cases that have been identified as common to all ATMS.

Figures 5.2 through to 5.5 show additional use cases derived from the interviews with the agencies in the Atlantic Blvd./I-710 Corridor. These are described in the following Sections.

Note that in Figure 5.2, a new Operator has been defined for the City of Commerce – that of Police Operator.

5.3.1 View CCTV Image

The Operator can select a camera and view its image on the ATMS workstation. This may also involve control of the camera movement (pan, tilt and zoom) and selection of monitor or display device other than the ATMS workstation.

5.3.2 Control City Camera

The ATMS can control the movement of a CCTV camera within the agency's jurisdiction.

5.3.3 Response to Incidents

The ATMS can respond to incidents on the freeways and so mitigate the impact on the arterials adjacent to the affected freeway. The ATMS can also respond to incidents on arterials to mitigate their impact. This includes the development and implementation of suitable traffic management strategies.

5.3.4 Priority to Transit

The ATMS can accommodate the modification of signal timings so as to give preferential treatment to transit vehicles in the network. This involves detection of the bus, determination of need for priority, implementation of the chosen control strategy (e.g. modifications of phasing or timing), monitoring of the action and removal of the priority treatment.

5.3.5 Priority to Emergency Vehicles

The ATMS can accommodate the pre-emption of signal timings so as to give preferential treatment to emergency vehicles in the network.

5.3.6 Manage Incidents

Having detected an incident in the network, or having been notified of an incident (such as a special event), this provides the Operator with tools to monitor the incident, record changes in status, and implement suitable mitigation actions. This may also include automated up-dates of the status of the incident based on data from external sources.

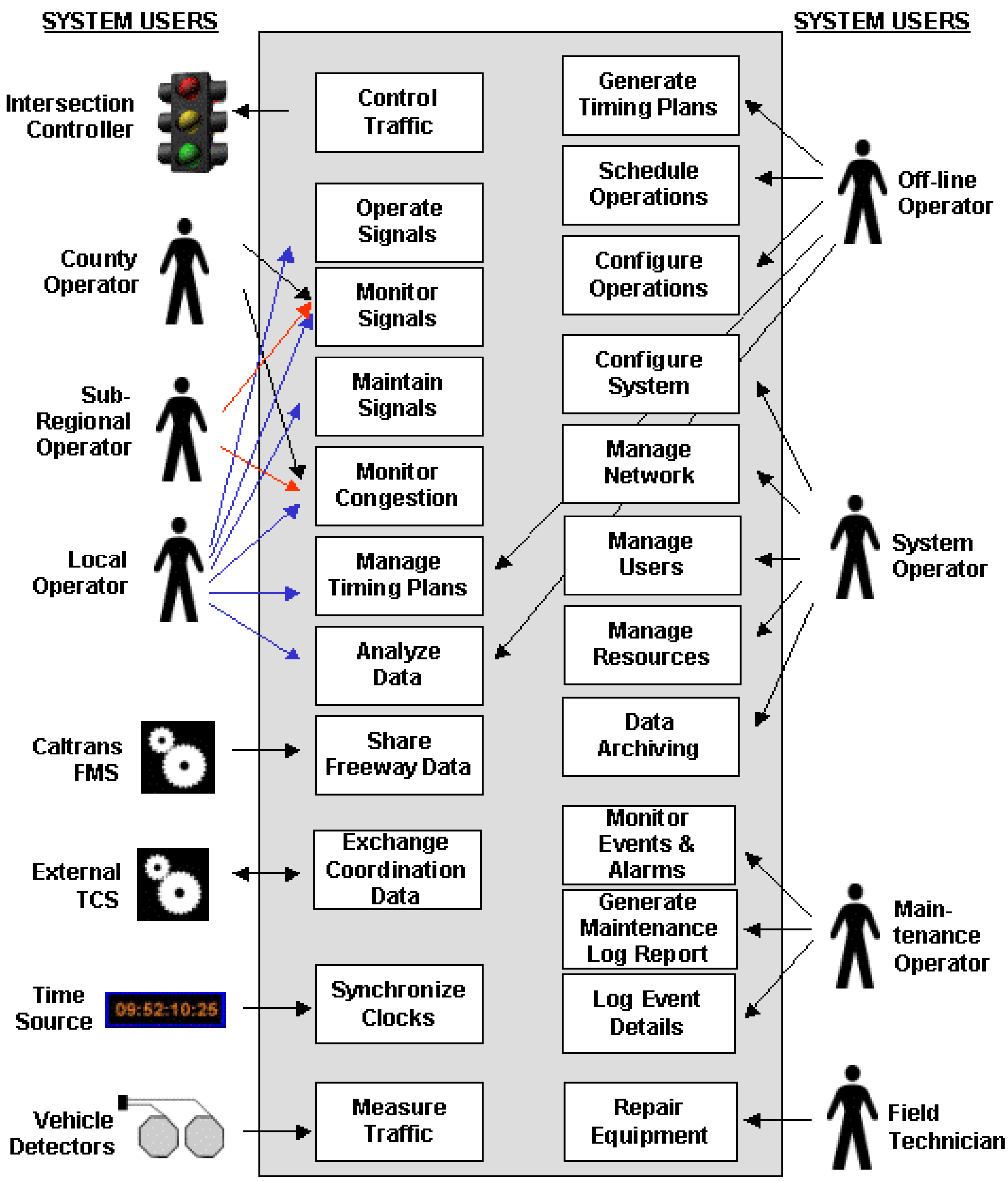


Figure 5.1: Common ATMS Use Cases

6 ATMS USER AND FUNCTIONAL REQUIREMENTS

In the following statements, "the system" and "ATMS" are interchangeable. The following sub-sections identify the key User and Functional Requirements for achieving traffic signal synchronization within the Project area. Each sub-section is made up of relevant User Requirements and derived Functional Requirements. Requirements are based on those developed in the I-5/Telegraph Road Corridor, and have been modified to reflect requirements of the current project.

The General Requirements sub-section groups together functionality and system characteristics that do not apply to a specific use case. The remaining sub-sections are use-case based.

6.1 General Requirements

6.1.1 System Philosophy

User Requirements

UR TS.1 ATMS will implement a download/plan select, distributed control philosophy (The term distributed control philosophy refers to current established practice of plans being developed and stored centrally, and implemented locally after being downloaded to the controller – this allows the system to be less susceptible to communications errors)

6.1.2 Inter-Jurisdictional Coordination

UR TS.4 The system shall provide seamless traffic flow between jurisdictions

UR TS.5 ATMS shall provide inter-agency plan selection capability

UR TS.6 The system shall be capable of corridor wide monitoring and traffic conditions

UR TS.7 With permission, one agency will be able to request/implement plan changes in other agencies to accommodate emergency operations and/or non-recurrent congestion situations

UR TS.8 Each agency's ATMS shall have the ability to reference plans and traffic conditions in the Corridor

Additional Functional Requirements are derived in the use-case based sections following this.

6.1.3 Agencies Involved

LA County Department of Public Works (LACDPW)

UR TS.9 LACDPW shall have operational control of signals within its jurisdiction

UR TS.10 LACDPW shall be able to perform operational monitoring (refers to phase displays and real time plan data) of all signals in the region

UR TS.11 LACDPW shall be able to perform functional monitoring (refers to alarms and faults) of all signals that it maintains

Caltrans

UR TS.12 Caltrans shall have operational control of arterial signals within its jurisdiction

UR TS.13 Caltrans shall be able to perform operational monitoring of arterial signals in the region

LACMTA

UR TS.14 LACMTA shall be able to perform operational monitoring of arterial signals in the region

6.1.4 Local Cities Involved

UR TS.15 Local Cities shall have operational control of signals within their jurisdictions

UR TS.16 Local Cities shall be able to monitor all signals within their jurisdictions

UR TS.17 Local Cities shall be able to monitor the operation of signals Corridor wide

UR TS.18 Local Cities shall be able to perform functional monitoring of controllers for maintenance purposes within their jurisdiction

UR TS.19 Local Cities shall be able to redirect control to alternate agencies

Additional Functional Requirements are derived in the use-case based sections following this.

6.1.5 System Architecture

User Requirements

UR TS.20 The ATMS shall be consistent with the County's IEN Architecture

UR TS.21 The ATMS shall be consistent with the National ITS Architecture

UR TS.22 The system shall be modular and scaleable

UR TS.23 ATMS hardware shall have networking capability

UR TS.24 The ATMS shall be based upon a client-server or thin-client architecture with remote user access available through the Web.

UR TS.25 Industry standard processors and network components shall be used

Functional Requirements

Open Architecture

FR TS.1 The system shall use the latest version of Microsoft's multi-tasking operating system for Intel-architecture PC-based servers in a client-server architecture.

FR TS.2 System workstations shall use the latest version of Microsoft's multi-tasking operating system for Intel-architecture PC-based clients in a client-server architecture.

FR TS.3 The Supplier shall place the source code for all such restrictive software that has been placed under configuration management and control (i.e. all software required to edit or alter the source code and successfully recompile and operate the software, including operating systems, libraries, tools and utilities, data base structures and code, and compilers, including a list of all software documentation tools) in escrow, accompanied by detailed source code documentation, including a list of applicable software development tools.

FR TS.4 Such software escrow shall be updated with respect to all source code in the account at least annually, or earlier, if the Supplier issues an update that contains substantial revisions to the software then retained in escrow.

FR TS.5 The escrow account will be released in the event that the Supplier is unable to deliver services (including warranty services, maintenance, upgrades, bug fixes, and expanded features).

FR TS.6 Upon release of the escrow account under these terms, the Client shall have a royalty-free, non-transferable, nonexclusive license to use, for the Client's traffic management system purposes only, the machine-readable/executable software.

Scalability

FR TS.7 The central signal system software shall be capable of handling a minimum of up to twice the number of intersection currently under the control of the agency.

FR TS.8 Detector data shall be collected and stored in the database for up to *n* detectors (n is equal to 8 times the number of intersections supported by the system).

FR TS.9 These detectors can be any combination of presence or system detectors.

FR TS.10 The delivered system shall support up to x simultaneous operators on the local area network (x is equal to the number of intersection supported by the system divided by 25).

FR TS.11 The delivered equipment shall be sized to support XX local Operators initially, with expansion requiring the addition of operator workstations only. (XX is dependent upon the specific system.)

6.1.6 User Interface

User Requirements

UR TS.39 All user accessible software shall use a Graphical User Interface (GUI)

UR TS.40 The GUI shall allow the use of a mouse

UR TS.41 The GUI shall provide users with drop-down menus for commands to the system

UR TS.42 The GUI shall provide context sensitive on-line help

Functional Requirements

General Ease of Use

FR TS.12 The GUI software shall provide the Operator with a graphical operating environment of the type commonly found on today's desktop computers.

FR TS.13 The GUI shall allow the Operator to select objects on the screen by point-and-click manipulation with the mouse, thereby minimizing typing and the need to memorize lengthy commands.

FR TS.14 It shall be possible to add or delete an intersection from a section through point-and-click manipulation of the intersections on the GUI.

FR TS.15 The GUI shall include standard Windows ™ printer interfaces and utilize standard Windows ™ printer drivers.

FR TS.16 All windows in the central signal system software shall support a mouse with a right button, a left button and a wheel.

FR TS.17 The GUI shall incorporate the following:

(1) Pop-up multiple display objects and windows;

(2) Menu icons and controls;

(3) Dialog boxes;

(4) Push button and other active commands;

(5) Visual and audio alarms; and

(6) Use of object characteristics such as colors, highlighting, and flashing to inform Operators of status changes.

FR TS.18 The GUI shall be oriented around graphic tools and based on the principle of direct manipulation.

FR TS.19 Several windows may be active at the same time and may overlap on the screen; however, the Operator shall be able to interact with only one window at a time.

FR TS.20 The Operator shall be able to easily switch from one window to another, such as by pointing with the mouse cursor to the uncovered part of another window.

FR TS.21 The Operator shall be able to move any window on the screen, to change window size, and to collapse a window to an icon.

Multi-User Capability

FR TS.22 The Supplier-furnished operating system and software shall support a multi-terminal, multi-user interface and the software shall allow access to multiple levels of the central signal system software simultaneously.

FR TS.23 Common icons shall be used as much as possible for all display levels.

FR TS.24 All icon colors shall be selectable by the Operator.

FR TS.25 A list of the Operators that are currently logged onto the central signal system software shall be available to be viewed by a user-defined set of Operators.

Integrity

FR TS.26 Each parameter entered in the database forms shall be checked to determine if the value entered is within an acceptable range, if possible.

FR TS.27 The user shall be notified if the parameter values entered in the form are determined to be outside acceptable ranges.

Confirmation

FR TS.28 The User shall be asked to confirm any action that would result in data being modified or deleted in the database.

Special Editing Facilities

FR TS.29 Cut, Copy and Paste functions shall be provided to the User for all appropriate data entry tasks.

FR TS.30 Drag and drop facilities shall be provided to the User where appropriate.

Help Facilities

FR TS.31 The Help facility should include an on-line version of the User Guide.

FR TS.32 A List of Contents shall be provided.

FR TS.33 A Keyword search facility shall be provided.

FR TS.34 Printing of Help topics shall be provided.

FR TS.35 Help on using Help shall be provided.

FR TS.36 Navigation through Help topics using hypertext links shall be provided.

FR TS.37 Context sensitive Help shall be provided for all screens.

FR TS.38 The software version of each application or optional module shall be displayed in the Help | About dialog.

Progress Indicator

FR TS.39 If the User is required to wait for the completion of an operation, where the wait time exceeds the time specified in the Timings Section, then a progress indicator shall be shown.

FR TS.40 In particular, a progress indicator shall be given for the generation of reports where the specified wait time is exceeded.

FR TS.41 The progress indicator shall graphically represent the completion status of the operation as a percentage.

FR TS.42 If a progress indicator is shown, the User shall be given the option of canceling the current function.

FR TS.43 Where the User is able to initiate several operations simultaneously, a separate progress indicator shall be given for each operation as required.

Tool Bar

FR TS.44 A tool bar shall be provided for the commonly used menu items.

FR TS.45 Standard icons shall be used wherever possible.

FR TS.46 Tool tips shall be provided for all icons.

Status Bar

FR TS.47 A status bar shall be provided to show information on the object currently selected.

FR TS.48 In particular, a description of the currently highlighted menu shall be shown.

FR TS.49 The status bar shall be divided into separate panels, as required, to separate various types of information.

FR TS.50 A list of status message types shall be specified in the documentation provided to the User.

Operator Error Messages

FR TS.51 Operator error messages shall be displayed in a consistent format.

FR TS.52 All operator error messages shall be specified in the documentation provided to the User, with corresponding indexing, and appropriate grouping of error message types.

FR TS.53 The text in an operator error message shall not imply that the User is at fault.

FR TS.54 The text in an operator error message shall give the User guidance regarding the corrective action to be taken.

FR TS.55 The text in an operator error message shall be free from technical jargon, as far as possible.

System Error Messages

FR TS.56 All Software or Hardware related exceptions shall be trapped and displayed to the User as system error messages, if possible.

FR TS.57 These shall also be logged to the Event Log.

FR TS.58 System error messages shall be displayed in a consistent format.

FR TS.59 All system error messages shall be specified in the documentation provided to the User, with corresponding indexing, and appropriate grouping of error message types.

FR TS.60 The text in a system error message shall refer the User to the Windows Application Event log, if applicable.

Multi-Tasking and Multi-Threading

FR TS.61 Several User Interface applications shall be able to be accessed concurrently by a User, up to a maximum specified.

FR TS.62 Within a single User Interface application, and where applicable, the User shall be able to initiate several operations that may execute concurrently (such as report generation).

Concurrent Users

FR TS.63 The system shall allow all Users to view any specified data concurrently.

FR TS.64 The system shall prevent a User from modifying or deleting data that is currently being modified or deleted by another User.

FR TS.65 User profiles shall be able to be stored and subsequently restored when that User logs on again.

6.1.7 System Control

User Requirements

UR TS.43 Operators will be able to manipulate intersection controllers if they have the proper privileges

UR TS.44 Local agencies will be able to delegate control authority to another agency

UR TS.45 Operator shall be able to log in from a remote location and be able to operate the system

Functional Requirements

The System Control Functional Requirements are derived and distributed in the appropriate portions of Section 6..

6.1.8 System Status

User Requirements

UR TS.46 The ATMS shall display status of system controllers

UR TS.47 The ATMS shall log and alarm equipment faults and errors

UR TS.48 The ATMS shall report events which is not faults or errors such as a cabinet door is open

Functional Requirements

The System Status Functional Requirements are derived and distributed in the appropriate portions of Section 6.

6.1.9 Map Display and Real-time Displays

User Requirements

UR TS.49 The user interface shall provide geographically accurate maps in the Project region

UR TS.50 Users shall be able to zoom and pan maps to provide more detail views, through the use of a mouse

UR TS.51 ATMS maps will allow the display of arterial incidents

UR TS.52 Operators with proper access level shall be able to edit maps

Functional Requirements

System Graphics

FR TS.66 The GUI shall incorporate a system map that covers the entire limits of the controlled area.

FR TS.67 When maximized, graphical views shall return to the scale at which they were displayed immediately prior to being minimized.

FR TS.68 Clicking on areas of the system map shall select more detailed views of controlled areas (area maps).

FR TS.69 The system shall provide the capability to draw map and graphic displays.

FR TS.70 The system shall provide the capability to import map displays from a Geographic Information System.

FR TS.71 The system shall provide the capability to import graphics in the following formats:

- .bmp – A .bmp file is a bitmap imager format (raster) developed by Microsoft.
- .wmf – Windows Metafile Format (.wmf) is a recording of the Windows graphics calls. .wmf is a vector based image format.

FR TS.72 The dynamic mapping shall incorporate full pan/zoom capability on system and area maps.

FR TS.73 The Operator shall be able to set up both dynamic and static informational layers that are displayed at different view scale levels by defining the view scale levels in a zoom level set-up configuration database table.

FR TS.74 Different layers shall be enabled as a default at different zoom levels.

FR TS.75 By setting the zoom scale range and appropriately enabled/disabled layers, the Operator shall be able to control which layers display at different zoom scales. For example, at the region-wide scale level the Operator might enable roadway centerlines (static information) as well as a communication status indication (dynamic information) for each intersection controller in the system.

FR TS.76 Display of freeway incidents is a function of the IEN and not the TCS. Arterial incidents will be displayed.

Intersection Displays

FR TS.77 The central signal system software shall allow Operators to view real-time intersection status and detector (volume, occupancy, and speed) data overlaid on maps and graphic displays showing the layout of the intersection.

FR TS.78 The Operator shall be able to double-click on a section of the main map area to maximize the previously minimized intersection graphics.

FR TS.79 The intersection graphics shall fill the entire screen when commanded by the Operator. In all menu selections, the central signal system software shall include a list of intersections by standard name and number.

FR TS.80 When an intersection graphics window is minimized, it shall be possible to maximize the window by selecting the same intersection from the menus.

Intersection Displays

FR TS.81 Intersection displays, which shall depict roadway curb lines and lane lines and shall include static displays of the following (as a minimum):

- Street names,
- Intersection number,
- Phase numbering,
- Special function definition; and
- North arrow.

FR TS.82 The intersection display shall also include dynamic indicators. The intersection display shall indicate the status of the following (as a minimum):

- Controller operational mode (TOD/DOW, traffic responsive, manual, free, free/flash, police flash, technician flash);
- Controller status (offset transition, preempted, type of preemption, conflict flash, etc.);
- The intersection display shall indicate the difference between the programmed offset and the actual timed offset;
- The intersection display shall indicate the difference between the programmed cycle length and the actual cycle length.
- Communications status (e.g., on-line, bad communication, or no communication);
- Cabinet door status;
- Timing parameters currently in effect (e.g., control mode, transition status, control section assignment, timing plan number, cycle length, offset, and split values);
- Color status of all vehicular phases and overlaps (including the circular red, yellow, and green indications and all arrows);
- Status of pedestrian push-buttons;
- Color status of all pedestrian phases (including walk, flashing don't walk, and steady don't walk);
- Actuation status of all local detectors (vehicular and pedestrian) and all system detectors associated with the intersection;
- Preemption in effect, and what preemption mode;
- Special function status;
- Indication of failure, and type of failure;
- Count-up of cycle clock; and
- Count-up of the number of seconds for the split of the phase in service.

FR TS.83 The intersection graphics window shall include a window header with the standard intersection name and number in it.

Detector Displays

FR TS.84	The detector status for a given intersection shall be displayed on the screen with the intersection graphics.
FR TS.85	Traffic detector information (volume, occupancy, speed, congestion level parameters) shall be displayed.
FR TS.86	Link detector information (volume, occupancy, speed, congestion level parameters) shall be displayed as colored links.
FR TS.87	It shall be possible for the Operator to select the relevant quality for display via the GUI.
FR TS.88	V+kO values will be displayed per detector.
FR TS.89	New data types available from existing or new controllers will be able to be displayed by the system. Once the new data is configured, it will be available to the rest of the ATMS without further configuration.

6.1.10 Report Generation

Functional Requirements

FR TS.90	The central signal system software shall generate reports for logged events, detector data, measures of effectiveness, alarms (triggered by traffic condition) and communications statistics.
FR TS.91	The reports shall be generated on a system-wide, section or intersection basis.
FR TS.92	The Operator shall be able to generate custom reports using COTS software.
FR TS.93	It shall be possible to schedule automatic report generation via the TOD scheduler.
FR TS.94	The system shall provide routine pre-formatted reports.
FR TS.95	The User shall be able to print reports.
FR TS.96	To facilitate importing the data to other systems for analysis, database reports shall be exported on command from this utility in the following formats: • text comma-delimited • text space-delimited • text tab-delimited.
FR TS.97	When a report is generated, the default mode of report output shall be to the screen.
FR TS.98	When displayed, reports shall appear in a window that can be resized by the User.
FR TS.99	Multiple reports shall be able to be displayed simultaneously on the User's screen.
FR TS.100	Once a report is displayed on screen, the User shall be able to print the report.

Equipment Reports

FR TS.101 The central signal system software shall permit the Operator to view the status of equipment on a filtered basis.

FR TS.102 The following elements shall be selectable basis for use as filters in the display of system, communications, or equipment status:

(a) System, section, intersection or individual detector

(b) Status

(c) Fault

(d) Time and date (limits)

Communication Reports

FR TS.103 The central signal system software shall have a display/report that shall show the communications throughput.

FR TS.104 The display shall include number of communication attempts, number of successes, number of failures, and percentage of successful communications per intersection, per channel, and per system.

FR TS.105 The communications status views shall include a reference to the standard intersection name and number.

Detector Fault Reporting

FR TS.106 The detector feedback from the field from loop detectors and video detectors shall be continuously monitored for proper operation.

FR TS.107 Detectors shall be classified as acceptable, marginal, disabled, and failed.

FR TS.108 Detector failures shall be reported to the system log and the system workstation.

FR TS.109 The system shall be able to generate reports on % availability of detectors at the intersection or area level.

FR TS.110 The central signal system software shall have user-definable failure filters that define the thresholds that a detector must exceed to be considered failed.

FR TS.111 The filter values shall be selectable on a time of day basis.

FR TS.112 The following failure types shall be provided at a minimum:

- Maximum Presence: If an active detector exhibits continuous detection for a program entered period (0-255 minutes in one minute increments);
- No Activity: If an active detector does not exhibit an actuation during a program period (0-255 minutes in one minute increments);
- Erratic Output: If an active detector exhibits excessive actuation (program entered maximum counts per minute 0-255 in increments of one); and
- Bad communication.

Detector Reports

FR TS.113 The system shall print formatted reports from logged VOS data.

FR TS.114 The system shall provide a report on “Monthly Delay Average” per intersection.

FR TS.115 The system shall provide the following graphical and tabular reports for a detector:

- Speed Reports
- V+kO Reports
- Volume Reports
- Occupancy

FR TS.116 Raw and smoothed volume shall be displayed in user-defined intervals.

FR TS.117 The system shall provide the following graphical and tabular reports for a link:

- Speed Reports
- V+kO Reports
- Volume Reports
- Occupancy

FR TS.118 The system shall provide a report computing Seasonal Volume Coefficients.

FR TS.119 The system shall provide a report of Historical Traffic Flow Reports (1-year).

FR TS.120 An Operator shall be able to select the time period for traffic counting reports.

FR TS.121 An Operator shall be able to select the destination for traffic counting reports.

FR TS.122 An Operator shall be able to schedule automatic report generation via the TOD scheduler.

6.1.11 Database Editing

User Requirements

UR TS.59 The system shall provide mechanisms for auto-upload, auto download and auto-compare

UR TS.60 The system shall provide on-screen display and editing of controller parameters

UR TS.61 The system shall be capable of printing reports

Functional Requirements

FR TS.123 The system shall utilize a multi-user, commercial database software product.

FR TS.124 The database shall be used to store, retrieve, and maintain system data and parameter files.

FR TS.125 The system shall provide a database interface for display and editing controller databases, which shall be integrated into the central signal system software to provide seamless operation for the Operator.

FR TS.126 The database editor shall be accessible directly from the intersection display.

FR TS.127 The resulting combination of central signal system software and database software shall provide for off-line and online database generation and maintenance.

FR TS.128 This shall include loading, modifying, examining, copying, and retrieving the data used to operate the central signal system software. These data include traffic system configuration, timing plans, TOD/DOW schedules, operator databases, and alarm databases.

FR TS.129 The central signal system software shall provide the means to keep multiple intersection database windows open simultaneously to facilitate comparison and data manipulation.

FR TS.130 It shall be possible to drag-and-drop these windows throughout the entire monitor screen.

FR TS.131 Any database changes shall be achievable without having to restart the central signal system software.

FR TS.132 All tables in the database shall be printable in the same form as shown on the computer screen for use by the traffic engineers and maintenance technicians in the field.

FR TS.133 When an Operator attempts to open a controller database that is in use, the central signal system software shall display a message explaining to the Operator that the database is already open and asks if they would like to assume the write privileges.

FR TS.134 Editing of the controller database entries shall be via a tabular format.

FR TS.135 The ATMS database will be a RDBMS, allowing SQL based queries to access data collected by the ATMS.

FR TS.136 The ATMS will support the format at the agency specific controllers.

Database Recovery

FR TS.137 All database backup and recovery shall be through the use of Commercial-Off-the-Shelf (COTS) Software. This COTS software shall be able to do the following:

- Automatically compress and back-up the database on a user-specified time-of-day setting or upon user command; and
- Restore the back-up copy of the database to the database.

FR TS.138 Static database back-ups shall be performed using a DAT tape back-up or writeable CD-ROM drive.

6.1.12 System Security

User Requirements

UR TS.62 Local agencies shall retain control authority

UR TS.63 ATMS shall recognize groups of operators to which access privileges are allocated

UR TS.64 ATMS shall have different access levels

UR TS.65 Access levels shall control access to functions

UR TS.66 Access levels shall control access to equipment

UR TS.67 The system shall allow multiple simultaneous operators to monitor controller behavior

Functional Requirements

FR TS.139 The central signal system software shall provide and maintain a security system to prevent unauthorized access to the system.

FR TS.140 Operator privileges shall be definable on a functional level.

FR TS.141 The security levels shall include, at a minimum: no access, view only, upload only, download only, and full access).

FR TS.142 Each Operator shall have a privilege level mask defined by the System Administrator.

FR TS.143 The mask shall define the specific functions that the particular Operator is authorized to perform. For example, a particular Operator may be given the ability to view all reports, but not to modify some or all levels of the database.

FR TS.144 This (the mask) shall allow for any number of different levels of operator access capability.

FR TS.145 The System Administrator level shall have full access to the system as well as the responsibility for maintaining account passwords and privilege level masks.

FR TS.146 Each Operator shall have a unique, Operator-definable password used to gain access to the system.

FR TS.147 Passwords shall be stored in the database in an encrypted format.

FR TS.148 Before gaining access to the system, the Operator shall be required to enter an operator identification code.

FR TS.149 The central signal system software shall validate the code against an encrypted database of authorized operators.

FR TS.150 Successful completion of the login shall result in execution of a session start-up procedure.

FR TS.151 The start-up procedure shall establish the privileges, object menu options, windows, and tools the Operator may utilize.

FR TS.152 Any functions that a particular Operator is not authorized to access shall either not be shown or shall be “grayed out” so that the Operator can easily distinguish the functions to which he/she has access.

FR TS.153 LAN access shall be limited to those activities that support the central signal system software.

FR TS.154 Unsuccessful login attempts shall be logged to the central signal system software log.

6.1.13 Communications

FR TS.155 The ATMS shall support serial communications at different baud rates for communication to signal controllers.

FR TS.156 The ATMS shall support multiple multi-drop channels for communications with traffic signal controllers.

FR TS.157 The ATMS shall support the AB3418E communications protocol.

FR TS.158 The ATMS shall support Ethernet communication with traffic signal controllers in installations using or planning to use Ethernet for traffic signal communications.

FR TS.158b The ATMS shall support Ethernet communication with CCTV camera in installations using or planning to use Ethernet for CCTV communications.

FR TS.159 The ATMS shall communicate with each intersection nominally once per second.

FR TS.160 The TCS shall support multiple communications protocols as needed by the specific installation.

6.2 Control Traffic (Control Modes)

User Requirements

The system shall support the following modes of operation:

UR TS.26 Central Coordinated: The controllers operate according to a pre-determined coordinated timing plan schedule that is stored in the central database

UR TS.27 Local Coordinated: The controllers operate according to a pre-determined coordinated timing plan schedule that is stored locally in the individual controllers

UR TS.28 Local Isolated (Free operation): The controller is not being commanded for on-line operation by a Master System

UR TS.29 Manual: The controller responds to system commands for plan selection issued from the central control using manual override

UR TS.30 Traffic responsive: The controller responds to system commands for plan selection issued from the central control based on the traffic-responsive algorithm

UR TS.31 Flashing: The controller is put on flash either manually by the central or at the cabinet. This also includes tripped conflict monitor at the local intersection

UR TS.32 Pre-empted: The controller is pre-empted by an external system to provide priority to fire or police vehicles

Functional Requirements

FR TS.161 An operator may delegate control authority to an operator at another agency.

FR TS.162 It shall be possible to delegate control authority to another agency by time of day.

Coordinated Modes

FR TS.163 The central signal system software shall operate in a distributed mode issuing plan and mode changes to local controllers.

FR TS.164 The central signal system software shall upload and download to intelligent local controllers the timing plans, time-of-day/day-of-week (TOD/DOW) schedules, and all other parameters required to operate the local intersection.

FR TS.165 All intersection controllers shall be monitored on a real-time basis by the central signal system software.

FR TS.166 The central signal system software shall support communication with the field controllers at a minimum rate of 1.2kbps.

FR TS.167 Upon system startup, the central signal system software shall establish communications with all intersection controllers and begin real-time monitoring.

FR TS.168 The central signal system software shall start to process both incoming data and Operator requests.

FR TS.169 Any upload, download, or time/date requests shall take precedence over real-time monitoring.

FR TS.170 The central signal system software shall be designed for unattended operation twenty-four (24) hours per day, seven (7) days a week, without requiring an Operator to be logged into the system.

FR TS.171 The central signal system software shall provide system control by coordinating intersection operation on an individual, section, or system-wide basis.

FR TS.172 Control modes shall be Operator-selectable from the Graphical Use Interface (GUI).

FR TS.173 For commanding an intersection to a timing plan different than the TOD/DOW, either by manual override or through the traffic-responsive algorithm, the controller shall be commanded to the appropriate plan.

FR TS.174 In the event that, while in software-commanded override, a controller does not receive a valid timing plan number from the central signal system software within an operator-defined time frame, it shall revert back to its local TOD/DOW schedule.

FR TS.175 Central override shall be allowable on an intersection, section, or system-wide basis.

FR TS.176 In the event of a failure other than power failure or the severing of communications between the central signal system software and the controller, the Operator shall have manual control over the intersection.

Upload/Download

FR TS.177 The System shall allow download on a system-wide, section, or intersection basis. Upload shall be provided on an intersection basis.

FR TS.178 Upload/download commands shall be executed immediately upon command at a minimum communication rate of 1.2kbps between the central signal system software and the field controllers.

FR TS.179 The central signal system software shall upload and download the following data, at a minimum:

- Intersection timing parameters
- Detector data from at least 32 detectors per intersection controller
- Controller and cabinet alarm data
- Event data
- Controller date and time

FR TS.180 The central signal system software shall highlight errors or missing data in timing plans prior to permitting download of the timing plans to a controller.

FR TS.181 The central signal system software shall generate a comparison report listing all data discrepancies between the database and controller.

FR TS.182 The central signal system software shall write this report to a text file for printing or editing.

FR TS.183 It shall be possible to schedule uploads and compares by TOD (auto-compare).

FR TS.184 The results of the auto-compare will be logged and made available for Operator review.

FR TS.185 It shall be possible to request a download from the field without the need for central operator support (remote download request).

Local Isolated

FR TS.186 It shall be possible to place controllers in a local isolated mode on system-wide, section, or intersection basis.

FR TS.187 The Operator shall be able to disable these components through the user interface.

FR TS.188 When disabled, the central signal system software shall not communicate with the component and the component shall run its local TOD/DOW schedule.

FR TS.189 The Operator shall have the ability to reactivate disabled, or off-line, intersections via the central signal system software.

FR TS.190 The central signal system software shall recognize the release of an intersection from communications into stand-by mode without displaying the status as a communications failure.

FR TS.191 The Operator shall be able to monitor the intersection components through the central signal system software, even while not commanding it.

Flash and Free/Flash

FR TS.192 In the flash mode, the controller shall run uncoordinated and will not provide green time to any movements at the intersection.

FR TS.193 To initiate flashing operation remotely, the controller shall be commanded to flash from the central signal system software.

FR TS.194 If the controller has been commanded to be in flash mode and remains on-line, it shall be shown as being in flash mode in the GUI.

FR TS.195 If the intersection is in flash mode because it is off-line, it shall be shown as being in free/flash mode.

Traffic Responsive

FR TS.196 In the traffic-responsive mode of operation, the central signal system software shall select the timing plan that is best suited to the existing traffic conditions as measured by the system detectors and analyzed by the system's traffic-responsive process.

FR TS.197 Once the traffic-responsive process has selected the appropriate timing plan, the plan number shall be commanded to the intersections on a continuous basis until the traffic-responsive process recognizes, based on sufficient change in traffic conditions, the need to command a different timing plan.

FR TS.198 The traffic-responsive algorithm shall be based on the UTCS algorithm or other approved traffic-responsive algorithm.

FR TS.199 In order to enhance traffic responsive operation, the following traffic-responsive process points shall be implemented:

- Each section shall be associated with zero to a maximum of ten (10) other sections.
- One section shall be designated as the master section.
- When traffic conditions warrant a traffic-responsive timing plan change for the master section, the central signal system software shall automatically change the timing plans for the other associated sections.
- If no other sections are associated with a section, only that section shall change timing plans.

FR TS.200 The Operator shall be able to define a single detector station as a section.

FR TS.201 When the traffic-responsive process detects that this detector station has exceeded operator-defined thresholds, the associated sections shall automatically change to the appropriate traffic-responsive plan. This process is intended for use in conjunction with special events (such as to detect and respond to a surge of traffic leaving the parking facility of a stadium or arena following the end of a sporting event).

FR TS.202 It shall be possible to group commands together by device or section.

6.3 Operate Signals (Manual Control)

FR TS.203 The Operator shall be able to invoke manual override of the plan currently in effect for the entire system, for a subsection of the system, or for individual intersections (system-wide, section, or intersection basis).

FR TS.204 Manual selection of timing plans shall have a higher priority than all other modes of timing plan selection.

FR TS.205 The Operator shall have two options for implementing manual override:

- Setting the manual override and later releasing the override manually; and
- Setting the manual override with a specified time frame for automatic termination.

FR TS.206 Under the second option, the manual override shall terminate automatically at the end of the specified time.

FR TS.207 When manual override is terminated, each affected controller shall revert to its previous mode of operation.

6.4 Monitor Signals

FR TS.208 The central signal system software shall monitor the traffic signal controllers on a second-by-second basis.

FR TS.209 If polling rates are restricted by elements of the field communications infrastructure, the central signal system software shall monitor the traffic signal controllers at the most frequent rate possible, up to second-by-second rates where possible.

FR TS.210 At startup, the central signal system software shall establish communications with all intersection controllers via the central communication system and begin second-by-second monitoring.

FR TS.211 The central signal system software shall process both incoming data and User requests.

6.5 Maintain Signals

Paging

FR TS.212 The central signal system software shall have the capability to automatically send alphanumeric messages to maintenance personnel upon detecting critical problems with the central signal system software.

FR TS.213 Upon detection of the critical event, which triggers a system event, the designated phone number shall be dialed and the message presented.

FR TS.214 This feature (critical event triggers) shall be fully programmable allowing designation of TOD/DOW, phone number, and which critical event to trigger.

6.6 Synchronize Clocks

User Requirements

UR TS.2 Time bases in each ATMS shall be synchronized

UR TS.3 The time reference clocks of each local ATMS shall be synchronized with the entire system to enable area-wide coordination

UR TS.37 The ATMS shall synchronize ATMS clocks based on an external, universal time reference time

Functional Requirements

FR TS.215 The Supplier shall provide the means by which the central signal system software's time clock is automatically synchronized with universal time through the WWV radio broadcast or WWV Internet source.

FR TS.216 Such automatic synchronization shall occur at least once per hour.

FR TS.217 The capability shall also be provided for the Operator to disable and re-enable this function.

FR TS.218 The central signal system software shall provide for the automatic downloading of clock updates to each field controller.

FR TS.219 The frequency of such updates shall be Operator-programmable within the range of once-per-minute to once-per-day.

FR TS.220 The central signal system software shall also permit the controller clock to be updated when a controller is brought on line.

6.7 Generate Timing Plans

FR TS.221 It shall be possible to export data to SYNCHRO.

FR TS.222 It shall be possible to import timings generated by SYNCHRO.

FR TS.223 The Operator must approve imported timings before inputting SYNCHRO generated timings into the controller database.

6.8 Manage Timing Plans

FR TS.224 The central signal system software shall permit the Operator to switch from the stored database to an uploaded controller database without either database closing or losing changes.

FR TS.225 The number of timing plans, timing plan pages, and coordination plan pages that can be stored by the central signal system software shall only be limited by the physical storage capabilities of the hardware.

FR TS.226 Each timing plan shall include uniquely programmable values for cycle length and offset, a uniquely programmable phase sequence, and uniquely programmable split values.

FR TS.227 The central signal system software shall provide the automatic calculation of permissive periods (based on splits values).

FR TS.228 The central signal system software shall also provide the capability to handle special signal and/or timing plans to accommodate unusual traffic flow patterns during special events.

FR TS.229 The central signal system software shall copy the timing plans, tables and coordination tables from one controller to another when commanded by the Operator.

6.9 Schedule Operations

Time of Day/Day of Week

FR TS.230 TOD/DOW mode shall be used for controlling traffic conditions that occur regularly.

FR TS.231 In this mode, each controller shall automatically select and implement traffic signal timing plans in accordance with the defined schedule, locally stored, on a TOD/DOW basis.

FR TS.232 TOD/DOW plans shall be downloadable from the central signal system software to the controller in the field.

FR TS.233 The Operator shall be able to schedule any plan or mode change command for execution at any time.

FR TS.234 The System Administrator shall be able to inhibit user access to the event scheduler.

FR TS.235 The entries in the event scheduler shall be automatically sequenced in ascending order by TOD/DOW, regardless of the order in which the entries were made.

FR TS.236 Operator commands shall have priority over scheduled entries in the event scheduler.

FR TS.237 The Operator shall be able to make entries into the event scheduler for up to a minimum of one year in advance.

FR TS.238 Up to 1000 entries shall be permitted.

FR TS.239 The scheduler shall have the capability to load multiple commands for the same time .

FR TS.240 For events scheduled at the same time, the execution shall occur simultaneously.

Temporary and Permanent Commands

FR TS.241 Commands entered into the event scheduler shall be of two types, permanent and temporary.

FR TS.242 Permanent commands shall be performed every time the matching of time parameters occurs.

FR TS.243 Temporary commands shall be performed once and then be deleted from the scheduler database.

FR TS.244 The Operator shall be able to enter the following permanent and temporary command times as a minimum:

- Permanent commands:
  - Every day basis (i.e., every day of the year);
  - Every week basis (i.e., on a given day or days of every week);
  - Every time span basis (i.e., every hour);
  - Every weekday (i.e., given weekday from Monday through Friday); and
  - Every weekend (i.e., given weekend day such as Saturday or Sunday).
- Temporary commands:
  - Specific date basis (e.g., December 25, 2000);
  - Specific time basis (e.g., at 2:00 PM or 1400 hours); and
  - Specific date/time basis (e.g., on 4/15/2001 at 11:00 AM).

FR TS.245 Fixed and "floating" holiday exception tables will be provided.

FR TS.246 Holidays will override the standard TOD/DOW control tables.

6.10 Exchange Coordination Data

User Requirements

UR TS.76 It shall be possible to share real-time detector data (at a minimum, Volume, Occupancy, Speed) among various jurisdictions in Atlantic Blvd./I-710 Corridor

UR TS.4 The system shall provide seamless traffic flow between jurisdictions

UR TS.5 ATMS shall provide inter-agency plan selection capability

UR TS.6 The system shall be capable of corridor wide monitoring and traffic conditions

UR TS.7 One agency will be able to request/implement plan changes in other agencies to accommodate emergency operations and/or non-recurrent congestion situations

UR TS.8 Each agency's ATMS shall have the ability to reference plans and traffic conditions in the Corridor

Functional Requirements

FR TS.247 Data exchange between systems shall conform with definitions established for the IEN.

FR TS.248 For data types not specified by the IEN, the NTCIP Center-to-Center Specifications should be followed.

FR TS.249 The IEN shall be supported.

FR TS.250 The ATMS shall accept external plan change commands.

6.11 Data Archiving

Collection and Retrieval

FR TS.251 The central signal system software shall automatically record detector data in the database.

FR TS.252 Detector data shall be stored in memory on a five minutes basis.

FR TS.253 If bad data or no data is received from the detector loops during any or all of the five-minute collection time, the data will be tagged as questionable or not available in the database.

FR TS.254 Each five-minute block shall be date and time-tagged.

FR TS.255 The User shall have the ability to enable or disable the detector data collection feature systemwide.

FR TS.256 Every twenty-four (24) hours the five-minute detector data shall be automatically compressed and written to the storage media.

FR TS.257 Detector data shall be retrievable from the storage media for use with the relational database or traffic modeling packages.

6.12 Monitor Congestion

User Requirements

Unnumbered: The ATMS should be capable of providing congestion monitoring with associated alarms.

Functional Requirements

FR TS.258 The system shall derive volume, occupancy and speed..

FR TS.259 System shall provide methods in the user interface to show levels of congestion for intersections including:

- Level of Service
- Detector Volumes, Occupancy, Average Speed
- Aggregate Intersection Detector Volumes, Occupancy, and Average Speed

6.13 Analyze Data

FR TS.260 The system shall provide a mechanism to export any data detector that is entered or archived in the central database for the purposes of analysis. Specific requirements are included in the appropriate sections included in these Functional Requirements.

FR TS.261 Delay simulations based on proposed timings with real-time volumes shall be carried out by exporting data to SYNCHRO.

FR TS.262 Travel time simulations, based on proposed timings with real time volumes, shall be carried out by exporting data to SYNCHRO.

Time/Space Diagrams

FR TS.263 The central signal system software shall have the ability to generate time-space diagrams from both real-time data and from programmed data contained in the database and to display such time-space diagrams on-screen.

FR TS.264 The Operator should then be able to perform "on-screen fine-tuning", using click and drag methods to adjust the offsets, with the resulting changes in the widths of the progression bands being displayed.

Split Monitor

FR TS.265 The system software shall have the ability to provide a graphical display/report showing split times for a past period for an intersection.

FR TS.266 The split time report shall be selectable as:

- Between specific times (on a given date)
- Plan number

6.14 Measure Traffic

User Requirements

UR TS.33 The ATMS shall provide the capability of collecting and maintaining all data required for monitoring, and confirmation of displays from all intersections concurrently

UR TS.34 If the intersection is not running coordinated, data shall be continue to be collected

UR TS.36 ATMS will be capable of exporting signal timing and volume information for off-line timing generation (Off-line Timing Generation)

UR TS.38 Data collected by the ATMS shall be capable of being aggregated to peak hour volume as used to satisfy the LACMTA Congestion Management Plan highway monitoring requirements

UR TS.70 At a minimum, per lane volume and occupancy between all major intersections (mid-block) shall be collected

UR TS.71 Above data will be used for planning purpose, timing plan generation, and as input into incident detection and future adaptive traffic control algorithms

UR TS.72 Detection technology shall be reliable and provide accurate data on a per lane basis

UR TS.73 Detection technology shall be cost-effective on a life-cycle cast basis, easy to operate and maintain and shall have minimal maintenance needs

UR TS.74 Detection technology may be permanent or temporary

UR TS.75 Detection technology shall perform in all weather conditions

Functional Requirements

FR TS.267 The central signal system software shall process detector data every one (1) minute for traffic responsive operation.

FR TS.268 The central signal system software shall re-evaluate the traffic responsive data every five (5) minutes to determine the appropriateness of the timing and make changes.

FR TS.269 The field hardware shall include both system and local detectors that shall be used for both traffic counting and traffic-responsive operation.

FR TS.270 The central signal system software shall process and maintain detector count and occupancy data on a continuous basis to be used for various traffic control strategies and/or reporting tasks.

FR TS.271 Detector feedback shall be obtained on a user definable time frame.

FR TS.272 The time frame shall not be less than once per minute.

FR TS.273 The central signal system software shall recognize, process and display detector information including traffic volume, occupancy and speed.

FR TS.274 Volume shall be defined as: The number of vehicles counted in an interval of time.

FR TS.275 Occupancy shall be defined as the percentage of time the detector loop is occupied.

FR TS.276 Speed shall be calculated if based on the output from detector loops.

FR TS.277 If calculated and not measured directly, the system shall calculate a speed value for links based on an assumed vehicle length and loop size.

FR TS.278 Assumed vehicle length and loop size shall be shall be user definable system-wide parameters.

FR TS.281.a The system shall detect a stopped vehicle or vehicles.

6.15 Monitor Events and Alarms

Alarms

FR TS.279 Malfunction detection and diagnosis and automatic status logging shall be provided to minimize the time-to-repair of critical components of the central signal system software.

FR TS.280 The system shall detect controller power failure and recovery.

FR TS.281 The system shall support as alarms any failures reported by the controller to the central.

FR TS.282 Upon failure, the central signal system software shall log the event and also display a visual alarm to the Operator.

FR TS.283 The occurrence of each such alarm shall be recorded in the system log.

FR TS.284 Alarms shall have at least two priority levels.

FR TS.285 Alarm priority level shall be user selectable. The central signal system software log shall include a reference to the intersection name and number with which any given event is associated.

FR TS.286 The event log shall include the central signal system software time that the alarm is recorded.

FR TS.287 The central signal system software shall continue to attempt communication with the failed component.

FR TS.288 If the failed component communicates successfully for an operator-specified amount of time, the component shall be considered operational.

FR TS.289 This event shall also be logged, along with the clearing of the alarm for the failed component.

FR TS.290 Alarms shall be displayed in the active window on the central signal system software screen.

FR TS.291 The alarm window shall be intrusive (preempt or interfere with the Operator's editing tasks).

FR TS.292 Alarms shall be automatically recorded in an alarm log.

FR TS.293 Alarms shall be automatically time stamped and routed to a specified Operator station.

FR TS.294 It shall be possible to change alarm routing to different Operator stations by time of day.

FR TS.295 Alarms: Immediate display of alarms taking into account the data latency of the system.

FR TS.296 Alarms shall be user selectable ignore by specific device.

FR TS.297 It shall be possible to specify that a given alarm must occur a user specifiable number of times before it is reported.

FR TS.298 It shall be possible to print the alarm log.

FR TS.299 The TCS shall monitor the controller to verify that the controller is operating under selected timing plan.

6.16 Generate Maintenance Log Reports

User Requirements

UR TS.53 The system shall be capable of generating maintenance reports

Functional Requirements

FR TS.300 The central signal system software shall generate information every 24 hours indicating device/system failures. A maintenance report suitable for in-house or contracted signal control maintenance shall be generated.

FR TS.301 A 24-hour maintenance report shall indicate type of device, failed device, and type and severity of failure, and responsibility for maintenance for the past 24 hours.

FR TS.302 It shall be possible to route maintenance reports to city operations staff.

FR TS.303 It shall be possible to route maintenance reports to city maintenance staff.

FR TS.304 It shall be possible to route maintenance reports to a signal maintenance contractor.

FR TS.305 It shall be possible to route maintenance information to LA County DPW.

FR TS.306 User will be able to schedule the printing and choose printer for traffic counting reports.

Preventive Maintenance

FR TS.307 For each traffic control device in the system, the central software shall track dates for preventive maintenance. This may include visual inspection, replacement of parts.

FR TS.308 Warranty for all traffic control devices shall also be maintained with each traffic signal.

6.17 Log Event Details

User Requirements

UR TS.55 The system shall record actions taken and changes of status

UR TS.56 The system shall record operator actions in a system log

UR TS.57 The operator shall be able to add comments to the system event log

UR TS.58 The ATMS shall record when timing plan changes have occurred

Functional Requirements

FR TS.309 The system event log shall record changes in the status of all traffic control devices and subsystems (E.g. Traffic Signals, DMS, CCTV, etc.).

FR TS.310 All database modifications, uploads/downloads, alarms, and system commands shall be logged in the system log.

FR TS.311 System logins and logouts shall be logged (with time and date stamp) and shall be accessible to the System Administrator.

FR TS.312 The event log shall be searchable by device type (or subsystem), specific device, User/Operator, and severity of error.

FR TS.313 Reports from the event log from the searchable event log viewer shall be printable.

6.18 Repair Equipment

FR TS.314 Based on information from the 24-hour Maintenance Report, the system shall track the status of maintenance including:

- Failure Date
- Maintenance Personnel/Contractor Contact Date
- Name of Maintenance Personnel/Contractor Contacted
- Scheduled time/Estimated time for Repair
- Actual Date of Failure Repaired

- Comments

6.19 Configure Operations

FR TS.315 The system shall enable the Operator to define a minimum of **Y** control sections, or subsystems where y is equal to the maximum number of intersections supported by the system.

FR TS.316 Each (control section) shall be completely independent of the connection of any particular intersection to the communications network.

FR TS.317 The number of intersections in a particular subsystem shall be programmable from a minimum of one to a maximum of the total number of intersections in the system.

6.20 Configure System

FR TS.318 It shall be possible to add new alarms or events to one component of the system without rebuilding any other part of the system.

To be further defined

6.21 Manage Network (Network Administration)

FR TS.319 Using tools provided with the Windows operating system, the System Administrator or Network Administrator shall have the capability to monitor the network, including:

- Which users are logged into the system
- The status of any system firewalls
- The status of system servers

6.22 Manage Resources (System Administration)

Recovery

FR TS.320 The central signal system software shall automatically recover from a power failure.

FR TS.321 The central signal system software shall automatically begin communications with all field equipment via the central communications system.

FR TS.322 If the central signal system software detects a non-fatal error within one or more of its processes, it shall log a message to the system log.

FR TS.323 The system shall continue to operate in a degraded state.

Archiving

FR TS.324 Every twenty-four hours the five-minute detector data shall be automatically compressed and written to the system disk.

FR TS.325 Each twenty-four hour history shall be date tagged.

FR TS.326 The User shall have the ability to enable or disable the detector data archival feature.

FR TS.327 Operators may select periodic archiving of certain dynamic data from the database to an archive file.

6.23 Manage Users

FR TS.328 The system shall provide a full range of security and administration functions. The types of functions shall include:

- Login, Logout and Exit
- Security - ID/Password Combination
- Add and Delete Users
- Specification of User's Rights on a menu-by-menu basis (User profile)
- System Administrator's ability to Change User's Password
- Operators ability to change their Own Password

FR TS.329 The System Administrator shall assign user rights.

FR TS.330 The User's profile shall be accessible from any Operator workstation on the system.

FR TS.331 The system shall provide secure access to the signal control system.

FR TS.332 Operator access will be by function and specific equipment.

FR TS.333 For access definition, equipment may be grouped together.

FR TS.334 Each User must log into the system Operator Interface (OI) with a username and password.

FR TS.335 These two identifiers shall be used by the system to determine if the requester is permitted on the system and what rights that individual will have.

FR TS.336 The System Administrator shall have the ability to limit user rights down to a specific menu level.

FR TS.337 Menus and functions to which the Operator has access will be in dark letters while restricted menus or command options will be grayed out.

FR TS.338 Remote Users shall be required to provide a user name and password to connect to the network and then a separate login to the central software.

FR TS.339 The rights of the remote User will be determined and set up in the same manner as a local User.

6.24 View CCTV Image

FR TS.340 View CCTV Image - The system shall allow Operators to use their workstations to assign input from any camera to any monitor in the Operations Center, or to the Operator workstation itself.

FR TS.341 The system shall display the images in views that can be minimized or maximized.

6.25 Control City Camera

FR TS.342 The system shall provide Operators with the capability to carry out all camera control functions from the Operator workstation.

FR TS.343 An individual camera may be chosen by clicking on the camera icon from the zoomed in map, or by selecting the CCTV button from the toolbar.

FR TS.344 From the CCTV menu, the Operator shall be able to select preset scenes by choosing the sample view that represents the scene they desire.

FR TS.345 The system shall enable Operators to create and store preset scenes for each camera in the database.

FR TS.346 The scene shall comprise camera position (pan and tilt), zoom, focus, and/or other controller selection options.

FR TS.347 Each preset scene shall allow an associated text phrase.

FR TS.348 Sample views of the preset scenes available for each camera shall be shown and the Operator shall be able to easily "activate" the desired preset sample image.

FR TS.349 It shall be possible to establish an initial set of preset scenes for each camera.

FR TS.350 The system shall support panning, tilting, and zooming CCTV cameras.

FR TS.351 Administrators will assign a unique name to each user.

6.26 Response to Incidents

FR TS.352 The IEN is responsible for recommending appropriate responses to incidents. The ATMS shall respond to a request for timing plan number change, originating from the IEN, in order to participate in the IEN's response plan.

6.27 Priority to Transit

FR TS.353 The system shall support transit priority consistent with the approach adopted by the LACMTA for countywide deployment.

6.28 Priority to Emergency Vehicles

FR TS.354 The central signal system software shall recognize the occurrence of locally initiated preemption for emergency vehicles and thereby not erroneously diagnose a coordination failure because the local controller has been preempted.

FR TS.355 The beginning and ending times of all preemption events shall be recorded in the system log.

FR TS.356 The central signal system shall include reports and displays that show the beginning and ending times (or alternately, the beginning time and duration) of all preemption events for a selected time period.

FR TS.357 Vehicle preemptions shall be reported by intersection approach.

6.29 Manage Incidents

The requirements associated to managing incident have been allocated to the IEN. Incidents are created and managed though the IEN Workstation and Corridor Server. The ATMS participates in the Incident response by responding to a request for timing plan change.

6.30 System Performance Criteria

The central signal system software shall meet the performance criteria outlined in Table 6.1.

Category	Performance Measure	Criteria
Central Workstations	(1) System start-up or re-boot time	10 minutes
	(2) Data latency	3 seconds
	(3) Display intersection graphic fully drawn and updated with dynamic attributes	10 seconds
	(4) Refresh rates: Largest map All other displays	 1 second 1 second
	(5) Time for user to monitor, display and access any control interface	3 seconds
	(6) Display of detail list views	3 seconds
	(7) Controller commands to occur	3 seconds
	(8) Number of intersections supported	2000
	(9) Number of system detectors (not only those for local actuation) supported	5000
	(10) Minimum number of simultaneous users	limited only by network
Dial-up access (telephone or cellular)	(11) Remote computer system start-up	5 minutes
	(12) Monitor and control any signal controller	15 seconds
	(13) Controller commands to occur	5 seconds
	(14) Display intersection graphics and status view, fully updated with dynamic attributes	15 seconds
	(15) Data latency	3 seconds

Table 6.1: Performance Criteria

7 SYSTEM DETECTION

In order to meet the objective of this Project; to deploy traffic control systems in the Corridor so that the signals along Atlantic Blvd./I-710 Corridor can be synchronized across the jurisdictional boundaries, it is necessary to provide system detection. System detectors are not used for direct intersection control, but for the collection of traffic data to enable a broader view of the network conditions to be taken into account in selecting signal timings. These devices collect volume and occupancy data for each lane. Speed may be measured directly or calculated based on volume and occupancy. System detectors are connected to a central system or on-street master controller, and are located in strategic sections where there is little chance of traffic conditions affecting the operation of the detectors (e.g. to avoid queuing over a loop detector, loops are located at least 250' to 300' from the stop-bar).

The installation of system detectors will allow for the collection of real-time traffic information that will present the system with a picture of current, up-to-the-second conditions on the Corridor. This information will then allow agencies to synchronize their signals with neighboring agencies, and exchange traffic information in real-time. Agencies will also be able to exchange data with other agencies. This will allow the agencies to respond to recurrent and non-recurrent congestion in a coordinated fashion across the jurisdictional boundaries.

7.1 Confirmation of Requirements

Previous efforts on this Project have identified User and Functional Requirements that necessitate system detection. Requirements fall under the following use cases:

Use Case: Monitor Congestion:

FR TS.258 The system shall derive volume, occupancy and speed

Use Case: Measure Traffic

User Requirements

UR TS.33 The ATMS shall provide the capability of collecting and maintaining all data required for monitoring, and confirmation of displays from all intersections concurrently.

UR TS.34 If the intersection is not running coordinated, data shall continue to be collected

UR TS.38 Data collected by the ATMS shall be capable of being aggregated to peak hour volume as used to satisfy the LACMTA Congestion Management Plan highway monitoring requirements

UR TS.70 At a minimum, per lane volume and occupancy between all major intersections (mid-block) shall be collected

UR TS.71 Above data will be used for planning purpose, timing plan generation, and as input into incident detection and future adaptive traffic control algorithms

UR TS.72 Detection technology shall be reliable and provide accurate data on a per lane basis

UR TS.73 Detection technology shall be cost-effective on a life-cycle cast basis, easy to operate and maintain and shall have minimal maintenance needs

UR TS.74 Detection technology may be permanent or temporary

UR TS.75 Detection technology shall perform in all weather conditions

Functional Requirements

FR TS.269 The field hardware is expected to include both system and local detectors that shall be used for both traffic counting and traffic-responsive operation.

FR TS.270 The central signal system software shall process and maintain detector count and occupancy data on a continuous basis to be used for various traffic control strategies and/or reporting tasks.

FR TS. 271 Detector feedback shall be obtained on a user definable time frame.

FR TS.272 The time frame shall not be less than once per minute.

Detector Data Types

FR TS.273 The central signal system software shall recognize, process and display detector information including traffic volume, occupancy and speed.

FR TS.274 Volume shall be defined as: The number of vehicles counted in an interval of time.

FR TS.275 Occupancy shall be defined as the percentage of time the detector loop is occupied.

FR TS.276 Speed shall be calculated if based on the output from detector loops.

FR TS. 281 (a) The system shall detect a stopped vehicle or vehicles

8 LOCAL CITY CONTROL SITE CONSIDERATIONS

8.1 Introduction

The I-105 Corridor Project has provided an analysis of requirements for the Sub-Regional TMC and local city control center sites. The County of Los Angeles DPW has a separate activity addressing the County's traffic management center needs. This Section of the Functional Requirements report applies the I-5/Telegraph Road Corridor Project local city control (LCC) site analysis to the Atlantic Blvd./I-710 Corridor Project agencies: Bell Bell Gardens, Cudahy, Huntington Park, Maywood, and Vernon.

This Section identifies relevant User and Functional Requirements from the I-5/Telegraph Road Corridor Project in order to derive typical requirements for the Atlantic Blvd./I-710 Corridor Project agencies. Agency specific requirements will be developed in a later deliverable.

8.2 Types of TMC

Located in Southern California are a range of traffic operations and management centers in use by local agencies. Examples are:

- City of Anaheim
- City of Irvine
- City of Inglewood
- City of Long Beach
- City of Los Angeles
- City of Pasadena
- City of Santa Ana

These are all examples of self-contained, purpose built facilities, sometimes occupying several thousand square feet. This has been dictated by the intensive, staff oriented nature of the operations of these systems. However, not all operations centers need to be on such a scale. Tailoring the control center, or LCC, to the City's needs is a critical aspect of the LCC's design.

The East San Gabriel Valley Pilot Project is implementing smaller scale traffic management centers, requiring less space, but still self-contained. These smaller scale centers address the needs of the city that wished to have an operational focus without the costs associated with a sophisticated, dedicated facility. A typical LCC for an agency that wished to have multiple operators and the ability to view CCTV images would likely involve two rooms: the control room, where the workstations are located, and the equipment room which houses the servers and communications equipment.

Figure 8.1: Example of the Control Area of an LCC

(Courtesy of the Spokane Region Transportation Management Center)

Figure 8.1 shows an example of what can be achieved in a relatively small area with such an arrangement. The photograph shows the control room of the Spokane Regional Transportation Management Center. This is a 20' by 30' room (600 sq. ft.). Behind the large screen display lies the equipment room which is 20' by 14' (280 sq.ft.) for a total of 880 sq. ft. This is providing ample space for three full operator workstations. (Note the use of the flat screen displays, which are discussed below).

The example is a relatively comprehensive traffic control facility. In relation to the Atlantic Blvd./I-710 Corridor Project this would represent one of the larger LCCs. For example, at a city which houses a traffic control system shared by several agencies, or even where the Sub-Regional TMC is located at a city.

In addition, the ESGV Pilot Project utilizes the concept of the desktop traffic management center which takes advantage of the use of PC-based equipment for the ATMS. This would be simply an area set-aside within an existing work area, such as a cubicle, where the ATMS equipment would be located. This would satisfy the need of the agency that wished to operate its own system, but kept the central equipment down to the minimum required. This would also be the LCC for an agency that simply used a workstation on a remotely located ATMS.

Figure 8.2 shows an example of an equivalent arrangement being used at the City of Englewood, Colorado. This system controls approximately 80 intersections.

Figure 8.2: Example of the Control Area of an LCC

Both the self-contained LCC and the desktop LCC are considered appropriate for consideration under this Project.

8.3 User Requirements

8.3.1 General

UR LCC 1. Local City Control Sites need to support the core ATMS, detection stations and communications system functionality.

UR LCC 2. The LCC must accommodate communications infrastructure enabling the ATMS located at that LCC to download information to, and upload information from, the Sub-Regional TMC.

UR LCC 3. LCC sites may be staffed as needed. Depending on the specific scope of a facility, a full staff contingent may not be necessary.

UR LCC 4. Sharing staff with another co-located non-TMC function (i.e., accident analysis) may also be a viable option. In this case, the space requirements for the local city control site are considerably reduced.

UR LCC 5. A minimum LCC sites would be considered as housing one or two workstations in a control area and a hardware area that contains communications equipment, modems, servers, etc. It is estimated that such a site may require as little as 200 to 500 sq. ft of space.

UR LCC 6. LCC's shall be developed on a cost-effective site. This shall take into account considerations such as agency preference, development cost, and communication cost to the field devices.

UR LCC 7. When applicable, the LCC will be capable of displaying local CCTV system video images on individual operator's workstations, and for larger TMC's on video monitors and selected TMC offices and conference rooms.

UR LCC 8. The LCC shall have back-up power, water, and other utilities systems so operations can be continued during interruptions of normal utility service.

UR LCC 9. The LCC shall be sized to accommodate agency's operations staff and administrative support staff, the computer systems, and video display systems.

UR LCC 10. The LCC shall employ means to protect from and detect unauthorized access, tampering, and destruction of critical system information and components.

UR LCC 11. The LCC shall make use of the existing infrastructure in the Project area to the extent possible.

8.4 Functional Requirements

The following are Functional Requirements for a typical LCC. Not all requirements are applicable when the TMC is not a self-contained room or rooms, but simply a defined work area (e.g. a cubicle) of an existing facility.

FR LCC 1. The specific layout of each room/area shall be configured on the basis of: staff allocation; equipment allocation; ergonomic interaction among various staff and equipment.

FR LCC 2. The LCC shall provide existing/new computer workstations and consoles/desks for the maximum number of operators expected to occupy the control room/area at one time.

FR LCC 3. In addition, a supervisor workstation and console/desk shall be provided, if required.

FR LCC 4. Ergonomically designed consoles/desks shall accommodate the surface equipment used by the operator (e.g., computer workstation components, telephone(s), detail monitor(s), etc.) allowing the operator to access the equipment easily and efficiently, while not blocking views of the other equipment and activities in the room/area.

FR LCC 5. Space for free paper work shall also be provided.

FR LCC 6. The TMC shall provide a desktop/console cable management system that allows easy reconfiguration for console monitoring.

FR LCC 7. The TMC shall provide glare control (positioning and/or filters) for workstations.

FR LCC 8. The dedicated video monitors to be installed in the larger TMC's shall have displays designed for extended viewing (adequate separation, high contrast background, etc.).

FR LCC 9. The camera-input-to-monitor ratio shall be 4:1 or less.

FR LCC 10. Adequate space (which includes space for the equipment as well as adequate wall clearances and access space) shall be provided for visual display equipment (i.e., CCTV monitor banks, large screen display) and other stand-alone equipment, such as printers.

FR LCC 11. The layout of the equipment shall support the overall functionality of the equipment and room/area.

FR LCC 12. Sight lines to visual display equipment shall be based on acceptable horizontal and vertical viewing angles from the work position of each staff member working in the control room/area.

FR LCC 13. The visual displays shall be located to minimize glare.

FR LCC 14. Equipment shall be placed near those accessing it most frequently.

FR LCC 15. If the control room/area has more than one workstation, desks/consoles shall be within close visual and communications distance of each other, to allow for consultation, giving of advice and coordination of response.

FR LCC 16. If a supervisor function exists in the control room/area, the position of the supervisor station shall enable viewing of all accountable staff and equipment, as well as the stand-alone visual display equipment.

FR LCC 17. The control room/area shall be provided with an effective lighting design, including variable overhead lighting (i.e., dimmable and/or with zone switching) to allow operators to adjust ambient light depending upon the circumstances.

FR LCC 18. The lighting shall be arranged so that there is no direct glare on the various terminals monitors and displays.

FR LCC 19. Good task lighting shall be provided for the operators.

FR LCC 20. Walls shall be colored so as to minimize glare on terminals, monitors and displays.

FR LCC 21. Natural light through windows shall be provided, with filters or blinds for illumination and glare control.

FR LCC 22. Storage space shall be provided for manuals and files, equipment accessories (e.g. printer paper), and for the belongings of staff who do not have office space elsewhere in the building.

FR LCC 23. A raised or lowered floor shall be provided to facilitate cable routing between operator consoles, and to/from the computer/communications room/area.

FR LCC 24. Proper air-conditioned environment shall be provided for the comfort of the operators and the operating requirements of the equipment.

FR LCC 25. The TMC shall provide noise abatement (e.g., carpeted floor/tiles, textured wall materials, ceiling baffles) for sound control.

FR LCC 26. The layout of equipment shall allow for logical circulation paths within the room/area.

FR LCC 27. The control room/area and the computer/communications room/area shall be located in close proximity and preferably adjacent to each other.

FR LCC 28. Proper security shall be provided (e.g., swipe card, combination punch lock, etc.) to prevent unauthorized access to the control room/area.

FR LCC 29. A computer/communications room/area shall house the computer and communications equipment, such as CPUs, system consoles, circuit termination cabinets, modem racks, video receivers, video switchers, etc.

FR LCC 30. The layout of this room/area shall be organized according to the specific computer and communications equipment used.

FR LCC 31. Adequate floor and rack space, wall clearance and access room/area shall be provided, based on the requirements of the specific computer/communications equipment used.

FR LCC 32. In addition, temporary maintenance workspace for computer and communications staff shall be provided.

FR LCC 33. The room/area shall be provided with a raised or lowered floor, for cable routing to/from the control room/area.

FR LCC 34. A separate air-conditioning and humidifying system with back up shall be provided, if required for the specific equipment in the room/area.

FR LCC 35. The electrical power shall be regulated and air conditioner drains shall be provided for moisture.

FR LCC 36. The TMC shall provide an uninterrupted power supply (UPS) with adequate capacity to allow organized system shutdown or short term operation for the electrical system.

FR LCC 37. If ongoing TMC operation during a power outage is required, the TMC shall have a back-up generator.

FR LCC 38. Flood and fire detection and other protection equipment shall be provided in the room/area.

FR LCC 39. To minimize equipment damage, the extinguishing system shall be linked to a power shut-off so that the power is shut off prior to activating the extinguishing system.

FR LCC 40. The layout of equipment shall allow for logical circulation paths within the room/area.

FR LCC 41. The TMC shall provide typical office environment conditions (e.g., temperature, humidity, lighting, etc.).

FR LCC 42. Receptacles shall be supplied for LAN access, so that telephones, faxes, modems, etc. can all be run simultaneously.

FR LCC 43. Outlets shall be provided in logical locations or based on user preference.

FR LCC 44. Main Entrance/Reception - For security purposes, all visitors shall enter and exit the building through a single main entrance.

FR LCC 45. Other building access points shall be controlled (e.g., swipe card, combination punch lock, key) to prevent unauthorized access.

FR LCC 46. The TMC shall provide a service panel adequate to handle the demands of projected workloads for the electrical system (e.g., future upgrades and additions).

FR LCC 47. All power supply to electronics and computer equipment shall be properly conditioned to avoid voltage fluctuations and power surges.

FR LCC 48. The TMC shall provide emergency lighting for the secured areas (to supplement for all areas as per the building code in effect).

FR LCC 49. The TMC shall provide an adequate number of standard duplex convenience outlets.

FR LCC 50. Outlets shall be supplied with single phase unconditioned power appropriate for the selected equipment.

FR LCC 51. Electrical systems for the computer/communications room/area and the control room/area shall address the following factors: design according to local standards and codes; nominal voltage; circuits for each computer; circuits for the computer peripherals and electronics equipment; maximum voltage variation from nominal; frequency and allowable harmonic distortion; 5 wire (4 wire plus ground) connection; duplex receptacles located beneath equipment bays.

FR LCC 52. With the exception of the control room/area and the computer/communications room/area regular office temperature and humidity values and ranges shall be provided throughout the TMC for the comfort of the operators and to ensure proper operation of the equipment.

FR LCC 53. HVAC requirements shall be sized individually for heat loading of control room/area and computer/communications room/area requirements.

FR LCC 54. The TMC shall provide physical separation for climate control purposes of the control room/area and the computer/communications room/area, along with providing separate control for each.

FR LCC 55. Noise levels for the TMC shall be limited to 55dBA.

FR LCC 56. Insulated wall construction (floor to ceiling) shall be provided in the control room/area and the computer/communications room/area.

FR LCC 57. The TMC shall provide noise abatement (e.g., carpeted floor/tiles, textured wall materials, ceiling baffles) for sound control in the control room/area.

FR LCC 58. The TMC shall provide a fire suppression system suitable for electronic equipment areas per codes.

FR LCC 59. The TMC shall provide central fire alarm notification for fire suppression.

FR LCC 60. The TMC shall provide for automatic shutdown of all electronic equipment prior to extinguishing operation.

FR LCC 61. The TMC shall provide water protection as per applicable building code requirements.

FR LCC 62. Structural design and update of the TMC shall meet local building code requirements.

FR LCC 63. The raised/lowered flooring system shall be capable of sustaining the required loads, including point loading of heavy equipment.

8.5 Local City Control Site Equipment Requirements

8.5.1 Equipment Considerations

The ATMS Functional Requirements identifies equipment and devices that are needed to support regional traffic management functions and to provide the Local City Control Sites with access to traffic control and information within the Corridor. Relevant requirements are:

UR TS.24 The ATMS shall be based upon a client-server or thin-client architecture.

UR TS.25 Industry standard processors and network components shall be used.

FR TS.1 The system shall use the latest version of Microsoft's multi-tasking operating system for Intel-architecture PC-based servers in a client-server architecture.

FR TS.2 System workstations shall use the latest version of Microsoft's multi-tasking operating system for Intel-architecture PC-based clients in a client-server architecture.

The requirements point to the use of standard, PC-based equipment.

As described above, for a self-contained facility it is recommended that the equipment be housed in two functional areas:

- Control Room/Area
- Computer/Communications Room/Area

Within the Local City Control Site, the Control Area and the Computer/Communications Area can either share the same space or be located in adjacent rooms depending on the space available at each Control Site location. This Section describes needed equipment for each space, and characterizes approximate dimensions, weight, power, and HVAC requirements of the devices.

8.5.2 Control Room/Area

Each Local City Control Site will likely house a single operator workstation. A workstation is comprised of a CPU, keyboard, mouse, and other computer accessories. The workstation will use two 19-inch high-resolution color monitors. The two monitors will be used for traffic management and control functions, as well as system maintenance functions. For example, operators will be able to enter data, monitor traffic and have access to incident information on system maps and informational windows. The monitors will also be capable of displaying the CCTV video images via the CCTV manager. For space reasons, it is recommended that flat screen monitors are used.

The operator workstation will be located either on a flat desk, or within a console (these options are discussed in Section 8.6). Other operator items that need to be located on a desk/console include a telephone, and possibly a radio for communications.

Some space for storage should also be provided for manuals, equipment, accessories, and staff belongings, especially for staff that do not have office space elsewhere in the building.

8.5.3 Computer/Communications Room/Area

The backend equipment for each Local City Control Site will vary for each site, depending on the capabilities of individual sites. It is estimated that a maximum of three equipment racks will be necessary. Local City Control Sites requiring no video will require fewer racks. Adequate floor space will need to be allocated for each equipment rack and for easy access to the equipment. The racks should be accessible from at least two sides. Some of the equipment to be stored on the racks includes all servers, distribution subsystems, routers, firewall, CCTV switch, video receivers, and UPS. The need for a telecom area is also necessary in this area. This will likely include a wall panel that has been estimated to require a 4-foot by 3-foot area for the installation of patch panels and WAN access hardware. The ability to use existing building telecom areas should also be considered depending on space available and ease of expansion.

If the Computer/Communications Area is housed in a separate room, the provision for a work area should also be considered. This could be as simple as including a desk, chair, and telephone.

8.5.4 Shared Areas

Other equipment that is necessary for operations includes a printer, fax machine, and photocopier. These items do not need to be exclusively for Local City Control Site use, but should be available to be shared with other department employees.

8.5.5 Summary

The following Table provides approximate quantities, dimensions, weight, and power consumption as well as HVAC requirements. The Table also provides a break down of rack space distribution.

Table 8.1: Local City Control Site Equipment Requirements

Room	Equipment	Quantity	Dimensions H x W x D	Weight	Power Consumption (Watts)	HVAC Requirements (Tons of Refrigeration per device)	Total (Tons of Refrigeration)
Control	CPU & Accessories	1	17”x7”x17”	30	400	0.114	0.114
	Monitors	2	18”x18”x10”	50	70	0.22	0.044
	Telephone	1	4”x10”x9”	4	6	0.002	0.002
	Task Lighting	1	NA	NA	75	0.021	0.021
Computer/ Comm	ATMS Server	1	.5 Rack	250*	500	0.142	0.142
	Video Switch / CODEC WAN	1	.5 Rack	250*	200	0.057	0.057
	Router / Firewall / CSU / DSU	1	.5 Rack	250*	500	0.142	0.142
	Local Signal Modems	1	.25Rack	250*	500	0.142	0.142
	Local T-1 Video / DSU / CSU / CODEC	1	.25 Rack	500*	1000	0.028	0.028
	Telephone	1	4”x10”x9”	4	6	0.002	0.002
* Includes weight of equipment’s portion of rack.					Approximate Total		**0.694**

8.6 Console Versus Desk Analysis

A major design consideration in the development of a Local City Control Site Control Area is the placement of operator equipment and devices. Factors such as workability, accessibility, space availability, and physical constraints must be examined. Conceptually there are two major options for arranging operator devices: a console design and a flat desk design. Each option has advantages and disadvantages, as well as unique requirements. This discussion addresses space requirements, access, lighting, and cable management factors for both options.

8.6.1 Equipment Requirements

Each option will have the same equipment/device requirements in order to meet the Functional Requirements of the TMC. Each operator will have a workstation at his/her desk or console. Both options will also be provided with task lighting, desk space for other work, and possibly a control system board, if not integrated into the workstation. These equipment/devices must be arranged in a way that provides accessibility, visibility, and ergonomic comfort to the operator.

Console Design

A console design "builds in" equipment such as monitors, and cables to provide an operator with a clean and attractive work area. Consoles can be custom made, or can be commercially available modular furniture. Typically a workstation requires approximately six (6) square feet of surface area. This may be higher in a console design depending on how monitors are oriented, and how much space is provided between viewing surfaces. An additional two to three (2-3) square feet should be provided for general work activities (i.e. paper work). Once a console design is determined, spatial concerns may become somewhat inflexible, as the re-arrangement of equipment and devices will be limited. This could hinder adding monitors or increasing monitor sizes if not accounted for.

Console designs have the advantage of providing cable management within the furniture itself. This allows for a clean, unobstructed area around the console with a limited amount of external or additional cable management devices. This is especially efficient with the use of a raised floor. The consoles can be placed on top of power and communication floor outlets, or against wall outlets, to provide for a system with no exposed cables. Typically each workstation will have its own dedicated power circuit and LAN outlet. In the event of an overhead cabling system it should be a goal to minimize any surface cable runs as cables switch from overhead to the floor. Also, placing workstations near walls or columns can create transfer points for cables. Any exposed cabling should be properly protected and meet applicable ADA standards.

In cases where neither raised floors or false ceilings are existing or feasible, other means of cable management will be necessary. This may reduce the appeal of using a console design, as external management methods will be required anyway. Typically console options are more expensive than flat desk solutions. Figure 8.3 shows a potential console layout. Note that an alternative is also shown in Figure 8.1.

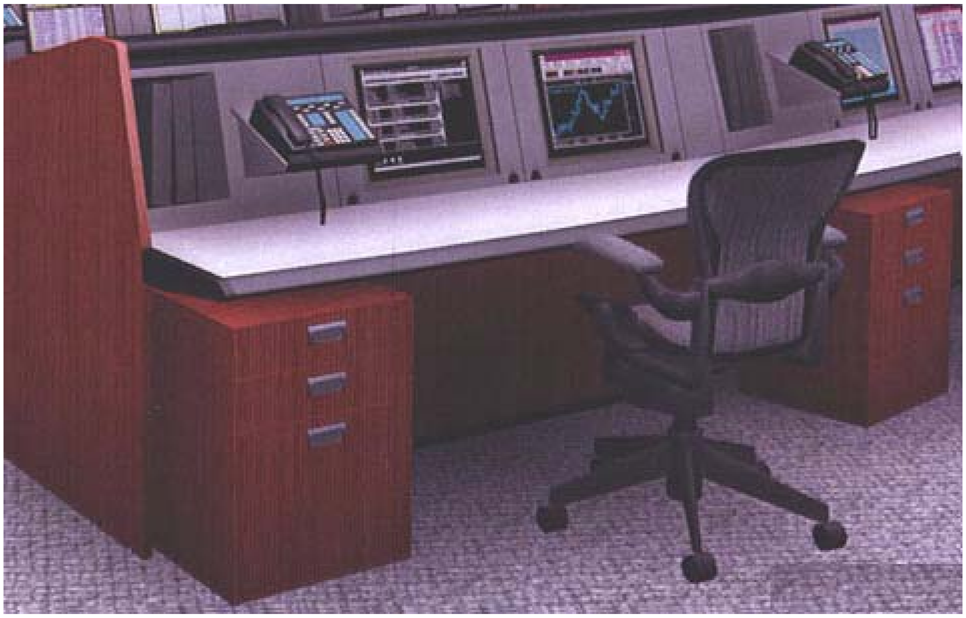


Figure 8.3: Example Console Layout

8.6.2 Flat Desk Design

A flat desk design places equipment such as monitors onto a flat surface desk. This allows for good flexibility in arranging equipment and allows for expansion (i.e. upgrading to larger monitors). The use of a flat desk still requires the same equipment, but may require slightly less space, as equipment may be placed more closely together. Desks such as these are commercially available at reasonable cost, and can easily be reconfigured and expanded (added onto) as required to meet not only current, but future system needs as well. Many facilities may also already have extra tables/desks that could be used for this application.

A flat desk design does not have a built in cable management function as with the console design. This option requires additional cable management techniques such as cable trays and embedded conduits/ladders under the desk surface to allow for a clean and functional installation. Skirts should be provided or other means of hiding wiring, the back of computers, etc. from view. Like the console design, this application works well with a raised floor management system. Floor outlets should be provided for both power, and communications. In the case of overhead cabling, any exposed cables should be properly protected and meet ADA requirements. Some manufacturers however also provide a hybrid solution that allows for a flat desk design with built-in cable management methods. This option allows for the flexibility of re-arranging or adding additional equipment to a workstation, while still providing solid cable management methods.

Figure 8.4 shows a potential flat desk layout.

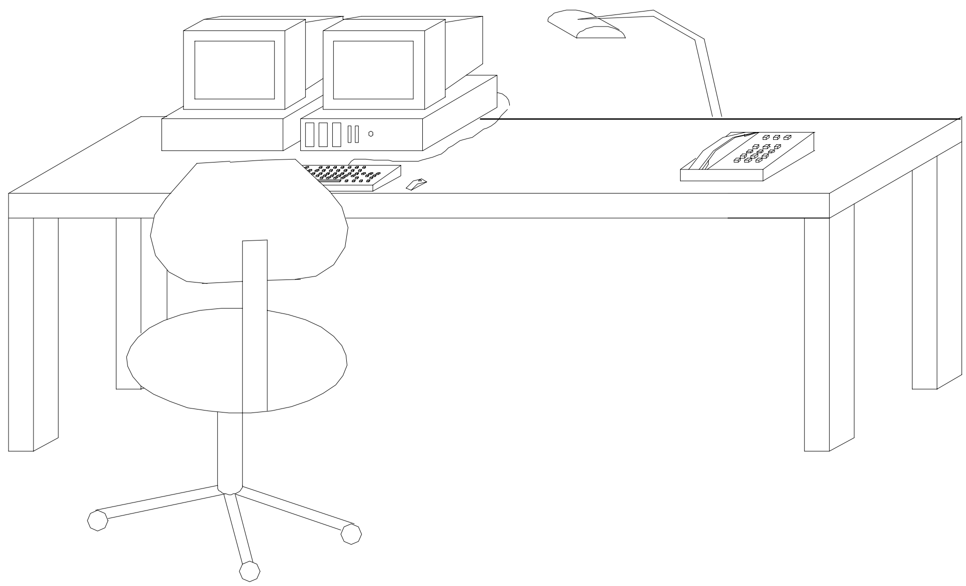


Figure 8.4: Flat Desk Layout

8.6.3 Summary

Both console and desk options have positive and negative features, and will likely be recommended on a site-by-site basis. Recommendations will be based on whether the sites have an existing desk or table that can be used or modified for this application. Also spatial concerns should be addressed. Since a console is likely to take up slightly more space, it maybe advantageous in tight locations to use a flat desk. Ideally it is recommended that a flat desk be used, with built-in cable management. This will allow for flexible equipment arrangement, and good cable management.

9 COMMUNICATION REQUIREMENTS

9.1 Relevant Requirements

9.1.1 ATMS

UR TS.20	The ATMS shall be consistent with the County's IEN Architecture
FR TS.157	The ATMS shall support controllers using the AB3418 protocol.
FR TS.158	The central signal systems software shall include communications support for standards based protocols such as AB 3418E or NTCIP.
FR TS.159	The ATMS will communicate with each intersection once per second.
FR TS.166	The central signal system software shall support communication with the field controllers at a minimum rate of 1.2kbps.
FR TS178	Upload/download commands shall be executed immediately upon command at a minimum communication rate of 1.2kbps between the central signal system software and the field controllers.
FR TS.208	The central signal system software shall monitor the traffic signal controllers on a second-by-second basis.
FR TS.319	Using tools provided with the Windows operating system, the System Administrator or Network Administrator shall have the capability to monitor the network, including: • Which users are logged into the system • The status of any system firewalls • The status of system servers
FR TS.350	The system shall support panning, tilting and zooming CCTV cameras.

9.1.2 LCC

None

9.1.3 Integration System

The Integration System requirements pertain to those requirements for system to system communications and functionality and will be addressed in Deliverable 2.3.2.1 Integration System User and Functional Requirements. The Integration System requirements that affect the communications systems design are included in this document.

UR IS 11	CCTV video images shall be available for viewing at other remote locations both in the Corridor and elsewhere.
UR IS 12	It shall be possible to view video images from CCTV cameras in other jurisdictions.
FR IS 27	The ATMS shall provide remote access via the IEN.
UR IS 28	At a minimum, the ATMS should have demonstrated the ability to support the relevant NTCIP protocol for C2C.

UR IS 29 Where there is a high degree of commitment or reasonable degree of use of the NTCIP protocol for C2C, then it should be specified for use.

FR IS 43 Access to the IEN shall required on a 24 hours per day, 7 days per week basis (excluding an acceptable down time for system maintenance, backup, etc).

9.1.4 Other Forum Projects

From SGV Pilot:

- Data must arrive at the destinations at the same rate it is introduced to the network.
- A high percentage of data (99.95%) must reach the workstations (over the IEN).
- The system must work over a 384 Kbps LAN for up to 2000 detectors, 20 workstations with 50 requests each.

From I-105 Corridor Project:

Functional Requirements

- FRD429: Existing communications infrastructure shall be used wherever feasible.
- FRD430: The communications system shall support the ability to monitor and download traffic signal timing plans to controller.
- FRD431: The communications system shall support the ability to view and control CCTV cameras.
- FRD432:
- FRD441: The agency owned cable-based communications system shall be sized with a minimum of 50% spare capacity (as standard practice), if used.
- FRD442: The communications system between the Local TMCs, Sub-Regional TMC and County TMC shall be sized to accommodate 50 simultaneous intersections sending second by second status information.
- FRD443: The communications system shall have diverse routing options (more than one physical communications path) where feasible.
- FRD444: Communications rates utilized shall be telephony standards.

  HLD Definitions and Recommendations

  - Camera control communications is considered low speed “bursty” and a 9600 bps asynchronous circuit is suggested.

  There are two types of serial transmission techniques synchronous and asynchronous commonly used. Synchronous transmission uses modems at each end to provide time references locked together by synchronizing signals at the start of the transmission. The information bits are sent in a continuous, uniformly spaced stream. This approach proves very efficient for transmitting large blocks of data at high data rates.

Traffic control systems more commonly use asynchronous transmission. In asynchronous transmission no particular time relationship exists among the characters. Stop and start bits at the beginning of each character control transmission. Since it contains these additional bits per character, the data information rate is lower than for synchronous transmission.

9.2 Communication System Requirements

The Communications System Requirements are derived, in part, from the requirements listed in the previous Section and grouped into the following categories:

- City work stations/control sites
- Integration System Requirements
- Non-transportation related issues
- Public relations issues
- O&M issues
- Expandability
- Bandwidth requirements
- Reliability
- Redundancy
- Diversity
- Performance requirements
- Communications system access points
- Potential bottlenecks and weak links

These categories are defined for the Center-to-center and the center–to-field communications links.

9.2.1 Center-to-center Communications Requirements

This includes requirements for IEN and Video distribution system.

City Work Stations/Control Sites

None

Integration System Requirements

UR IS 11	CCTV video images shall be available for viewing at other remote locations both in the Corridor and elsewhere.
UR IS 12	It shall be possible to view video images from CCTV cameras in other jurisdictions.
UR TS.20	The ATMS shall be consistent with the County's IEN Architecture
FR IS 31	The ATMS shall provide remote access via the IEN.
UR IS 28	At a minimum, the ATMS should have demonstrated the ability to support the relevant NTCIP protocol for C2C.
UR IS 29	Where there is a high degree of commitment or reasonable degree of use of the NTCIP protocol for C2C, then it should be specified for use.

Non-Transportation Related Issues

FR CS 1.	Evaluation of the cost of the communications network shall consider a 10-Year Life Cycle cost analysis.

Public Relations Issues

None

O&M Issues

FR TS.319 — Using tools provided with the Windows operating system, the System Administrator or Network Administrator shall have the capability to monitor the network, including:

- Which users are logged into the system
- The status of any system firewalls
- The status of system servers

FR CS 38.	The communications technology should be easy to operate and maintain.
FR CS 39	If new technology is deployed to an Agency, the agency staff should be provided training in maintenance and trouble shooting of the equipment.
FR CS 40	Tools should be provided to the agencies for automatic checking of the communication equipment and media.

Expandability

FR CS 2. (FRD441): The agency owned cable-based communications system shall be sized with a minimum of 50% spare capacity (as standard practice), if used.

FR CS 3.

Bandwidth Requirements

FR CS 4. (FRD444): Communications rates utilized shall be telephony standards.

UR IS 11 CCTV video images shall be available for viewing at other remote locations both in the Corridor and elsewhere.

UR IS 12 It shall be possible to view video images from CCTV cameras in other jurisdictions.

FR CS 5. The IEN system must work over a 384 Kbps LAN for up to 2000 detectors, 20 workstations with 50 requests each (excluding CCTV video transfer).

FR CS 6. (FRD429) Existing communications infrastructure shall be used wherever feasible.

Reliability

FR IS 43 Access to the IEN shall be required on a 24 hours per day, 7 days per week basis (excluding an acceptable down time for system maintenance, backup, etc).

Redundancy

FR CS 7. (FRD443): The communications system shall have diverse routing options where feasible.

Diversity

FR CS 8. (FRD429): Existing communications infrastructure shall be used wherever feasible.

Performance Requirements

FR CS 9. The IEN shall be continuously available and not require an application to request connection.

FR CS 10. Data must arrive at the destinations at the same rate it is introduced to the network.

FR CS 11. A high percentage of data (99.95%) must reach the workstations (over the IEN).

FR CS 12. (FRD442): The communications system between the Local TMCs, Sub-Regional TMC and County TMC shall be sized to accommodate 50 simultaneous intersections sending second by second status information.

Communications System Access Points

FR IS 31 The ATMS shall provide remote access via the IEN.

Potential Bottlenecks and Weak Links

See redundancy.

9.2.2 Center-to-Field Communications

City Work Stations/Control Sites

Not applicable

Integration System Requirements

Not Applicable

Non-Transportation Related Issues

FR CS 13. Evaluation of the cost of the communications network shall consider a 10-Year Life Cycle cost analysis.

Public Relations Issues

Not applicable

O&M Issues

FR CS 38 The communications technology should be easy to operate and maintain.

FR CS 39 If new technology is deployed to an Agency, the agency staff should be provided training in maintenance and trouble shooting of the equipment.

FR CS 40 Tools should be provided to the agencies for automatic checking of the communication equipment and media.

Expandability

FR CS 14. (FRD441): The agency owned cable-based communications system shall be sized with a minimum of 50% spare capacity (as standard practice), if used.

FR CS 15.

FR CS 16.

FR CS 17.

Bandwidth Requirements

FR TS 158 The central signal system software shall support Ethernet communication with traffic signal controllers in installations using or planning to use Ethernet for traffic signal communications.

FR TS.158b The ATMS shall support Ethernet communication with CCTV camera in installations using or planning to use Ethernet for CCTV communications.

Traffic Signals

FR TS 157	The ATMS shall support the AB3418 communications protocol.
FR TS 159	The ATMS will communicate with each intersection nominally once per second.
FR TS 166	The central signal system software shall support communication with the field controllers at a minimum rate of 1.2kbps.
FR CS 18.	(FRD430): The communications system shall support the ability to monitor and download traffic signal timing plans to controller.
FR TS 178	Upload/download commands shall be executed immediately upon command at a minimum communication rate of 1.2kbps between the central signal system software and the field controllers.
FR TS 208	The central signal system software shall monitor the traffic signal controllers on a second-by-second basis.

Appendix A contains an analysis of the NTCIP and AB3418 protocols. The resultant bandwidth requirements are as follows:

FR CS 19. At 9600bd per channel the following shall be the maximum number of traffic signal controllers per 9600 baud circuit:

- AB3418 (no overlap) 5 controllers per circuit
- AB3418 (with overlaps) 6 controllers per circuit
- NTCIP (no overlap) 5 controllers per circuit
- NTCIP (with overlaps) 6 controllers per circuit

CCTV

FR TS 350	The system shall support panning, tilting and zooming CCTV cameras.
FR CS 20.	(FRD431): The communications system shall support the ability to view and control CCTV cameras.

Analog

FR CS 21.

Digital

FR CS 22. Either motion JPEG or MPEG formats should be used.

Control

FR CS 23. Each camera will also require a camera control signal to control camera functions such as pan, tilt, zoom, etc.

FR CS 24. Camera control signals for several cameras, each ranging from 300 bps to 9600 bps, will be accommodated over a common communications channel in a multi-dropped environment.

FR CS 25. In a twisted pair network, one channel (one or two pairs as appropriate) shall be used to address camera control for multiple cameras.

CMS

FR CS 26.

FR CS 27.

Reliability

FR CS 28. The field-to-center communications shall have 99.5% availability.

Redundancy

FR CS 29. (FRD443): The communications system shall have diverse routing options (more than one physical communications path) where feasible.

Diversity

FR CS 30. FRD429: Existing communications infrastructure shall be used wherever feasible.

Performance Requirements

FR CS 31. The field-to-center communications shall be continuously available and not require an application to request connection.

FR CS 32. Data must arrive at the destinations at the same rate it is introduced to the network.

Communications System Access Points

Not Applicable

Potential Bottlenecks and Weak Links

See Redundancy.

10 REQUIREMENTS TRACEABILITY

APPENDIX A

STANDARDS FOR CENTER-TO-FIELD COMMUNICATIONS

AB3418 and NTCIP

Overview

The essence of electronic communications can be described as having three essential attributes: Data Elements, Messages, and Protocols. We can think of Data Elements in much the same way that we think about words in our language. In a manner similar to the spelling, pronunciation, and definition of words, Data Elements contain an object name, syntax for use, and a description of how the data is defined. We can assemble Data Elements into Messages in much the same manner that we assemble words to form a sentence. A Message is an assemblage of Data Elements that carry a specific meaning. An example of a Message might be ***vehicle location*** consisting of individual Data Elements for ***vehicle ID***, ***altitude***, ***longitude***, and ***latitude***. Protocols are essentially sets of rules for how we move data from one place to another. One might think of an example like a two-way telephone conversation whereby I speak in a way that solicits a response, you then speak when I finish asking the question by providing the appropriate response, and then I speak again when you are finished acknowledging the response.

Two examples of communications protocols in the traffic signal and Intelligent Transportation Systems (ITS) community are AB3418E and the National Transportation Communications for ITS Protocol (NTCP). These protocols are described in the following Sections.

AB3418E

California Assembly Bill No. 3418 (AB 3418) became law on January 1, 1995. The bill requires all new or upgraded traffic signal controllers installed in California after January 1, 1996, to incorporate a standard communications protocol. As the State agency responsible for implementation of the bill, Caltrans has published a specification document entitled *Standard Communications Protocol for Traffic Signals in California* for use by developers of traffic signal controller software and by California users of traffic signal controllers.

The document states that the purpose of AB 3418 is to facilitate improved coordination and management of traffic signals in situations where adjacent signals are operated by different agencies. The protocol specified allows basic communication messages to be sent to and from multiple traffic signal controllers on the same communications channel, even if the controllers are of different types or utilize different software.

While AB3418 is intended to facilitate the coordination of traffic signals operated by different jurisdictions, the following are the key elements and repercussions of the legislation for agencies operating traffic signals in California.

- AB3418 establishes a means by which traffic signal controllers installed after January 1, 1996, can be communicated with through a non-proprietary, equipment independent, communications protocol (i.e. a standard protocol).

- There is no requirement to replace or retrofit existing controllers that are not being upgraded or replaced for other reasons.
- The AB3418 standard protocol supports remote control and monitoring functions only. The control function is to enable the maintenance of signal coordination with adjacent intersections. The monitoring function is to allow verification of controller operation.
- The AB3418 standard protocol does not provide comprehensive support of all control functions, including uploading and downloading.
- The AB3418 standard protocol does not replace or supersede existing communications protocols.
- The AB3418 standard protocol may coexist in a controller with any proprietary or otherwise non-standard protocol.

The AB3418 protocol is specifically intended for use at TRAFFIC SIGNALS that require remote operation, coordination, or monitoring. AB3418 requires provision of the standard protocol in all new and upgraded controllers. The controller may use the protocol to communicate with another controller, with a field master, or with a remote computer. Such other controller, master, or computer may be owned or operated by the same or a different agency.

A controller containing a communications protocol which otherwise meets all requirements of the AB3418 specification, may incorporate, within that protocol, additional capabilities, providing such additional features are not necessary for, nor impair, use of the basic features required by the specification. A protocol may, for example, provide additional messages. In this way, the standard protocol may be a subset of a more comprehensive, and possibly proprietary, protocol. The messages added to the base protocol for specific user's needs may ultimately become candidates for adoption into the protocol standard at some later date.

It should be noted that AB3418 consists of a series of predefined messages that are exchanged using a protocol based upon an early draft of NTCIP. Unfortunately, a minor change was made in the NTCIP protocol, a minor change in a single protocol header parameter. As such, this subtle change prevents AB3418 and NTCIP from exchanging messages.

NTCIP

The NTCIP is a family of standards that provides both the rules for communicating (called protocols) and the vocabulary (called data elements or data objects) necessary to allow electronic traffic control equipment from different manufacturers to operate with each other as a system. The NTCIP is the first set of standards for the transportation industry that allows traffic control systems to be built using a "mix and match" approach with equipment from different manufacturers. Therefore, NTCIP standards reduce the need for reliance on specific equipment vendors and customized one-of-a-kind software. To assure both manufacturer and user community support, NTCIP is a joint product of the National Electronics Manufacturers Association (NEMA), the American Association of State Highway and Transportation Officials (AASHTO), and the Institute of Transportation Engineers (ITE). The NTCIP part of a larger effort to develop a family of ITS standards for use in all aspects of implementing the National ITS Architecture.

NTCIP standards cover both data elements (called "objects") and protocols for center-to-field communications, and protocols for center-to-center communications. Message Set standards are generally used to describe how data elements are combined to form pre-defined messages to be exchanged. Message Set standards are typically used in Center-to-Center exchanges. Center-to-Field applications within NTCIP typically use a dynamic arrangement of messages as described in *Transportation Management Protocol*. For use in NTCIP, Protocol Standards have borrowed heavily from existing Internet Standards. Many of the existing Internet Standards are being applied directly for use within the ITS world.

NTCIP standards are developed in such a manner as to allow for flexibility and extension so that innovation can continue without restriction. The most readily observable method of extension is in the use of manufacturer's specific data elements that are created in a similar context to the standard. In practice, we find that all devices will have two sides to their Management Information Base (MIB), the underlying database structure within the device, consisting of the Standardized side and the Manufacturer's Specific side. The Standardized side of the MIB represents that core functionality essential to promoting interoperability and interchangeability. The Manufacturer's Specific side of the MIB represents functions that are beyond that defined in the standard. Such extensions may result from functions that are unique to specific manufacturers, agencies, or projects and are often proprietary.

The key to successful implementation and long-term deployment of NTCIP rests in documentation. This is particularly important when referencing project critical functions that are beyond those standardized in the NTCIP documents. The importance of detailed documentation of MIBs, Data Elements, Messages, and Protocols used within a project will be recognized as invaluable when the time comes to expand the system.

Bandwidth Requirements

The following Table shows an example of how AB3418 compares to NTCIP using STMP when considering the number of drops per communications channel. As previously mentioned, AB3418 and NTCIP are quite similar in design and one would expect that an analysis would yield similar results when considering a similar message length. The Table shows this to be true when NTCIP uses STMP to implement dynamic objects with message content that is similar to that of AB3418. It is important to note that if STMP is not used the results for NTCIP will be dramatically lower.

Field Communications Analysis				
Parameter	AB3418 Status8 NoOvlap FullDup	AB3418 Status8 Overlap FullDup	NTCIP STMP Example NoOvlap FullDup	NTCIP STMP Exampl e Overlap FullDup
Transmission speed (bits per second)	9600	9600	9600	9600
Bits per byte	10	10	10	10
Primary Station:				
Ave bytes in non-overlapped part of normal polling message	6	1	8	1
Ave bytes in non-overlapped part of abnormal polling message	9	1	9	9
Proportion of polling messages abnormal	10%	10%	33%	33%
Proportion of bytes requiring mask byte	0%	0%	0%	0%
Time quiet (after last response) before start RTS	0	0	0	0
Time from start of RTS to start of CTS	0	0	0	0
Delay time from CTS to start sending polling message	10	5	9	5
Time from end of polling message to end of RTS	0	0	0	0
Time from end of RTS to quiet	0	0	1	1
Time (ms) to transmit polling message on average	7	1	9	4
Modem time before and after transmission of poll message (average)	10	5	10	6
Total time for each poll message on average	17	6	19	10
Reserve time at end of round	0	0	0	0
Secondary:				
Bytes in normal response message	24	24	18	18
Bytes in average abnormal response message	39	39	11	11
Proportion of response messages abnormal	10%	10%	33%	33%
Proportion of bytes requiring mask byte	1%	1%	1%	1%

Propagation delay	0	0	0	0
Normal response preparation time (end of poll message to start of RTS)	30	30	50	50
Abnormal response preparation time	50	50	50	50
Time from start of RTS to start of CTS	10	10	9	9
Delay from CTS to start sending response message	0	0	0	0
Time from end of response message to end of RTS	0	0	0	0
Time from end of RTS to quiet	1	1	1	1
Time to send response message on average	27	27	17	17
Modem and other delay times, per response message	43	43	60	60
Total time per response message (normal & abnormal)	70	70	77	77
10.1.1.357.1.1.1 One Second Round:				
Maximum number of secondary devices on channel	11.6	13.2	10.5	11.6
Rounded down	11	13	10	11
Design Number of devices per pair (TWP cable)	5	6	5	5

Note: Overlapping is a communication transmission technique that allows the Center to transmit its next message prior to the receipt of the response from the previously sent message.