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Deliverable For:

Gateway Cities Traffic Signal Synchronization and Bus Speed Improvement Project

Atlantic Blvd./ I-710 Corridor

Deliverable 2.3.2.1

Integration System

User and Functional Requirements

Draft

Version 1

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Revision History

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Draft Version 1	February 1, 2005	Initial submission

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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 User Requirements document represents the first layer of requirements by specifying 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 system developers.

The second layer of requirements is the development of the Functional Requirements. Functional Requirements document 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.

The Integration System User and Functional requirements for Atlantic Blvd. /I-710 Corridor are based on the requirements developed for the I-5/Telegraph Road Corridor project.

At the time when I-5/Telegraph Road requirements reports were developed, County's IEN architecture included integration of inter-jurisdictional sharing of CCTV monitoring and control functions. Since then, County has made a decision to not include Video Sharing as part of the IEN architecture. Instead, the video sharing will be accomplished using an Internet based video distribution system. The requirements for video sharing have been updated to reflect this change in direction.

1.3 Organization of the Document

This document is organized into the following Sections:

Section 1: Introduction

Presents the Project background and introduces the document.

Section 2: System Overview

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

Section 3: Concept of Operations

Describes the 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: Requirements

Presents the high-level requirements and functions of the ATMS from the standpoint of what the users wish to achieve with the Corridor system and so defines what the integration system component must support.

1.4 Referenced Documents

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

- Atlantic Blvd. /I-710 Corridor Project

  Deliverable 2.2.1: Initial Concept of Operations Report

  Deliverable 2.1.1: Stakeholders' Operational Objective Report

  Deliverable 2.3.1.1: ATMS and Communications User and Systems Requirements Report
- I-5/Telegraph Road Corridor Project

  Deliverable 3.3.2: Integration System User & Functional 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 1-2. This is the architecture that will be followed in the design of the Atlantic Blvd./I-710 Project.

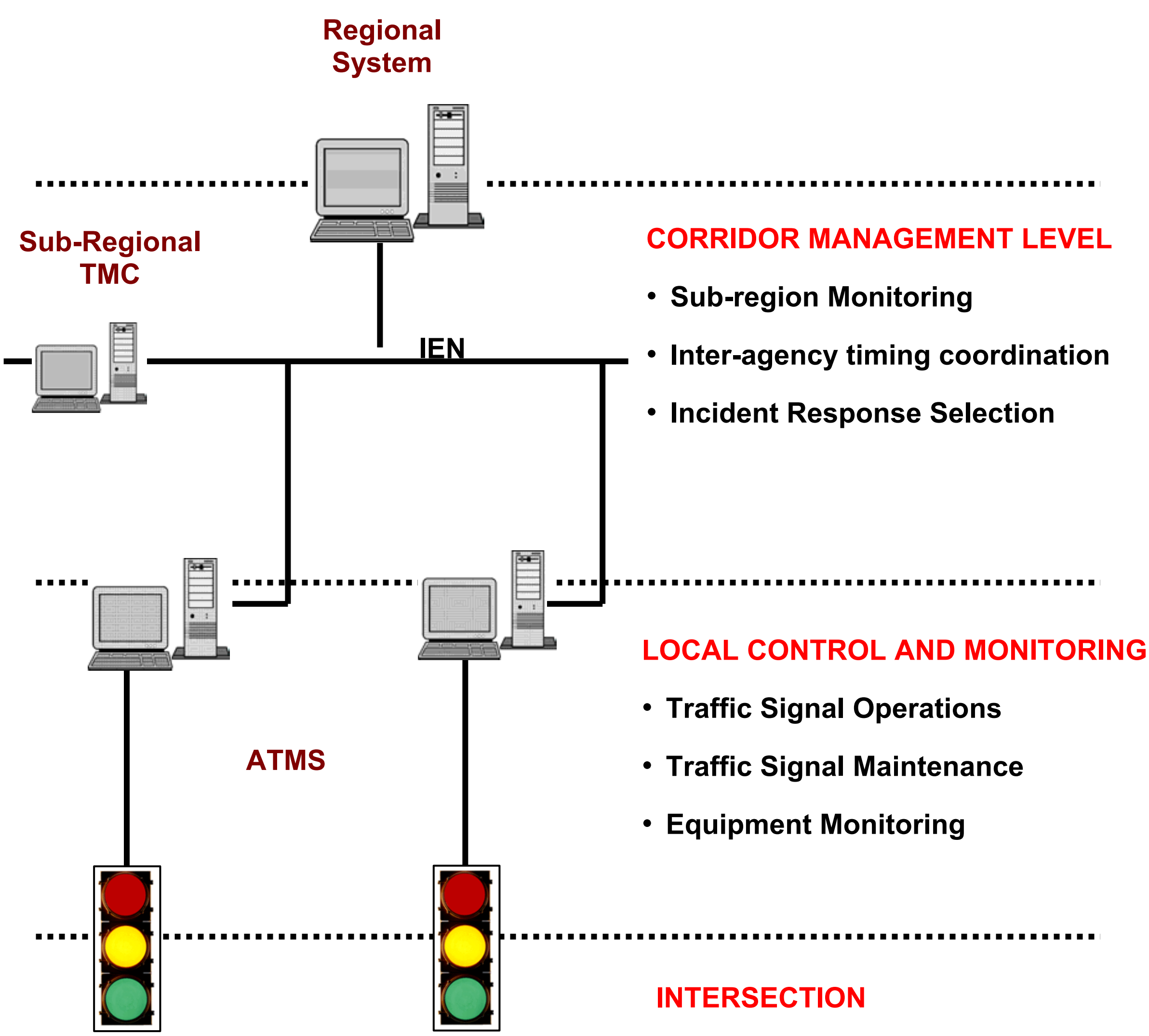
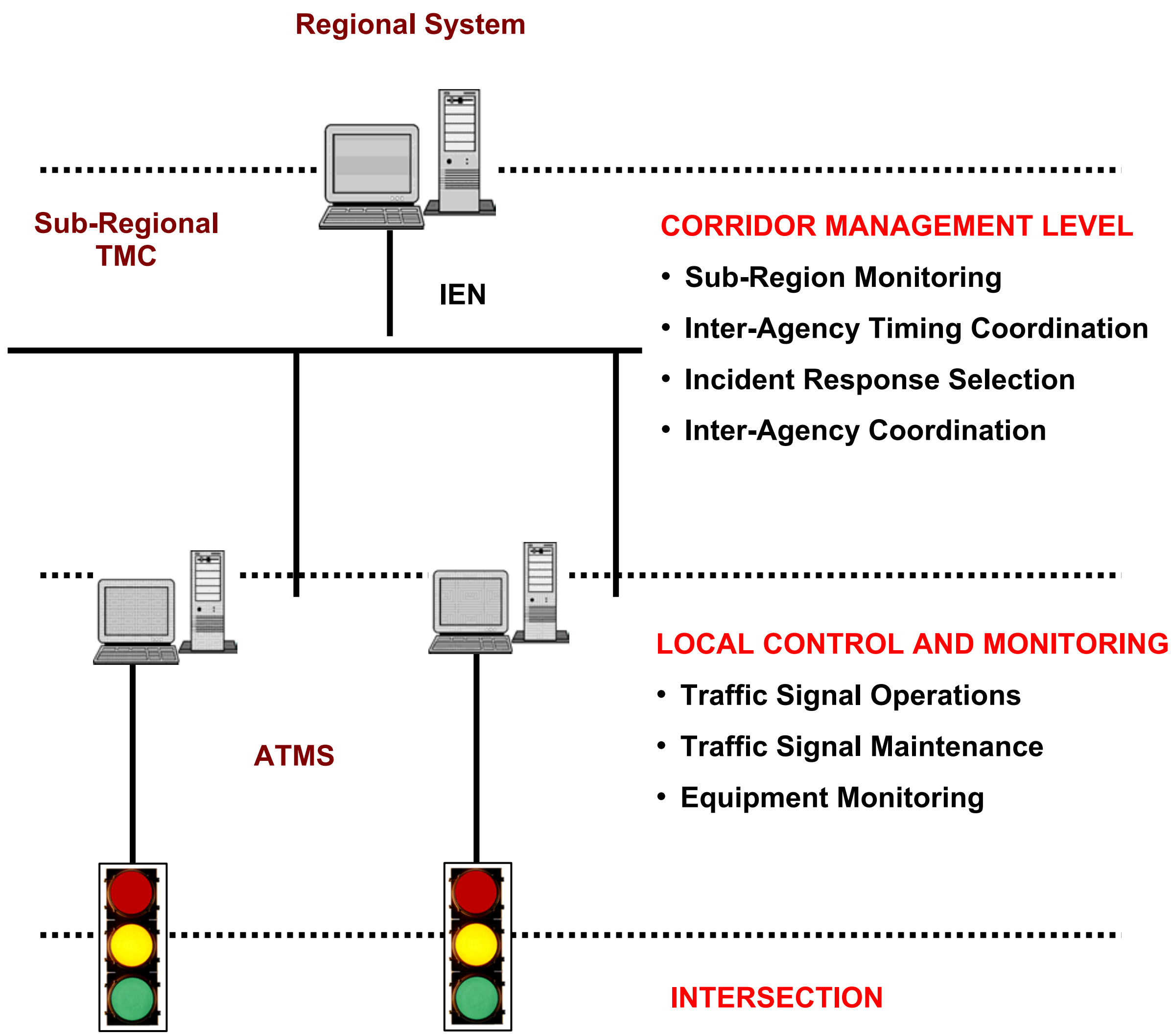


Figure 2.1: The Information Exchange Network Architecture (IEN)



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 Blvd./I-710 Project.

The Atlantic Blvd./I-710 Project assumes the availability of the IEN at the corridor and regional levels. The project is focused upon the selection of traffic control systems and integration of those systems into the IEN at the local level. The eventual design will include IEN workstations at the local level. These are being defined as part of other projects. The design of the traffic control systems will, however, take into account the interface to the IEN and its requirements at the local level.

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 Blvd. /I-710 corridor project, 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

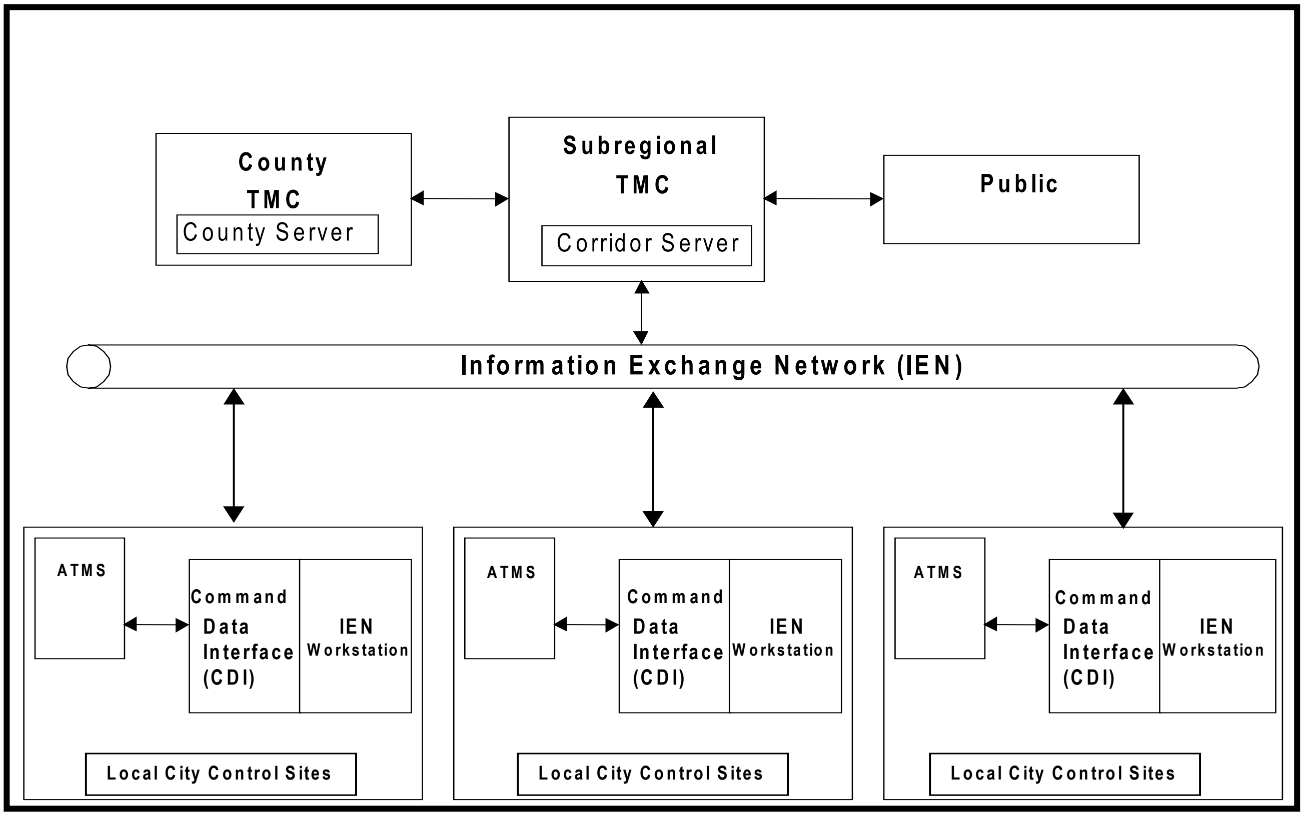


Figure 2.2: I-105 Corridor System Relations

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

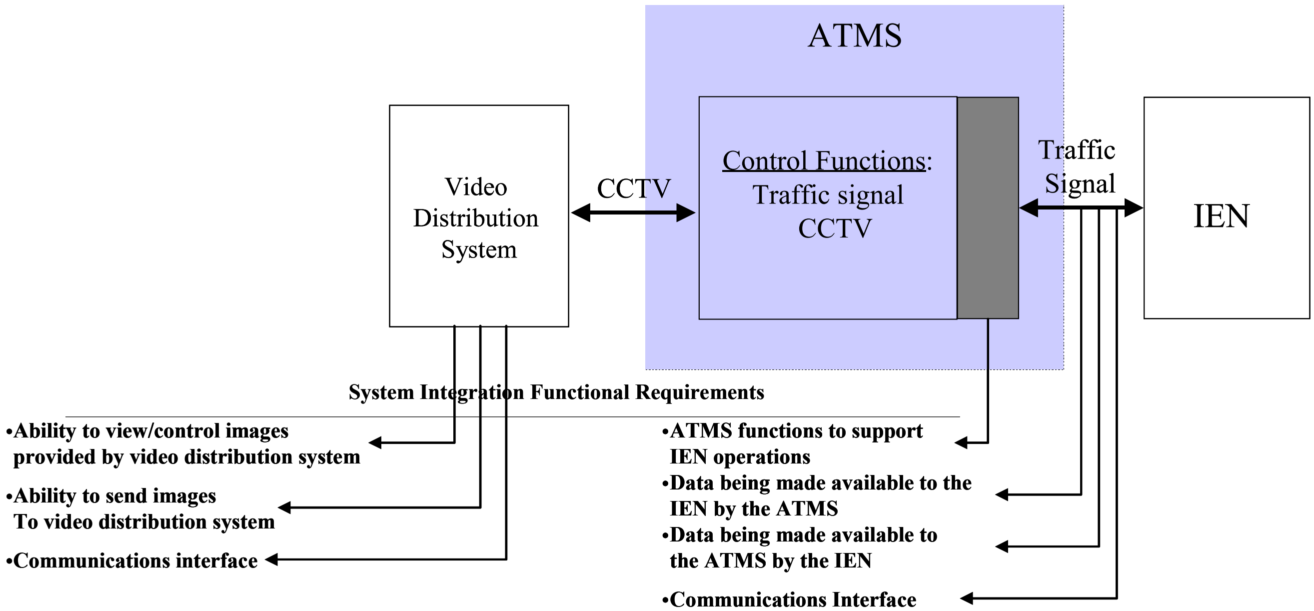


Figure 2.3: ATMS Interface with IEN and Video Distribution

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 Blvd. /I-710 Corridor Project, 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.

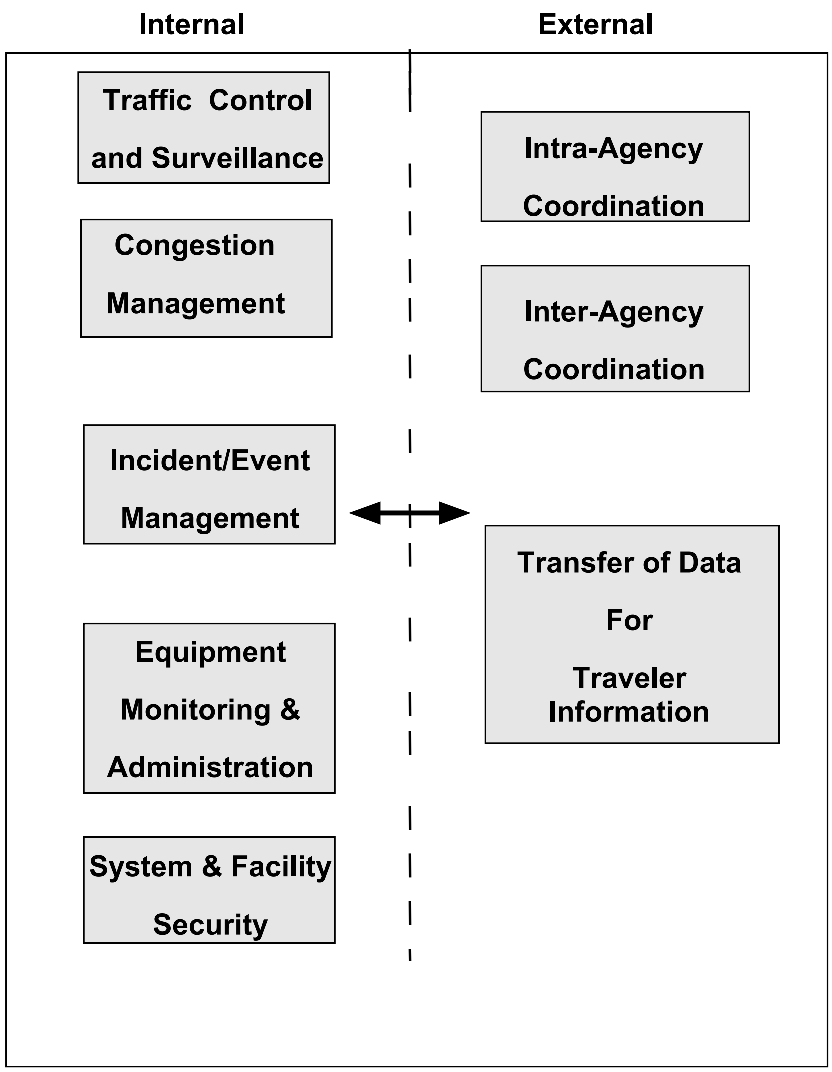


Figure 3.1: ATMS Functions

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	ITE, NEMA, AASHTO (Joint	Center-to-field protocols and

Group Name (unofficial)	Sample Standards *	Standards Development Organizations **	Scope ***
	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 .	Committee for NTCIP)	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 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, NEMA, AASHTO (Joint Committee for	Hardware, and software interface, for the controller component of field

Group Name (unofficial)	Sample Standards *	Standards Development Organizations **	Scope ***
	ITE – ATC Application Program Interface	ATC)	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.

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 REQUIREMENTS

5.1 Introduction

The requirements for functions at the sub-regional TMC have addressed as part of the I-105 Corridor Project activities, and have also been identified in the East San Gabriel Valley Pilot Project Design Report. The Integration System (IS) User and Functional Requirements have been derived from these sources.

Note the following nomenclature is used in this project:

UR IS	User Requirement for Integration Systems
FR IS	Functional Requirement for Integration Systems
UR TS	User Requirement for the ATMS to support traffic system operations
FR TS	Functional Requirement ATMS to support traffic system operations
UR CS	User Requirement for the Communications Systems in the project
FR CS	Functional Requirement for the Communications Systems in the project

5.2 Operational

5.2.1 Intra-Agency Coordination

Event Management

UR IS 1. The ATMS shall provide the ability to implement pre-calculated response plans for pre-planned and un-planned events at the request of the Sub-Regional TMC.

Functional Requirements

- See *Scenario Management* (below)

Congestion Monitoring

UR IS 2. The system shall report congestion. (For a definition of congestion see the ATMS Functional Requirements)

Functional Requirements

FR IS 1. The ATMS shall make available via the IEN congestion data, both recurrent and non-recurrent, as derived by the ATMS from detector data.

5.2.2 Inter-Agency Coordination

Data Sharing

UR IS 3. The ATMS shall provide data to support the graphics displays at the sub-regional and regional levels. (Change in User Requirements).

UR IS 4. It shall be possible to view signal timing data of an ATMS from another LCC.

UR IS 5. Exported signal timing data shall support coordination across jurisdictional boundaries and along Atlantic Blvd. between multiple jurisdictions.

UR IS 6. It shall be possible to reference local device configuration data from the sub-regional TMC.

Functional Requirements

FR IS 2. Status, main-street greens, and cycle timer data for corridor-level maps and displays will be made available to the IEN once per second.

FR IS 3. Offset/split data for corridor-level maps and displays will be made available to the IEN once per cycle (if not running a cycle timer, will be collected once per minute).

FR IS 4. The ATMS shall aggregate detector data and events/alarms and make this data available to the IEN.

FR IS 5. The ATMS shall make alarms available for export via the IEN on a device basis.

FR IS 6. The ATMS shall make available to the IEN the following device data:

- Name
- Type
- Location (descriptive)
- Location (reference)

FR IS 7. The ATMS shall make available CMS status (including current message) to the IEN.

<u>*Video Sharing*</u>

<u>*Quality of Video*</u>

UR IS 7. The ATMS shall make available CCTV video images for viewing at other remote locations both in the corridor and elsewhere.

UR IS 8. It shall be possible to view video images from CCTV cameras in other jurisdictions.

UR IS 9. The system shall deliver reasonable quality video with 384kbps link and full motion video where links with sufficient bandwidth are available.

Functional Requirement

FR IS 8. The system shall enable reasonable quality video to be delivered to users on communications links with bandwidth availability as low as 384 kbps. A minimum quality video display would show at least two frames per second under all conditions including full-speed panning, with a display resolution of at least CIF (352 x 240 pixels), and no obvious image breakup or other artifacts under any conditions.

FR IS 9. The system shall avoid trans-coding or decoding and re-encoding of video if that will noticeably degrade the quality of the video otherwise available to users.

FR IS 10. The system shall take advantage of higher bandwidth center-to-center links to provide better quality video, and full television quality video where feasible.

FR IS 11. The system shall allow simultaneous distribution of at least two different quality feeds for each camera. One feed will be a high-quality feed (up to the quality of the feed available from the camera) available to users with a high-bandwidth connection. The other feed will be a lower-quality feed available to users with only a low-bandwidth connection, or who wish to conserve available bandwidth. The high-quality feed may consume 2 Mbps or more. The low-bandwidth feed may consume as little as 350 kbps, or less.

FR IS 12. The system shall allow an authorized user, as part of system configuration, to determine the quality and approximate bandwidth requirement of each alternative feed to be made available for each camera, with such parameters potentially being different for different cameras.

FR IS 13. The system shall use multicasting techniques where feasible to minimize the bandwidth required for serving the same camera feed to multiple users simultaneously. IP multicasting may not be supported in the network infrastructure, and alternative techniques are therefore required.

System Configuration

UR IS 10. The system shall not require manual downloading of any plug-in or other software.

Functional Requirements

FR IS 14. The system shall allow users to configure and use the system via the Microsoft Internet Explorer web browser.

FR IS 15. The system shall use a normal web browser on user's computers and shall not require user's computers to have other software pre-installed. One or more small software modules may be dynamically and automatically loaded on a user's computer as part of the video feed retrieval process.

FR IS 16. The system shall use a popular, well supported video compression standard. Due to this and other requirements such as those addressing bandwidth, quality, and performance, suitable compression standards are probably limited to Motion JPEG and MPEG-4.

FR IS 17. The system shall not perform any automatic download of a plug-in or similar enabling software that requires more than ten seconds to download over a 384 kbps link. In order to meet other requirements, such automatic download may need to be restricted to occurring only the first time a camera is accessed after the user's web browser is started.

User Rights

UR IS 11. It shall be possible to assign user rights for use of the viewing and control of the camera.

Functional Requirement

FR IS 18. The system configuration mechanism shall enable different users and different cameras to be associated by different sets of privileges. A scheme involving user groups with users and privileges assigned to such groups is desirable.

FR IS 19. The system shall enable a user with appropriate privileges to add cameras and users, and enter appropriate configuration data for each.

FR IS 20. For each camera, the system shall be configurable to allow all or any subset of users to *view* that camera.

FR IS 21. For each camera, the system shall be configurable to allow all or any subset of users to *control* that camera (e.g., activate presets, pan, tilt, and zoom) in addition to being able to view it.

FR IS 22. The system shall at least have the option to require user name and password entry to prevent unauthorized use. Initially, access will not be provided to the public.

FR IS 23. The system shall not provide camera controls to a user that does not have control privileges for the selected camera or if the selected camera has no remote control capabilities.

FR IS 24. The system shall enable authorized users to set and name camera presets.

Ease of Use

UR IS 12. The system shall provide a map based GUI

Functional Requirements

FR IS 25. The system shall enable a user to access an on-screen street map with a clickable icon for each camera. A camera is selected for viewing, and control if feasible, by clicking on its icon.

FR IS 26. The system shall enable a user to access an on-screen list of clickable text strings, each being associated with a camera and showing the street names and other information needed to uniquely identify the camera location.

FR IS 27. The system shall provide on-screen controls for cameras with remote control capabilities, enabling the user to easily select a preset camera position or to interactively apply pan, tilt and zoom actions.

FR IS 28. The system shall enable the user to select a preset from a list of preset names.

UR IS 13. The system shall have easy access and shall be easy to use and fast to respond.

Functional Requirement

FR IS 29. The system shall distribute streaming digital video over the Internet and agency-owned WANs using the Internet Protocol, and Ethernet interfaces to user computers.

FR IS 30. The system shall start displaying video within 5 seconds of a user selecting a camera for viewing, except for the first camera selected after the user's web browser is started. This requirement assumes a network link supporting at least 384 kbps and a typical modern computer not significantly loaded with other applications, so that any delay is primarily in the video distribution system.

FR IS 31. The system shall exhibit a camera control latency of no greater than one second, and desirably well less than one second. Control latency is measured from the time a camera movement action is initiated (e.g., a mouse click) to the time that the field of view of the on-screen video image is seen to start changing accordingly.

FR IS 32. The system shall allow a user to view any number of cameras simultaneously, subject only to overall system sizing limits and bandwidth constraints. It is assumed a user will control only one camera at a time, and a single set of on-screen controls may be provided for all camera being viewed if the user is provided a suitable means of selecting the camera to be controlled.

System Expandability

UR IS 14. The system shall be expandable.

Functional Requirements

FR IS 33. The system shall impose no inherent limitation (other than some very large number) on the number of configured cameras. However, implementation of support for a particular number of cameras may require the owner to add expansion options such as more licenses, more bandwidth, more server computers, etc.

FR IS 34. The system shall impose no inherent limitation (other than some very large number) on the number of configured users. However, implementation of support for a particular number of users may require the owner to add expansion options such as more licenses, more bandwidth, more server computers, etc.

FR IS 35. The system shall impose no inherent limitation (other than some very large number) on the number of cameras that can be viewed simultaneously. However, implementation of support for a particular number of simultaneous viewed cameras may require the owner to add expansion options such as more licenses, more bandwidth, more server computers, etc.

FR IS 36. The system shall impose no inherent limitation (other than some very large number) on the number of users that can view the same camera simultaneously. However, implementation of support for a particular number of simultaneous feeds-to-users for the same camera may require the owner to add expansion options such as more licenses, more bandwidth, more server computers, etc.

FR IS 37. The system shall be initially configured to support a maximum of at least 120 cameras, a maximum of at least 30 users, and a maximum of at least 120 cameras being viewed simultaneously, each being viewed by up to 6 users. The simultaneous feeds-to-users for a particular camera may be any mix of the available different bandwidth and quality feeds for that camera.

<u>Signal Operations</u>

UR IS 15. ATMS shall provide inter-agency plan selection capability. (ATMS UR 3.1.2.2)

UR IS 16. One agency will be able to request/implement plan changes in other agencies to accommodate emergency operations and/or non-recurrent congestion situations. (ATMS UR 3.1.2.4)

UR IS 17. The ATMS shall export traffic responsive plan data to enable the coordination of signal timing plans under TRPS conditions.

UR IS 18. The ATMS shall be able to use detector data from another system for its own processes such as TRPS and incident detection and management.

UR IS 19. Each agency's ATMS can reference plans and traffic conditions in neighboring agencies in order to select suitable plans.

Functional Requirements

FR IS 38. The ATMS shall make available for export via the IEN volume and occupancy on a detector basis for use in traffic responsive plan selection by another agency.

FR IS 39. The ATMS shall be able to import volume and occupancy on a detector basis via the IEN for use in its own traffic responsive plan selection.

FR IS 40. It shall be possible to request a report of all detectors of other agencies' systems used by the ATMS.

FR IS 41. The report shall include:

- Detector number
- Detector location (descriptive text)
- Current values
- Traffic responsive tables in which used

FR IS 42. The ATMS shall receive requests for plan changes on an intersection basis via the IEN.

FR IS 43. The ATMS shall respond to the IEN with a confirmation of the action taken in response to the request to implement an intersection plan.

Scenario Management

UR IS 20. The ATMS shall support the IEN Scenario Management functionality.

UR IS 21. The ATMS's will translate scenario response plans from the corridor system into the correct set of local plan changes.

UR IS 22. Scenario response plans shall include signal timing changes, changeable message signs and other devices.

UR IS 23. Each local agency can confirm, reject, or amend scenario Response Plans.

Functional Requirements

FR IS 44. The ATMS will translate Scenario Response Plans from the corridor system into the correct set of local actions.

FR IS 45. The Scenario Response Plans will include traffic signal timing plan selection for an intersection, section or system

FR IS 46. The Scenario Response Plans will include dynamic message sign selection for a sign.

FR IS 47. The ATMS shall respond with a confirmation of the action taken in response to the request to implement a response plan.

FR IS 48. Libraries of plans will be maintained so that local agencies can match plans with neighboring agencies when regional efforts are in process.

FR IS 49. The ATMS will support the viewing of locally stored plans via the IEN.

FR IS 50. The Corridor Server will maintain a list of "Scenario Response Plans" that may be implemented from the corridor level as the result of incident response. The ATMS shall provide a list of locally stored plans to the IEN.

FR IS 51. The list of locally stored plans shall comprise a plan identification and a description of the plan.

Incident Management

UR IS 24. If required to provide a single agency response to freeway incidents, the ATMS should be compatible with the SHOWCASE approach to freeway incident management and response.

UR IS 25. The system design should use the incident management standards which have been developed through the ITS Data Registry process.

Functional Requirements

- None for Integration Systems; functionality is incorporated in the IEN and the ATMS.

Time Synchronization

UR IS 26. The ATMS shall make available its current system time for reference by another system.

Functional Requirements

FR IS 52. The ATMS shall make its time available to the IEN in response to a query via the IEN

FR IS 53. The ATMS shall be able to receive and implement time synchronization via the IEN.

5.2.3 Transfer of Data for Traveler Information.

UR IS 27. The ATMS shall export real-time detector data to the IEN.

Functional Requirements

FR IS 54. Detector and congestion data for corridor-level maps and displays will be made available to the Corridor server once per cycle (if not running a cycle timer, will be collected once per minute).

FR IS 55. The ATMS shall export link-based detector data (volume, occupancy and speed) for the last data collection period.

FR IS 56. The ATMS shall export link-based congestion data for the last data collection period.

FR IS 57. The ATMS shall export dynamic message sign status (including current message).

5.2.4 Security

UR IS 28. It shall be possible to restrict access to the ATMS by remote users accessing the system via the IEN. (ATMS FR 23.1.10 *et seq.)*

UR IS 29. It shall be possible to define levels of access to users from another agency. (ATMS FR 23.1.10 *et seq.)*

Functional Requirements:

FR IS 58. The ATMS shall provide remote access via the IEN.

FR IS 59. 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 23.1.11)

FR IS 60. The rights of the remote User will be determined and set up in the same manner as a local User. (FR TS 23.1.12)

5.3 Maintenance

Field Equipment Maintenance

FR IS 61. The ATMS shall advise maintenance staff of the need for routine maintenance.

Corridor Communications

UR IS 30. The status of the IEN communications link shall be monitored and failures reported to local and sub-regional operators as appropriate.

UR IS 31. Facilities shall be provided for the testing of the CDI to ATMS interface.

Functional Requirements

FR IS 62. The ATMS graphical user interface (GUI) shall contain a visual display of the availability of the IEN to the ATMS.

FR IS 63. It shall be possible to initiate disconnection from the IEN at the ATMS user interface.

FR IS 64. It shall be possible to initiate connection to the IEN at the ATMS user interface.

5.4 Staffing and Training

No requirements

5.5 Cost

UR IS 32. The integration of systems shall make use of software developed under parallel County projects wherever possible to avoid duplication of effort.

UR IS 33. The integration of systems shall make use of software available from other agency projects (e.g. SHOWCASE) wherever possible to reduce deployment costs.

5.6 Public Relations

No Requirements

5.7 System Requirements

Communications Protocols

UR IS 34. At a minimum, the ATMS should have demonstrated the ability to support the relevant NTCIP protocol for C2C.

UR IS 35. 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.

Functional Requirements

- See Center-to-Center Communications, below.

Center-to-Center Communications

UR IS 36. NTCIP Center-to-Center is covered by two standards: Datex ASN and CORBA. In addition, a Message Sets for External TMC Communications is being developed. The Southern California Regional Architecture, as well as the County's IEN, is based upon the CORBA standard. This should be specified for use on this project.

Functional Requirements

FR IS 65. The ATMS shall support an ORB compatible with the IEN.

FR IS 66. The ATMS shall use CORBA v2.2 or later compliant interfaces.

FR IS 67. The ATMS shall use the IDL's defined for the IEN.

System Architecture

UR IS 37. The ATMS shall be consistent with the County's IEN Architecture

Functional Requirements

FR IS 68. All system components of the Atlantic Blvd. /I-710 Corridor project will communicate via the IEN.

FR IS 69. Command Data Interfaces (CDIs) will be used to interface existing Traffic Control Systems to the IEN.

FR IS 70. The ATMS shall interface with the IEN's CDI for transferring and receiving data from the IEN.

FR IS 71. Protocol definitions will be documented to assist in future component additions.

Operational Requirements

FR IS 72. Access to the IEN shall be on a 24 hours per day, 7 days per week basis (excluding an acceptable down time for system maintenance, backup, etc).

FR IS 73. For systems to be integrated seamlessly, all software used for integration shall be fully modular, expandable, and upgradeable.

Location Referencing

UR IS 38. Message profiles as specified by the SAE's Location Referencing Message Specification Information Report and as adopted by the IEN should be used as the basis for location- referencing data elements.