ITS SYSTEM ARCHITECTURE

San Diego Region Intelligent Transportation Systems Architecture: Detailed Document

Draft

Prepared for:
San Diego Region ITS Planning Subcommittee

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1.0 INTRODUCTION

Since the completion of the San Diego Region Intelligent Transportation System (ITS) Strategic Deployment Plan, the San Diego Region has been working to deploy a series of integrated ITS projects to improve operations of the freeway, arterial, transit, and emergency management systems. The specifics of each of these ITS projects differs, but all seek to apply advanced sensor, computer, electronics, communications technologies and management strategies to improve the safety and efficiency of the surface transportation system. Basically, these ITS projects are deployed to deliver a series of transportation network services to managers and users of the transportation system.

As part of the Transportation Equity Act for the 21st Century (TEA-21), under Section 5206(e), FHWA and FTA have established rules/policies requiring that all ITS projects funded from the Highway Trust Fund be in compliance with the National ITS Architecture. The National ITS Architecture is, “a general framework for planning, defining, and integrating ITS.” As part of meeting this requirement, the San Diego Region is required to develop a regional ITS architecture to ensure technical integration and institutional agreement for ITS projects deployed in the region. SANDAG is the responsible agency for reviewing ITS projects and determining whether or not they conform to the regional architecture and meet the intent of the National ITS Architecture.

1.1 Purpose of this Document

This document is provided as a supplement to the San Diego Region System Architecture Summary and the ITS information in the Mobility 2030 Regional Transportation Plan (RTP). It is intended to meet the following needs:

- Provide more detailed information for technical staff in the process of planning, designing, or deploying ITS projects, so that they may understand the relationship their project has with other ITS projects and their responsibilities to the region.
- Meet the federal guidelines and provide the San Diego region with a comprehensive regional ITS architecture.
- Identify the current status of the adoption of standards and operational agreements in the San Diego region and provide a path for agencies to follow as they work towards adopting standards and setting up operational agreements.

It is important to understand that the San Diego Region ITS System Architecture, and this document are focused on the systems and interfaces currently in planning, design, deployment, or operation. The regional architecture is a "living document" that will be updated to reflect ITS deployment efforts in the San Diego Region. Most of the on-going and currently planned ITS projects in the region are reflected in this architecture, however it is likely that new systems will be developed over time that go beyond the architecture and agencies will need to work with SANDAG to expand the architecture as necessary.

1.2 Architecture Overview

A system architecture is meant to act as a blueprint within which the regional deployment of ITS can occur. This architecture supports the National Architecture and the statewide architecture. It does not replace these two documents. The details contained in a system architecture vary from situation to situation. The architecture contained in this document outlines potential paths/methods for the connection and integration of systems. It also provides guidelines on the relationships between the various ITS project elements discussed in Section 9.0 and national
ITS standardization efforts currently underway. This architecture uses National Architecture Market Packages, suitably customized for the San Diego region, as a baseline for intermodal system connectivity. The San Diego ITS system architecture also recognizes the US DOT Critical Standards currently in development as the key standards for regional project development. These standards are discussed in detail in Section 8.0.

1.2.1 BASIC ARCHITECTURE OVERVIEW

What is an architecture, and why is it important to know about architectures? In its most basic form, an architecture is a set of rules that facilitate the building of systems and that allow these systems to communicate and interoperate after being built. An ITS architect is to an ITS system as a building architect is to a building. A building architect could not build a structure without a set of plans. Neither could an ITS architect build a complex regional ITS system without a set of plans. These plans are the system architecture. It is important to distinguish between an architecture built for planning and implementation guidance and an architecture used to build actual working systems. In our discussions regarding this Plan, the former context is most appropriate. We are using best practice in architecture development within California to fit the San Diego Region operational and institutional environment.

To put the concept of an ITS architecture into the real world, consider the following example of a “smart corridor” with the following elements, including:

- A Regional Transportation Management Center that controls a set of freeway management devices within the defined corridor boundaries;
- One or more local Transportation Management Centers that control arterial traffic signals for one or more connected cities in the defined corridor (most “practical” smart corridor projects typically are limited to one or two cities);
- The freeway management devices (ramp meters, Dynamic Message Signs (DMS), CCTVs and Highway Advisory Radio (HAR)) and arterial traffic control signals;
- The vehicles that drive the freeways and arterials; and
- The local and/or regional communications systems that allow these elements to communicate.

The architecture describes how these elements will interoperate by detailing element locations, physical communications links, and most importantly what kinds of information must be transferred among the different elements. The architecture also tells us what “functions” are performed by each of the “Smart Corridor” elements. Later in the Architecture we will see how an architecture can be gradually built up using the market packages.

An architecture is important in the development of complex systems because it provides detailed guidance on how to design the systems and because it provides a vehicle to decompose larger systems into more understandable subsystems. An architecture is particularly important if more than one system is to be built and these systems must talk to each other or if multiple systems will be expanded over a period of time. In the San Diego Region both of these elements are clearly present.

A complex systems development process includes concept development, needs assessment, functional requirements definition and architecture development. To develop the architecture we first need to know about the system vision (concept) and what proposed system users need, in other words, what are their requirements? What do they want the system to do? At this point the details of physical elements such as communications links and traffic signals and TMC’s are not important. The next step is to take the user needs and develop functional requirements. Here
the emphasis is on what the proposed system must do to meet the users’ needs. In the process of developing functional requirements, we determine what functions must be performed by the system and what data must flow between the functions. For example, if a function of ACTIVATE VIDEO is defined, we need to know what data is input to the function, what data is output from the function and the source and destination of these data flows. The final step in the system development process is to allocate the functional requirements to hardware, software or humans (operators). Part of this last process includes the development of an architecture for the system. This is referred to as High Level Design, or in some circles Preliminary Design. The major difference between these steps in a long range planning process (i.e. ITS Strategic Deployment Plan) versus a specific system development process is the degree of precision needed as the steps are performed.

1.2.2 ARCHITECTURE DEFINITIONS

When we speak of an architecture, we mean the logical and physical relationship of certain defined subsystems within a system. A system can be thought of in many ways: the Internet is a system. The highway network within the San Diego Region is a system. The Caltrans Transportation Management Center in San Diego is a system. For purpose of our representation in this Plan, we define a system as the collection of subsystems including communications networks, operations centers, roadside devices and multimodal vehicles that control or operate on the region’s transportation network in its broadest sense: roads, railroads and airports. Subsystems can be directly related to the National ITS Architecture through what is commonly referred to as the “Sausage Diagram”. Communications network subsystems range from underground fiber optic networks to commercial broadcast stations and paging networks. Operations Center subsystems are as diverse as the CHP communications center in San Diego, a local Traffic Management Center in the city of Oceanside, a private information provider or a private truck dispatch facility desiring information about travel conditions in San Diego County. Roadside subsystems include railroad warning signals, motorist aid call boxes, traffic signals, changeable message signs, vehicle detection loops in the pavement and closed circuit TV monitors. Vehicle subsystems include cars, buses, commercial vehicles, emergency vehicles, trains (passenger and freight) and aircraft.

What is the difference between the physical and logical elements of an architecture? The physical architecture largely represents the communications links and the components that we can touch and feel that are connected by these links: operations centers, traffic lights, railroad crossing signals, loops in the pavement. The logical architecture is harder to define and to visualize, but it includes the functions (actions to be performed), and the flow of information between the functions that the system is supposed to accomplish.

For example, one of the Market Packages being used for the transportation system in the San Diego Region is Emergency Vehicle Routing. To perform this routing, the Emergency Management function needs to have real-time traffic conditions for the roadway links that emergency vehicles will travel to their destination. Conversely, the Information Service Provider function providing real-time traffic information needs to have the real-time location of the vehicle so it can intelligently select the routes for which traffic data is needed. If traffic signal preemption is required, additional functions and data flows are needed. These functions, and the data flows between them, represent a piece of the logical architecture of the transportation system. Figure 1-1 illustrates the separation of logical and physical architectures. The diagram shows the appropriate functions and data flows, therefore it represents a logical architecture needed to implement this Market Package. The physical architecture would include the CHP communications center, the Caltrans TMC (which we will assume includes the Information
Service Provider function), the patrol car, and in the case illustrated, traffic signals along the route that will be preempted. The physical architecture would also include the communications links necessary to support these data flows. These would include leased lines or other wireline networks and short-range wireless radios.

Figure 1-1 also illustrates another important point about the separation of logical and physical architectures: a physical implementation may include any combination of logical functions. As shown, the functions of Traffic Management and Information Service Provider are combined in a single center, in this case, the Caltrans TMC. The architecture design process consists of developing a logical architecture based on user needs and functional requirements as previously discussed, and then allocating the logical functions to physical entities to build a physical architecture. Once the physical architecture is completed, the system design process can start, and specific centers or other system elements can be designed and developed. In the context of this Plan, the architectural design process will continue during development of the Plan. The system design process is an activity that occurs during individual project deployments. There will be, however, a continuous refinement process for the architecture as project requirements, technology options and institutional relationships change over time.

Figure 1-1: Example of Logical and Physical Architecture for Emergency Vehicle Routing Market Package

1.3 Using & Compliance with the Regional & National Architecture
The goal of the regional architecture is to assist agencies in planning, designing, and deploying systems that work together in an integrated fashion. In the past, systems were often deployed
with a single agency or type of agencies in mind without regard to what information or functional services of the system would be helpful to transportation managers/operators throughout the region. In extreme cases, two agencies could deploy two similar yet different systems, only to find that sharing information between these systems is not possible despite an operational need to share the information. As the San Diego region continues to grow, the separation between agencies is shrinking, and agencies are already recognizing an increased need to work together to manage towards their transportation goals.

Agencies that are developing ITS projects should identify the following during the early project development/conceptualization stages:

- A basic concept of operations identifying who the users are for the systems being developed in the project, what operational roles they will play as part of the project, and how they will use the systems.
- A listing of functional services (as specific as possible) that will be provided through the project to the various users. The supporting system architecture information for this summary outlines functional services that are already part of the architecture and which can be used by agencies to complete this listing.
- A data flow diagram showing the exchange of information between systems and agencies both internal and external. Any standards which the agency knows they want to consider for this exchange of information should be noted.

This information is required for a project, so that a determination can be made whether or not it will comply with the regional and national architecture. This project information is also a requirement of the federal rule regarding architecture compliance.

Given this basic information for their project, agencies should use the regional ITS architecture at three different levels:

- During the early conceptualization of a project to recognize that projects must consider how they fit into regional ITS plans and the regional ITS architecture.
- During the early planning/programming stages of a project this summary should be used to determine what types of information and functional services they should expect to share with other agencies and other transportation modes. In addition, review of this information can point out several systems already being deployed that may save money and effort for the agency in deploying their project. Finally, the data flow diagrams in this summary can be used by an agency to help show where their project fits into the regional architecture.
- During the system design phase the supporting architecture documentation can be used to assist agencies in defining the details of the data flows to/from their systems, as well as identifying what types of institutional arrangements may be used to support the effective operation of their project.

Confirmation from SANDAG that a project is consistent with the regional architecture identifies that this project is in compliance with the National ITS Architecture. This consideration is important to obtaining federal funds for a project.
2.0 REGIONAL DESCRIPTION

The San Diego Region ITS System Architecture applies to the area and agencies encompassed by San Diego County. The architecture does contain information relating to wider regional integration with ITS projects and systems in Orange, Los Angeles, Riverside, and San Bernardino counties. This wider area was originally referred to as the Southern California Priority Corridor. The San Diego region has participated in the ITS development efforts of this wider area in an attempt to ensure consistency with what is being done throughout Southern California.

2.1 The San Diego Region

The San Diego region is a one-county area matching the boundaries of San Diego County. The region encompasses 4,261 square miles from the coastline of the Pacific to the county boundaries in the east resting in mountains up to 6,500 feet elevation. The boundary to the north is Orange County with somewhat of a de-urbanized buffer zone provide by Camp Pendleton, while the region shares an international border with the State of Baja Mexico. The San Diego region contains 18 incorporated cities and 17 unincorporated communities with a total population of over 2.8 million (Year 200 Census). San Diego County is the 3rd largest county in the State of California in terms of population. The City of San Diego is by far the largest city in the region, and is the 7th largest city in the nation in terms of population. Approximately ½ of all residents in the region live within the City of San Diego limits. The Gross Regional Product (GRP) of the region has been estimated at just over $110 billion (Year 2000). According the SANDAG’s Mobility 2030 (Draft October 2002) document, the population of the region is expected to grow by more than one million with an associated increase of 500,000 more jobs and 340,000 new homes. Growth has and will continue to exert a growing pressure on the region’s transportation facilities. Efficient management of existing facilities, along with the development of new and expanded facilities, will be required to deal with increased levels of trip making.

2.2 Overview of Transportation Facilities

As a major urban center with outlying rural communities, San Diego County is host to a diverse set of transportation facilities including an extensive network of freeways, highways, major arterials, and transit services. A brief summary of these facilities is provided in the system architecture consistent with federal guidelines. This summary assists in understanding the extent of the facilities that will eventually be covered by the various regional ITS systems, and it also highlights the infrastructure improvements that are being planned of which ITS deployment is a part. Much of the information on facilities, including some of the graphics, are based on the most recent SANDAG Regional Transportation Plan (RTP), known as Mobility 2030 (Draft October 2002). Therefore the information in this section is meant to reflect forecast conditions and planned facilities out to the year 2030.

Figure 2-1 displays the Year 2030 highway network which includes $11 billion in improvements and new facilities. The focus of new facilities will be on filling in missing links of the network, such as the completion of SR56, SR125, SR905, and SR56. Major improvement efforts are already underway along I-5, I-5/I-805 merge, and I-15. I-15 improvements are particularly notable as they involve the development of a series of managed lanes between approximately SR163 and SR78. The number of lanes available for travel in either the northbound or southbound directions will be adjusted based on travel demands.

Figure 2-2 displays the regionally significant arterial network which encompasses most of the major travel corridor arterials in the region. This arterial network is the focus of the major
Figure 2-1. 2030 Highway Network (Existing + Planned)
Figure 2-2. Regionally Significant Arterial Network

Source: SANDAG Mobility 2030 Draft October 2002
improvements through the year 2030. These arterials are critical to the movement of travelers throughout the region, and the Mobility 2030 plan has outlined $500 million in improvements and $700 million has been identified for completion of the regional arterial network based on local circulation elements.

A major focus of improving mobility in the San Diego region has been the improvement and expansion of transit options. The region has developed a broad regional transit vision which includes commuter rail, light rail, bus rapid transit, fixed route bus, and demand services. Figure 2-3 displays the regional transit network (Year 2030) as included in the RTP. An increased use of technologies and integration between transit and traffic signal systems is envisioned as critical to the success of this planned transit vision.

There are many other transportation facilities in the region which are important, but are not a focus of the current system architecture:

- Airports & port – While these facilities are important to the economic vitality of the region, the development of systems for these facilities is currently outside the arena of this particular architecture. However, these facilities will benefit from the modal management systems supporting access to these facilities. For example, improvements to arterial, freeway, and transit systems and networks will aid ground access to these facilities, and traveler information will also be provided.

- Border crossings – The San Ysidro border crossing is the busiest in the nation, and the Otay Mesa crossing is a key commercial port of entry. Commercial vehicle regulatory and safety systems are not a concern of this regional architecture based on the regional decision that these systems are more a function of state and national institutional structures.

### 2.3 Overview Of San Diego Intelligent Transportation Systems

Table 2.1 identifies the major systems discussed in this summary. For each system, the table summarizes some of the basic functional services and major types of data from the system and the types of agencies likely to share these functions/data.

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<th>Description</th>
<th>Basic Functional Services/Data Types</th>
<th>Agency Types</th>
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| IMTMS Network        | Regional communications network including leased and agency-owned communications resources that form the backbone for the exchange of information between ITS systems in the region. | **Services:** System integration, security, communications, regional network management, etc.  
**Data:** All types of data, including both data exclusive to a particular project and data shared between multiple ITS projects. | All agencies       |
| Freeway Management System | Focused around the Advanced Transportation Management System (ATMS) being deployed by Caltrans District 11; it is the core of freeway management including the use of cameras, changeable message signs, and vehicle detection sensors. | **Services:** Field device (cameras, CMS, vehicle detection stations) control/mgmt., incident/event mgmt., incident response, resource mgmt., etc.  
**Data:** Freeway speeds, incidents, video, sign messages, etc. | Caltrans, CHP, cities, transit, and emergency services. |
Figure 2-3. 2030 Transit Network (Existing + Planned)
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<th>Systems</th>
<th>Description</th>
<th>Basic Functional Services/ Data Types</th>
<th>Agency Types</th>
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<tr>
<td>Regional Arterial Management Systems</td>
<td>Focused around the Regional Arterial Management System (RAMS), and comprised of two basic Tiers: 1. Interjurisdictional signal coordination/mgmt. 2. Local advanced traffic and event mgmt. In addition, the Mission Valley Advanced Transportation Management &amp; Information System (ATMIS) is viewed as an initial implementation of RAMS Tier 2 for architecture purposes. MV ATMIS functions will be incorporated and expanded on as part of RAMS Tier 2.</td>
<td><strong>Services:</strong> Signal timing/control, interjurisdictional signal timing, regional timing plan implementation, field device (cameras, CMS, vehicle detection stations) control/ mgmt., incident/event mgmt., incident response, resource mgmt., etc. <strong>Data:</strong> Signal status, timing, local incidents/events, arterial cameras, vehicle sensors, and message signs.</td>
<td>Cities, Caltrans, local law enforcement, and transit agencies.</td>
</tr>
<tr>
<td>Transit Management Systems</td>
<td>Comprised of several transit management systems in the region for purposes of fleet management, enhanced schedule performance, improved fare payment, and improved interagency coordination.</td>
<td><strong>Services:</strong> Fleet mgmt., vehicle tracking, emergency alerts, transit schedule &amp; arrival info., transit traveler info., automated fare payment, etc. <strong>Data:</strong> Transit vehicle locations, vehicle status, schedule performance/adherence, real-time info. displays at stops, dispatch/vehicle text messages, etc.</td>
<td>Transit agencies, some local cities, and emergency services during safety related incidents.</td>
</tr>
<tr>
<td>Traveler Information Management Systems</td>
<td>The public sector will provide a common interface for private information service providers to obtain selected information from the IMTMS Network.</td>
<td><strong>Services:</strong> Portal for public sector transportation info. on IMTMS Network to private sector info. providers, data translation, data filtering, etc. <strong>Data:</strong> Freeway/roadway speeds, incidents, announcements, transit schedule information, and next stop arrival, etc.</td>
<td>Private sector traveler information providers.</td>
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2.3.1 INTERMODAL TRANSPORTATION MANAGEMENT SYSTEM (IMTMS) & IMTMS NETWORK

System Description

The term Intermodal Transportation Management System (IMTMS) refers to the San Diego region’s “system of systems.” In layman’s terms, IMTMS is the “glue” that ties together the management systems of the individual modes and allows for the intermodal sharing of data and functional capabilities. For example, IMTMS is what allows a transit agency to receive information on traffic conditions, and IMTMS is the system that allows cities to share event management information, as well as traffic video and camera control, with other cities and Caltrans. IMTMS is the critical system concept in the San Diego regional system architecture. As a term, IMTMS is used to describe the integrated development and operation of the major modal management systems in the region, and without it age.

The IMTMS Network refers both to the communications network across which each of the individual management systems communicates to share information and functional services, as well as the interfaces, equipment, and software that allow this communication to occur. Figure 2-4 displays, at a general level, the various management systems and operations centers that...
Figure 2-4. IMTMS Logical Architecture (high level data flows).

From Transit
Public (Call Boxes, Mobile 911)

Emergency Mgmt

Fwy Traffic Mgmt (Dist 11 TMC)

Planning & Evaluation

Arterial Traffic Mgmt (e.g.)

Local Traffic Data

Transit Operations

Traffic/Route/Transit Data

Static schedules
Dynamic schedules

To Emergency Management, Fwy Mgmt & Arterial Mgmt

User Statistics

To Planning & Evaluation (SANDAG)

Incidents

From Transit

VDS
CMS
RMS
HAR

From Transit

From Transit

Signal Priority
Grade Crossing

Grade Crossing

VDS
Signals
CMS
HAR

Shared Control

SD Transit
No Co Transit
CTS
SD Trolley
Private

Auto/Transit/CVO User

Patrol/FSP Units

Signal Preemption
comprise the IMTMS Network, and it also indicates the basic types of information being shared across the network. **Figure 2-5** displays at a more specific level, some of the physical systems and links between systems that are currently being deployed as part of the IMTMS Network.

Communications across the IMTMS Network occurs at two basic levels:

1. **Communications between agencies within a system** – The IMTMS Network is utilized to link together various agencies utilizing a single system. For example, several cities will utilize the IMTMS Network for communicating information internal to the Regional Arterial Management System (RAMS). A specific example is when one agency is sharing signal timing coordination data with another agency. This coordination data travels between the agencies in a format specific to RAMS, and is not available to the broader users of the IMTMS Network. At this level, the IMTMS Network lets agencies throughout the region to make use of a common integrated management system.

   Communications between different modal management systems – The IMTMS Network is utilized to communicate information and share functionality between modal management systems. For example, information may travel from the Transit Management System to the Freeway Management System or vice versa. Data at this level utilizes the standards set in the Southern California SHOWCASE development effort. This means that systems in the region can share information and functionality with other management systems in Southern California. The IMTMS Network is also provides a common public/private sector information “portal” known as the Advanced Traveler Information Management System (ATIMS). Private sector providers of traveler information can access information such as freeway speeds, lane closures, transit schedules, bus arrival times, and a great deal of other data through ATIMS.

The IMTMS Network is comprised of:

- **Physical Communications** – Including the Caltrans District 11 Traffic Operations System Network, or TOSNET, consisting of phased fiber optic projects being deployed across the San Diego region; fiber and other high capacity communications being deployed by cities and transit agencies; and leased communications used to reach locations where agency owned communications are not practical or available. Over time, it is anticipated that the balance of connections that comprise the IMTMS Network will shift from largely leased communications to more agency owned communications.

- **Integration/Management Software & Systems** – Including the San Diego region regional intertie software which provides network management and security services, the various “seeds” and clients that allow the individual management systems to communicate across the network, and supporting software and equipment for operations of the network.

**Deployment Considerations**

The IMTMS is being developed to support numerous standards and communications approaches. Caltrans District 11, has taken the lead in supporting the coordinated development of the IMTMS Network in cooperation with the cities and transit agencies in the region. Caltrans also operates and maintains the statewide Wide Area network (WAN) that connects the District 11 TMC with other Caltrans TMC’s in Southern California. These connection are generally displayed in **Figure 2-6**. Agencies seeking to deploy an ITS project in the Region should consider:
Figure 2-5. Regional IMTMS Physical Architecture (generalized)
Figure 2-6. Conceptual Main Points of Communications Connectivity
• What information and functions will their project share with other agencies? – The data flow diagrams in this summary will help an agency in answering this question.

• Which existing components and standards of the IMTMS Network will their project use? – There is a general discussion of standards in this summary, however agencies should contact SANDAG for the latest information on the standards which have been previously used or adopted for the IMTMS. Nationwide many ITS standards are still in flux, and agencies should review operational system deployments in the region to get a feel for which standards have proven effective so far.

• Has a functionally similar management system already been deployed on the IMTMS Network, and can it be utilized or modified to meet the agencies needs? – As a part of IMTMS and the associated management systems, many of the most common functions desired by transportation managers are already being developed or deployed. Agencies should consider if these systems either meet their needs or can be modified to meet their needs, and if so they should strongly consider incorporating these systems into their project.

• How frequent will data and functions be shared with this project across the IMTMS Network, and with what agencies will it most often be shared? – This information is the first step in determining what sort of communications will be required, and whether or not any modifications need to be made to the IMTMS Network.

If an agency has some preliminary answers to these questions, it should be sufficient to work with the region and further the development of their project.

2.3.2 Freeway Management Systems

System Description

There are four key regional systems that taken together comprise Caltrans District 11’s freeway management system:

• Advanced Transportation Management System (ATMS) – ATMS Version 2.0 is currently being deployed in the San Diego region. This will bring Caltrans District 11 up to the current state standard for ATMS. In addition, Caltrans District 11 will deploy intermodal functionality for the ATMS which is referred to as the ATMSi. This intermodal functionality accomplishes three primary objectives: (1) it facilitates Caltrans and local transportation agency data sharing and shared control over the IMTMS Network; (2) it provides local agencies a real-time view of freeway congestion and incidents; and (3) it brings information from other modes and agencies into Caltrans providing a more comprehensive picture of surface transportation management in the San Diego region.

• Ramp Metering Information System (RMIS) – RMIS was designed to provide centralized management of the District’s ramp metering system. RMIS provides real-time congestion data to the ATMS, to a data analysis application at UC Berkeley and to the legacy SDRMS computers. Data polling and ramp meter control are exercised through a Front End Processor.

• I-15 Reversible Lane Control System (RLCS) – RLCS manages and controls the reversible High Occupancy Vehicle/Toll lanes on I-15. An updated RLCS is in the process of being designed and deployed. RLCS will provide information to the ATMS on the status of the HOV lanes, including whether they are open and in which direction.
• **Freeway Service Patrol and Traffic Management Team Automatic Vehicle Location System (FSP/TMT AVL)** - The AVL system will track FSP and TMT units in real-time to allow improved incident management on the regional freeway system. A management capability will be provided that allows data collection and analysis to replace the current manual methods.

ATMS and RMIS are both capable of handling expanded regionwide deployment of field devices such as ramp meters, CCTV cameras, changeable message signs (CMS), etc. The only new system which is likely to come into play within the foreseeable future is the Managed Lanes Control System (MLCS) which would control the managed lanes along I-15 from SR 56 to SR 78. Similar to the RLCS, the MLCS would provide status information to the ATMSi and the regional IMTMS Network regarding status of the managed lanes.

The ATMSi is the core system that connects the freeway management systems and field devices to the IMTMS Network, and therefore to the other systems in the region. Figure 2-7 displays the freeway management functions and architectural flows that are, or will be implemented in the region. This figure also shows the coordination between freeway and arterial traffic management operations. Caltrans will input freeway related incidents and events in ATMSi, and this data will be available to local agencies. In addition, It is envisioned that Caltrans, using ATMSi, and local agencies, using a Regional Integrated Workstation, will work together towards managing the surface transportation network. The FSP/TMT AVL system will improve incident management activities in the region by displaying the location and status of these valuable freeway management resources to Caltrans and CHP TMC operators. Figure 2-8 depicts the architectural flows that will support regional incident management across all modes of transportation.

**Deployment Considerations**

Caltrans has commenced deployment of a significant communications and field device infrastructure including fiber optic communications, CCTV cameras, CMS, and vehicle detection stations (VDS). Through the ATMSi, information, and shared control under certain circumstances, will be made available to agencies on the regional IMTMS Network. The RAMS Integrated Workstations are being developed to support the sharing of information and control between local agencies and Caltrans District 11. If an agency wants to deploy a new system which can work with Caltrans devices (especially CCTV video, CMS signs and communications), they will need to carefully consider the standards they will use. The San Diego regional architecture will provide guidance in this regard.

Crucial standards to be considered are those that impact management center to field device communications and control as well as standards that govern the transfer of information between modal management systems, e.g. between a local agency traffic signal control system and the District 11 ATMSi. Additional information is available on the currently used standards in the supporting regional ITS architecture documentation. Agencies will need to work closely with Caltrans District 11 and the regional ITS Planning Working Group during local project conceptualization stages if they want to ensure compatibility and interoperability between the systems they are deploying and the Caltrans field device information available on the IMTMS Network.
Figure 2-7. Freeway and arterial traffic management architecture.
Figure 2-8. Incident Management/Traffic Management Data Flows
2.3.3 **REGIONAL ARTERIAL MANAGEMENT SYSTEM**

*System Description*

The San Diego region has undertaken a cooperative effort to establish a common Regional Arterial Management System (RAMS). RAMS is being deployed as a regional effort with direct involvement from the City of San Diego, Caltrans D11, and the Cities of El Cajon, Escondido, Oceanside, and Chula Vista. These agencies have been sharing information with other cities about the requirement and development progress of RAMS. Figure 2-7 (previously noted) displays the architectural relationship between RAMS, the freeway management system, and other supporting systems in the region. RAMS is comprised of two interrelated yet separate deployment efforts:

- **Tier 1 – Regional Interjurisdictional Signal Coordination** – Includes the deployment of the QuicNet 4+ software to state, county, and local city agencies to provide managed and enhanced interjurisdictional signal coordination functions. In a secured network environment, agencies will be able to view signal status, controlled time, timing/coordination information, and implement previously input regional timing plans both for their own signals and for preselected signals from neighboring agencies. The deployment of Tier 1 will greatly simplify interjurisdictional signal coordination along major corridors.

- **Tier 2 – Local Advanced Transportation Management Systems** – Provides a map based “windows” style interface as part of the Integrated Workstation (IWS). The IWS allows agencies to control/view video, message signs, vehicle sensors, and incident/special event information. Agencies can also establish shared control and viewing of field device information. The IWS serves as the local simplified version of Caltrans D11 freeway management system and allows agencies to view traffic information for arterials and freeways throughout the region. The IWS also offers intermodal information such as transit schedules, status, and arrival information. A combination of local traffic and police departments are expected to utilize the IWS in their daily operations. Transit operators will receive IWSs to provide them with traffic and road conditions information. Finally, the IWS serves as a critical communications link and shared resource between transportation agencies in the region should a major emergency event occur.

*Deployment Considerations*

Agencies which have already deployed QuicNet 4.0 for their centralized signal control system may upgrade to the RAMS Tier 1 QuicNet 4+ to provide enhanced features and interjurisdictional signal coordination with comparatively little effort. A regional license has already been obtained for any city, state, or county agency wishing to make this upgrade. In addition, agencies which are deploying Transportation Management Centers (TMC), traffic surveillance cameras, changeable message signs, vehicle detection sensors, and similar devices may make use of the RAMS Tier 2 Integrated Workstation to control these devices.

Agencies which are seeking to upgrade their centralized signal management systems or deploy local traffic management features such as cameras, speed loops, incident reporting, event management, and or changeable message signs are strongly encouraged to use the systems already being developed for RAMS to support their projects. RAMS has been developed as a cooperative effort with the regional architecture and required local functionality planned for from the early stages. The use of RAMS can result in significant savings for an agency when compared with deploying a separate system. If an agency chooses not to use the RAMS systems, they will need to define how their project will provide equivalent information on the regional IMTMS Network for use by other agencies in the region.
2.3.4 TRANSIT MANAGEMENT SYSTEMS

System Description

Transit management systems in the San Diego region will be mostly comprised of several independent management systems integrated together:

- **Regional Automatic Vehicle Location (RAVL) Transit Demonstration** – This ITS project will test several capabilities of a transit management and vehicle tracking system, as well as establish the transit interfaces for the regional IMTMS Network. The RAVL system will demonstrate the capability of providing transit vehicle status, incident, schedule, arrival time, and similar information to the IMTMS Network.

- **Regional Transit Management System (RTMS)** – The largest transit management system deployment effort in the Region, RTMS will deploy fleet management, vehicle tracking, computer aided dispatch, transit information, and related functions on all fixed route buses being operated by the San Diego and North County Transit agencies. In the future, RTMS will be expanded to include further enhanced functionality, as well as a majority of transit vehicles in the region. Similar to the RAVL demonstration, RTMS will provide transit vehicle status, schedule, schedule adherence, and emergency incident information to the regional IMTMS Network.

- **Smart Card System** – The development and deployment of the Smart Card System will simplify fare payment for transit patrons. It will speed boardings and may eventually incorporate more advanced payment options and integration with other financial services.

Additional transit management and information systems are being considered for deployment in the region, including: on-board transit information, enhanced fare payment/financial integration, and various options for transit signal priority. The intermodal integration of the transit fleet management systems, traveler information systems, and freeway/arterial management systems will allow transit agencies to get the full picture of the conditions on the roadway network in order to better manage their resources. Intermodal integration is also seen as crucial to effective event management, and improved emergency response to transit security or safety situations. **Figure 2-9** displays the basic architecture relationships and data flows between transit management systems and other systems in the region.

Currently, the plan for interfacing transit management systems to the IMTMS Network centers around providing information to a common regional transit database. This database will be integrated with the regional IMTMS Network through a translation “seed” that packages transit data into commonly defined data objects. These objects will be understandable to other modal systems on the IMTMS Network. In addition, many transit agencies will be utilizing common systems and internal systems communications will occur over the IMTMS Network.

Deployment Considerations

Agencies considering deployment of a transit management or fleet/vehicle tracking system should consider: (1) how they may make use of existing systems such as RAVL or RTMS being deployed for this purpose; and (2) what information their system will need to provide to the regional IMTMS Network. The Metropolitan Transit Development Board (MTDB) has taken the lead on the development of the RTMS. Agencies should discuss their deployment plans with MTDB to consider what interrelationships exist. As mentioned, each transit management system will need to provide information to a common regional transit database that interfaces with the IMTMS Network.
Figure 2-9. IMTMS Consolidated Transit Data Flows.
2.3.5 TRAVELER INFORMATION MANAGEMENT SYSTEM

System Description

The San Diego region, in terms of the regional ITS architecture, has made a distinction between public agency management systems and private sector traveler information systems. All of the major public agency management systems in the region will make information available to the IMTMS Network. A public/private information “portal”, known as the Advanced Traveler Information Management System (ATIMS) will be established on the IMTMS Network. This portal will be the conduit for the private sector to receive information from the IMTMS Network that is useful for traveler information purposes. Therefore, ATIMS will act as a “translator” between the Common Object Request Broker (CORBA) object based standards used on the IMTMS Network and eXtensible Markup Language (XML) which may be used by the private sector. ATIMS will also act as an additional security layer, security is already established on the IMTMS Network using SHOWCASE procedures, ensuring that any sensitive information is not released uncontrolled. Figure 2-10 displays ATIMS data flows and relationship with other regional management systems.

In addition to providing information from the IMTMS Network, ATIMS will allow value added private sector information to be returned to public agencies. The private sector data would be converted back to the CORBA object standards and made available on the IMTMS Network. Overall, ATIMS is meant to allow some IMTMS information to be provided to private sector traveler information service providers without generating the institutional, security, and configuration problems that could occur by placing private sector entities directly onto the IMTMS Network. ATIMS is not necessarily meant to be the only outlet from public agency management systems to the private sector. For example, Caltrans District 11’s ramp metering system provides freeway speed information to an openly available web page. Those agencies desiring to maintain separate interfaces from their individual systems may do so at their own discretion. However, the single interface from the IMTMS Network to the private sector will be ATIMS.

For regional systems architecture purposes, the San Diego region has determined that commercial vehicle operations (CVO) systems will be dealt with as specialized aspects of traveler information. This means that while the region will endeavor to provide traffic conditions and related information for CVO purposes, the regional architecture will not attempt to address systems dealing with CVO credentialing, enforcement, etc. The region feels that the architectural development of these systems is best left to the state and federal agencies responsible for CVO.

Deployment Considerations

The success of the ATIMS deployment will in large measure be dependent on the acceptance of this means of accessing regional data by the private sector. Current private sector efforts have moved beyond the simple provision of real-time traffic data on the Internet to more sophisticated means of dissemination including the 5-1-1 Traveler Information number and Telematics Service Providers who provide emergency services and data directly to both privately-owned and fleet vehicles. The ATIMS Server is the logical interface point for any and all of these private sector services. It is anticipated that the private sector will also employ their own data collection infrastructure, largely based on the emerging capability of tracking cellular-equipped vehicles, to obtain travel time data. The region will need to adopt strict privacy principles to protect the identities of individuals and their vehicles as these systems are deployed.
Figure 2-10. Transit Traveler Information and Basic ATIS Market Packages
2.4 Overview Of ITS Supporting Infrastructure

The San Diego region has a significant ITS infrastructure made up of communications and field devices that support the management systems outlined in Section 2.3. This infrastructure is being expanded and improved to provide data along the numerous “gaps” where the required supporting infrastructure is currently missing. The existing and planned supporting infrastructure is briefly summarized below:

- **Communications** – As noted in Section 2.3, the IMTMS Network is comprised of public (leased) and private (agency) communications resources. Early-on, the majority of the communications infrastructure between the major modal systems will be leased, and this will be replaced by agency communications as they continue to link together. Field devices are linked to their appropriate management systems most often through agency owned communications, but some field communications are leased from teleco providers. A major component of the communications resource in the region is the Caltrans fiber optic projects which are displayed in Figure 2-11 (existing and planned). Already this fiber optic network has been used to connect certain City of San Diego systems to Caltrans, and plans are underway for transit agencies to use this network to reach their different dispatch centers. Finally, this network is key to linking most of the Caltrans field devices (cameras, changeable signs, vehicle detection sensors, etc.) to the freeway management systems and IMTMS Network.

- **Vehicle Detection Stations (VDS)** – Caltrans has deployed a series of VDS on many of the major freeways in the region. This system is currently utilized primarily to provide data to the ramp metering and freeway management systems. Figure 2-12 displays the existing and planned VDS deployments in the region.

- **Traffic Surveillance Cameras (CCTV)** – Caltrans is deploying CCTV cameras along many of the major freeways in the region. This process is in its early stages. Figure 2-13 displays the existing and planned locations for CCTV cameras. The cities of San Diego, Poway, Chula Vista, and some others have or are planning to deploy CCTV cameras. These camera locations are not displayed in this architecture document.

- **Changeable Message Signs (CMS)** – Caltrans has deployed CMS at key locations throughout the region along major freeways and some highways. Figure 2-14 displays existing and planned Caltrans CMS locations. The City of San Diego has also deployed a handful of CMS in the Downtown and Qualcomm Stadium areas to support special events management.

In addition to the infrastructure being deployed by Caltrans, many agencies have significant communications and field sensor resources. From a regional perspective these resources are generally more locally focused and serve the needs of providing data to the specific modal management systems. Much of local city resources are focused on signal systems along arterials, however a handful of cities have or are deploying more advanced sensors and communications to support special events management. The transit agencies are working to deploy significant communications network in the region that links each of the major transit dispatch and administrative centers together, as well as utilizes the Caltrans fiber. Finally, the transit agencies, Freeway Service Patrol, and Caltrans Traffic Management Team are deploying vehicle tracking and mobile communications technology in support of their fleet management systems. Plans include the use of information from these vehicles for incident identification, travel probe, and related information. In short, while the San Diego region has a significant and
Figure 2-11. Existing + Programmed Caltrans Regional Fiber Optic Communications Projects.
Figure 2-12. Existing Vehicle Detection Sensor Coverage

Note: Future Coverage is Planned for All Major Freeways at ½ mile Spacing or Better

Source: Caltrans D11 Traffic Studies Branch; January 2003
Figure 2-13. Existing & Near-Term CCTV Deployment

Source: Caltrans D11 Traffic Studies Branch; January 2003

Note: Future Coverage is Planned for Most Segments of Freeways
Figure 2-14. Existing + Planned Caltrans CMS Deployment
important supporting infrastructure deployed, there are still many gaps to be filled and improvements to be made.

More detailed information on ITS supporting infrastructure can be obtained from SANDAG or the other appropriate owning agencies.
3.0 STAKEHOLDERS

The San Diego region has long had an institutional structure for dealing with ITS issues and deployment. Over time some modifications have been made to this structure to better meet the needs of the level of ITS deployment underway at any one time. Figure 3-1 displays the regional ITS institutional or governance structure. Within this structure are each of the stakeholders in this regional system architecture. Each of the components of this structure and the major stakeholders for each component are outlined below.

**Figure 3-1. San Diego region ITS institutional/governance structure**

**SANDAG Board**

The SANDAG Board of Directors is the highest level of the ITS decision making structure for the San Diego region. They are responsible for ultimate approval of projects for funding and the acceptance of regional policies that impact or relate to ITS. ITS related items are brought to the Board on a as needed basis.

**Regional Executive Management (CEO Group)**

In 2002, a regional agency executive management group was established to oversee ITS projects and to resolve interagency ITS deployment considerations. This group meets bi-monthly to quarterly depending on what issues are at hand. The group is comprised of the following people:

- SANDAG Executive Director
- MTDB General Manager
City of San Diego – Special Projects Director – representing local cities
Caltrans District 11 Director

San Diego Region ITS Planning Subcommittee

This group was originally established to develop the regional ITS deployment plan which was completed in 1997. The group has continued to play a key role in making policy and project programming suggestions and recommendations. The group represents all of the ITS stakeholders in the region including representatives from the following more active participants:

- SANDAG
- California Highway Patrol
- Caltrans District 11
- Caltrans Headquarters/New Tech.
- County of San Diego
- Cities of:
  - Carlsbad
  - Chula Vista
  - Coronado
  - Del Mar
  - Encinitas
  - El Cajon
  - Escondido
  - Imperial Beach
  - La Mesa
  - Lemon Grove
  - National City
  - Oceanside
  - Poway
  - San Diego
  - San Marcos
  - Santee
  - Vista
- Corridor Commercial Vehicle Operations Group
- Metropolitan Transit Development Board (MTDB)
- North County Transit District (NCTD)/North County Rail

In addition, representatives from FHWA, City of Tijuana, U.S. Navy, community groups, and various city fire and police departments are often present depending on the particular issues being dealt with at the time. While specific representation on the Subcommittee varies from
time to time; SANDAG, Caltrans, City of San Diego, and several other cities are almost always present.

**Project Management Working Group**

In 2002, a project management working group was formed comprised of each of the project managers for the major regional ITS projects currently in deployment. These managers meet to discuss the details of their projects in terms of how they may impact or be related to the other projects being deployed in the region. As of January 2003, this group is comprised of representatives from MTDB, SANDAG, City of San Diego, and Caltrans District 11.

**IMTMS Task Force**

The IMTMS Task Force deals with near-term deployment and configuration management issues relating to the IMTMS Network and communications between the various intermodal systems. This group is more of a technical management group than a user group and can be seen as supporting the regions ITS stakeholders.

**Working Groups**

Various working groups have been formed to support project deployment and to sort out operational considerations and issues. Taken together these groups represent a broad set of ITS stakeholders in the region.

- **Incident Management Working Group** – Deals with reviewing and proposing regional incident management policies and projects. This group meets monthly and is comprised of CHP, Caltrans, City of San Diego, various fire agencies, and other emergency response agencies.

- **Traveler Information (ATIS) Working Group** – This group provides input on regional traveler information policies and projects. The activity of the group has varied over time depending on the particular issues at hand.

- **Traffic Systems (Arterial) Working Group** – This group is responsible for developing and reviewing user needs for regional arterial management systems and operational policies. It typically meets monthly and is comprised of local city traffic engineers selected by the San Diego Traffic Engineers Council (SANTEC) to deal with represent local city ITS interests.

- **Transit Systems Working Group** – This group is comprised of Caltrans, SANDAG, MTDB, NCTD, San Diego Transit, San Trolley, and other transit agencies. The group helped to develop the concept for a common regional transit communications system, and has also provided input on what types of traffic and incident conditions information may be useful to transit operators.

- **ATMSi Working Group** – This group is predominately a Caltrans representative group focused on freeway management systems relating the Advanced Transportation Management System (ATMS).
4.0 OPERATIONAL CONCEPT

The purpose of a Concept of Operations is to help stakeholders gain a better understanding of how a proposed regional architecture will support future agency interactions. It is not important to have a detailed knowledge of the architecture’s component systems but to visualize how that architecture will operate and what roles and responsibilities are needed to support various operational scenarios. This Concept of Operations will form the basis for future inter-agency agreements (bi-lateral or multi-lateral) to operate and maintain the IMTMS regional network and it’s multi-modal elements.

4.1 Overview of Architecture Views

A regional architecture can be viewed from a number of perspectives, depending on the emphasis desired by the regional stakeholders. One way is to view the architecture from a degree of interaction perspective. This is illustrated by the Concept of Operations work done for the Southern California ITS Priority Corridor Showcase Project. A second method is to look at intermodal interactions and intramodal interactions. In this method, the coordinated operations of two or more agencies are examined using a scenario approach. The scenarios look at how different transportation modes work together (e.g. transit – public safety, freeway – transit) and also how operations within a specific mode can be improved through system upgrades (e.g. within transit, fixed route buses coordinating schedules with commuter rail services). To illustrate the scenarios, National ITS Architecture Market Package notation is used. Market Packages are a good fit for this architectural view because they encapsulate high level data flows between systems (agency centers) as well as the functional requirements needed to execute the scenarios. Obviously not every conceivable scenario can be captured, but this Section of the San Diego regional architecture covers the more common and likely categories of interaction between regional stakeholders. Each scenario is documented through a time-phased sequencing of the relevant data flows in the Market Package. Later in the architecture (Section 7), we investigate Market Packages again, but from a more inclusive view that includes and defines all the required system interfaces for the different transportation modes.

Finally, we look at the architecture from a Roles and Responsibilities perspective, in this case including operation of the regional network itself as well as operations and maintenance of the participating modal management systems. The Roles and Responsibilities view is highlighted as very important in the U.S. DOT guidance document on regional architectures. The reason is obvious: most institutional issues that pose barriers to adoption and effective use of a regional architecture center on responsibility (management, operations and funding support) for the existing and planned systems covered by the architecture.

4.1.1 SHOWCASE

In the Southern California region, the Showcase Project was an integrated set of projects and a wide area network architecture that provides intermodal transportation information and differing degrees of shared ITS device control among a variety of public sector agencies located in San Diego, Orange, Los Angeles, Ventura, Riverside and San Bernardino counties. As part of the development of a Concept of Operations for the Showcase Project, two matrices were created for Advanced Transportation Management Systems (ATMS) and Advanced Traveler Information Systems (ATIS) that summarized the differing ways these systems could interact with each other. For example, ATMS systems can be characterized by the degree of coupling (or interaction) between two or more agencies involved in some aspect of transportation operations management. ATIS systems can be characterized by the manner in which data is collected, fused (integrated) and disseminated. Even though the Showcase project is largely history, these
interaction matrices are still valid for operations within the San Diego region. These characterizations are summarized in Figure 4-1 and Figure 4-2.

**Figure 4-1 Showcase ATMS Concept of Operations**

### 4.2 Modal Interaction

The following sections describe various scenarios that are applicable to the Modal Interaction. These scenarios use the National Architecture Market Packages.

The Market Packages provide an accessible perspective to the National ITS Architecture. They are tailored to fit, separately, or in combination, real world transportation problems and needs. Market packages collect together one or more equipment packages that must work together to deliver a given transportation service and the architecture flows that connect them and other important external systems.

**Figure 4-3** displays how the Emergency Management, Transit Management, Arterial Management and Freeway Management market packages interact with each other in the six scenarios illustrated in this Section. The numbered box indicates the scenario number associated with that interaction. The arrows within the diagram indicate that each Management package has a linkage to another Management package.

The Emergency Management Market Package is further detailed in **Figure 4-4** by drilling down into the next layer of detail from the EM node of Figure 4-3. This diagram indicates the various Emergency Management Systems that interact with each other. The City FD and City PD Systems represent the local City Fire Department systems and the local City Police Departments respectively.
Figure 4-2. Showcase ATIS Concept of Operations

Figure 4-5 shows the standard Market Package Legend. In the following scenarios, only the relevant portions of the National ITS Architecture for an individual market package are shown. The scenarios include only the architecture subsystems, equipment packages, system terminators, and architecture flows that are most important to the operation of that particular scenario. The scenarios use the following market packages:

- Emergency Management
- Transit Management
- Freeway Management
- Arterial Management (Surface Streets in National ITS Architecture)
Local FD, SDSD, CHP and CDF coordinate on major brush fire evacuations and traffic control.

City PD and CHP coordinate on high-speed pursuit.
4.2.1 **Six Scenarios**

4.2.1.1 **Emergency Management – Transit Management**

This scenario, shown in Figure 4-6, uses the Emergency Management and Transit Management market packages and is based upon a Bus Panic Alarm being activated. The following steps correspond to the appropriate numbered data flow.

1. Information is shared by the Emergency Management systems. The information could include current conditions and emergencies.
2. The transit driver activates the panic alarm indicator.
3. This bus panic alarm activation is transmitted through the Transit Vehicle location determination system to the Transit Management system.
4. Acknowledgement of the alarm is sent from the Transit Management System to the Transit Vehicle On-board computer system.
4’. This step occurs only when the alarm is for a medical emergency and indicates on the transit driver display that the panic alarm has been acknowledged.
5. The Transit Vehicle location update rate is set to 10 seconds.
6. The Transit Management system transmits information to the appropriate emergency management agencies. In this example scenario, notification is sent to the SD Police Department, as well as the SD County Sheriff Department.
7. Acknowledgment of this alert and the appropriate response actions to be taken are transmitted back to the Transit Management system.
8. Information concerning the transit alarm is then disseminated to the appropriate ISP agencies.

9. Filtered transit alarm information is then disseminated directly to the media.

4.2.1.2 Emergency Management – Freeway Management

This scenario, shown in Figure 4-7, is based upon an incident occurring on the freeway. This example freeway incident has several vehicles involved as well as a fatality. The following steps, corresponding to the data flows, indicate the data that is transferred to each of the different equipment systems. Many of the steps occur simultaneously, so these steps are the same number, just indicated differently. For example, step 1 and step 1’ can occur simultaneously.

1. From a callbox and/or a 9-1-1 cell phone call, the Emergency Management system for the California Highway Patrol (CHP) is alerted to a possible incident.

1’ Also occurring is a possible incident being directly reported to an operations or maintenance radio operator within the Freeway Management System, the Caltrans ATMS.

1’. After the Emergency Management system confirms the incident, exact incident location and associated supplementary information as received from investigating officers

2. After the incident is confirmed, the Freeway Management system transmits the incident location and pertinent data to the Emergency Management systems. The Emergency Management systems in this example include the City Fire Department (FD), California Highway Patrol (CHP), and the County Medical Examiner.

2’. To assist in confirmation of the incident, the Traffic Management Team (TMT) Vehicle transmits additional incident information to the Freeway Management System.

3. The CHP CAD system receives the incident information and prepares the appropriate Paramedic, fire and Law Enforcement (LE) responses. If the accident involves one or more fatalities, the County Medical Examiner’s Office is notified. The pertinent information in the responses is transmitted back to the Freeway Management System.

4. The Freeway Management system transmits to the TMT Vehicle specific response plan actions.

5. Filtered information concerning the freeway incident and the response actions is then disseminated to the appropriate ISP agencies.
6. Filtered incident information is then disseminated directly to the media agencies.

**Figure 4-6. Emergency Management – Transit Management Scenario**

**Table 4.1 - Roles and responsibilities – Transit emergency scenario.**

<table>
<thead>
<tr>
<th>Agency</th>
<th>Role</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transit agency</td>
<td>Operate fixed route bus service</td>
<td>Notify public safety agency(s) in the event of an on-board emergency</td>
</tr>
<tr>
<td>City PD</td>
<td>Provide backup transit security in a local city’s jurisdiction</td>
<td>Respond to transit emergency within city jurisdiction</td>
</tr>
<tr>
<td>SD County SD</td>
<td>Provide backup transit security in unincorporated areas of county</td>
<td>Respond to transit emergency within unincorporated areas of county</td>
</tr>
</tbody>
</table>
Figure 4-7. Emergency Management – Freeway Management Scenario

Table 4.2 - Roles and responsibilities – freeway fatal incident scenario.

<table>
<thead>
<tr>
<th>Agency</th>
<th>Role</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caltrans</td>
<td>Operate and maintain state highway system</td>
<td>Respond to and assist with clearance of freeway incidents</td>
</tr>
<tr>
<td>CHP</td>
<td>Provide for safe operation of state highway system</td>
<td>Receive incident notification calls and respond to incident. Notify other agency responders.</td>
</tr>
<tr>
<td>County Medical Examiner</td>
<td>Conduct medical examinations and assist investigations of all unnatural deaths in County</td>
<td>Respond to accidents with fatalities. Remove bodies to County Morgue.</td>
</tr>
<tr>
<td>Local FD</td>
<td>Provide fire suppression, vehicular rescue and paramedic services</td>
<td>Respond to incident for victim extraction, fire suppression and/or medical assistance</td>
</tr>
</tbody>
</table>
4.2.1.3 Transit Management – Freeway Management

This scenario, shown in Figure 4-8, uses the Transit Management and Freeway Management Market Packages. The scenario is based upon an unplanned freeway closure that affects the route of a Transit Express bus. The following lists the steps and the data flows that are associated with the scenario.

1. The Emergency Management system for the CHP is alerted to a possible freeway closure.

1’. The Caltrans Freeway Management system (ATMS) is alerted to a possible freeway closure via CCTV sites and/or the Traffic Monitoring System (sensor inputs).

2. After the closure is confirmed, the Freeway Management system transmits the confirmed closure location and pertinent data to the Transit Management system. In this example, the Transit Management system is the Regional Transit Management System.

2’. Roadway information from the Freeway Management system is also transmitted to the Transit Management system. This information includes current congestion and incident information.

2”. The Freeway Management system transmits Closed Circuit Television (CCTV) video images to the Transit Management system. Data from steps 2, 2’ and 2” is displayed on the transit operator’s Integrated Workstation.

3. The Transit Management system receives the closure information and prepares a revised route for the Transit Express bus affected. The revised route is transmitted to the Transit Vehicle On-board computer system or via voice communications to the driver.

4. The revised route information is displayed to the transit driver.

5. The Transit Vehicle On-board computer system transmits the acknowledgement of the revised route to the Transit Management system.

6. Depending on the length of closure revised route information is then disseminated to the appropriate ISP agencies.

7. Filtered route information is then disseminated to the media agencies. This step is performed primarily for long-term reroute occurrences.
Table 4.3 - Freeway Incident Affecting Transit Operations.

<table>
<thead>
<tr>
<th>Agency</th>
<th>Role</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caltrans</td>
<td>Operate and maintain state highway system</td>
<td>Respond to and assist with clearance of freeway incidents</td>
</tr>
<tr>
<td>CHP</td>
<td>Provide for safe operation of state highway system</td>
<td>Receive incident notification calls and respond to incident. Notify other agency responders.</td>
</tr>
<tr>
<td>Fixed Route Transit Operator</td>
<td>Operate Fixed Route bus service</td>
<td>Reroute affected express buses to avoid major delays on affected routes</td>
</tr>
</tbody>
</table>

4.2.1.4 Freeway Management – Arterial Management (Intertie)

This scenario, shown in Figure 4-9, uses the Freeway, Arterial and Emergency Management Systems. This scenario is based upon the Caltrans ATMS exchanging event, congestion and field device control with local TMC’s that operate QuicNet 4 signal control systems and possess an Integrated Workstation. In this example, a freeway incident occurs, shutting down main
lanes and causing motorists to divert to regionally significant arterial(s). The diversion is not mandated or suggested by Caltrans. The following steps correspond to the appropriate numbered data flows.

1. The Emergency Management system (CHP) receives a cellular 9-1-1 call concerning a roll-over accident with life-threatening injuries. Basic incident data is passed to the Caltrans ATMS
2. The Caltrans ATMS passes TMT response and if available, CCTV video to the CHP CAD system
3. CHP CAD system updates ATMS with traffic officer and supporting agency response data
4. Caltrans ATMS passes updated incident data, CCTV video and traffic congestion data to the City Integrated Workstations located at the City TMC and City 9-1-1 center
5. Caltrans ATMS activates nearby cameras for scene and approach surveillance and CMS signs suggested by the event response plan; a regional traffic signal response plan number is transmitted to the City TMC
6. The City TMC affected by the freeway closure activates local CMS signs and HAR(s) as appropriate and verifies receipt of regional traffic control plan number; City TMC decides to activate the pre-agreed regional traffic control plan on its QuicNet 4 system. After hours, Caltrans may have the authority to use City CMS signs or CCTV as needed and as regionally agreed.
7. The City 9-1-1 center transmits its unit response information as appropriate
8. The ISP receives automatic event initiation data and event updates as occurring; the ISP may also get CCTV video.
9. The media receives evaluated and filtered event information
Table 4.4 - Freeway Incident Affecting Arterial Operations.

<table>
<thead>
<tr>
<th>Agency</th>
<th>Role</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caltrans</td>
<td>Operate and maintain state highway system</td>
<td>Respond to and assist with clearance of freeway incidents</td>
</tr>
<tr>
<td>CHP</td>
<td>Provide for safe operation of state highway system</td>
<td>Receive incident notification calls and respond to incident. Notify other agency responders.</td>
</tr>
<tr>
<td>City Traffic Engineer</td>
<td>Operate and maintain city traffic control systems</td>
<td>Monitor traffic conditions and adjust signal control systems as needed</td>
</tr>
<tr>
<td>City PD (or 9-1-1)</td>
<td>Provide local law enforcement and traffic control</td>
<td>Close city streets and on/off ramps affected by the incident; assist in arterial traffic control as needed</td>
</tr>
</tbody>
</table>

**4.2.1.5 Emergency Management – Emergency Management (High-Speed Pursuit)**

This scenario, shown in Figure 4-10, is based upon a high-speed pursuit initiating with a local Police Department who requests CHP assistance when the pursuit reaches the freeway. The following steps, corresponding to the data flows, indicate the data that is transferred to each of the different equipment systems.

1. The Emergency Vehicle transmits to the Emergency Management system for the CHP of a suspected alert.
2. The Emergency Management system sends an acknowledgment of the alert to the Emergency Vehicle On-board computer system.

3. The CHP Emergency Management system transmits information concerning the pursuit to the Local City Police Department Emergency Management system, as well as to the Caltrans Freeway Management system.

4. The Emergency Management system for the local City PD generates an appropriate Law Enforcement (LE) response and transmits it to the CHP Emergency Management system.

4’. Transmission of available Freeway Management CCTV video images to the CHP Emergency Management system is also occurring.

4”. The Freeway Management system is also transmitting Roadway information to the CHP Emergency Management system. This roadway information includes current incidents and congestion information.

5. Emergency incident information is disseminated to the appropriate ISP agencies.

6. Filtered emergency incident information is then disseminated to the media agencies.

4.2.1.6 Emergency Management – Emergency Management (Major Brush Fire)
This scenario, shown in Figure 4-11 uses the Emergency Management Market Packages. The scenario is based upon a major brush fire. The following lists the steps and the data flows that are associated with the scenario.

1. The Public calls 9-1-1 to report a brush fire. The PSAP notifies the cognizant Fire Department and alerts CDF.

2. The cognizant Fire Department responds and after initial evaluation, notifies the California Division of Forestry and Fire Protection (CDF) and requests traffic control from SD County Sheriff and CHP.

3. The responding FD activates Automatic Mutual Aid. SD County Sheriff and CHP generate appropriate responses and transmit that information to the CDF Fire Emergency Management system.

4. The Freeway Management system is also transmitting available CCTV video images to the Emergency Management systems for CDF Fire, responding FD, SDSD and CHP.

4’. Roadway information is transmitted from the Freeway Management system to the Emergency Management systems.

5. Information concerning the fire-related traffic impacts is disseminated to the appropriate ISP.

6. Filtered information is disseminated directly to the media agencies.
Figure 4-10 High Speed Pursuit (Emergency Management)

Table 4-5. High Speed Pursuit.

<table>
<thead>
<tr>
<th>Agency</th>
<th>Role</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caltrans</td>
<td>Operate and maintain state highway system</td>
<td>Provide timely notification of related traffic congestion and CCTV surveillance as requested</td>
</tr>
<tr>
<td>CHP</td>
<td>Provide for safe operation of state highway system</td>
<td>Primary pursuit command when pursuit is on freeways</td>
</tr>
<tr>
<td>City PD (or 9-1-1)</td>
<td>Provide local law enforcement and traffic control</td>
<td>Primary pursuit command when pursuit is on city streets</td>
</tr>
</tbody>
</table>
Figure 4-11  Major Brush Fire Scenario (Emergency Management)
### Table 4-6. Major Brush Fire.

<table>
<thead>
<tr>
<th>Agency</th>
<th>Role</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caltrans</td>
<td>Operate and maintain state highway system</td>
<td>Respond and assist with TMT vehicles, portable CMS signs and appropriate CMS activation</td>
</tr>
<tr>
<td>CHP</td>
<td>Provide for safe operation of state highway system</td>
<td>Freeway and state highway traffic control as requested by CDF</td>
</tr>
<tr>
<td>CDF &amp; FP</td>
<td>Provide fire suppression and command and coordination of county fire resources</td>
<td>Overall incident command of fire operations</td>
</tr>
<tr>
<td>Local FD</td>
<td>Provide fire suppression and EMS/Rescue services in local jurisdictions or fire districts</td>
<td>Provide mutual aid as directed by CDF</td>
</tr>
<tr>
<td>SD Co. SD</td>
<td>Provide law enforcement and traffic control in unincorporated county areas and certain cities under contract</td>
<td>County road and city street traffic control, evacuation support and animal rescue services as required</td>
</tr>
</tbody>
</table>

### 4.3 Operations and Maintenance Roles and Responsibilities

In addition to the specific roles and responsibilities that agencies are called upon to assume as part of their individual mandates, being partners in the IMTMS Regional Network presents some additional ongoing requirements. This section focuses on agency roles and responsibilities as they relate specifically to participation in the IMTMS Regional Network.

#### 4.3.1 Regional Network

The following highlights how participating agencies “fit” into the IMTMS Regional Network:

- Participation in the Regional Network is voluntary, but can be tied to funding, support or ‘re-use’ opportunities.
- Agencies that are interested in developing Regional Network interfaces may obtain the standard interface definitions from the Configuration Management repository.
- Agencies may request changes to the interface definitions or architecture components by completing the System Change Proposal and participating in the Configuration Control Board meetings.
- Agencies may elect to provide information such as source code, interagency agreements, documents, etc., to be shared by others but not controlled by the regional CM process.
- Participating agencies receive notification of all proposed and approved changes, new version releases of standards, and information regarding meetings.

#### 4.3.2 Local (Legacy) Systems

For the IMTMS network to offer the most benefits to all participating agencies, it is desirable that agencies ensure the integrity of their individual systems and be willing participants in inter-agency discussion, where needed.

For each agency providing data to the IMTMS network, it is desirable that a strong commitment be made towards operations and maintenance considerations. It is desirable that each participating agency:

- Place an emphasis on keeping the agency’s base system operational so that data can be continuously provided;
• Provide data that is timely, accurate and complete;
• Maintain the devices or other sources that provide data to the owning agency;
• Establish and maintain a security system for the agency’s system to isolate and protect their own application from the IMTMS network. This could include the use of firewalls to protect the agency’s environment.
• Determine which partners are granted access to the agency’s data and define what data would be available to each.

In addition to maintaining the integrity of their individual systems, it is the vision that each agency would be willing to actively participate in discussions with other agencies, where needed. Typical interagency discussions include:

• **Configuration Management Activities:** Agencies are encouraged to work with the established IMTMS Change Management Team that is responsible for conducting change management.

• **Interagency Agreements:** Agencies are encouraged to participate in the establishment of interagency agreements that could define parameters such as how agencies may use each other’s data, if agencies may control each other’s field devices, if agencies are permitted to disseminate shared data; how agencies might coordinate event management activities, etc.
5.0 OPERATIONAL AGREEMENTS

The San Diego Region System Architecture Detailed Document includes background and information on the existing types of ITS agreements in place, as well as what types of agreements should be considered by agencies during the development of their systems. Deployment of core ITS capabilities in the San Diego region has been focused around a handful of regional deployment efforts discussed in Section 2.0 of the architecture. The advantage of this focus is that once the initial agreements have been made between the early participants, it becomes easier for additional agencies to join and make the agreements necessary for their participation.

5.1 Overview of Intermodal Policy Objectives

It is important to note that operational policies and agreements are largely affected by three factors:

- The complexity of the data or functionality being shared between agencies, as well as the associated complexity of the systems they are using.
- The level of criticality of the operation of the system (i.e., is it a mission critical system central to the daily operations of the agency?).
- The standard operating procedures and/or administrative “level of comfort” desired by the agency.

Overall the policy the “intermodal” policy objectives of the IMTMS are as follows:

- To allow for the widespread sharing of information related to the management of the region’s transportation resources and network.
- To allow agencies responsible for transportation management to share the functionality of their individual management system tools where such shared functionality would result in improved information or efficiency for one or more agencies.
- To establish the necessary “level of comfort” for agency transportation managers in terms of their ability to safely share and reliably receive important transportation network information from other agencies without creating an onerous requirement for detailed operational agreements or limiting operational flexibility.
- To define responsibilities for operations and maintenance costs for shared systems components, especially communications.

The goal is to reach an operational understanding and confirm appropriate policies at the minimum level necessary to achieve these goals. Generally, the stated desire of the transportation managers in the region has been to avoid clauses or statements in policies that go so far as to shift liability or operational responsibility away from the primary responsible or “owning” agency. Finally, policies and operational agreements for IMTMS should focus first on typical conditions without trying to make allowance for every possible contingency.

5.2 Basic Reasons for ITS Agreements

Each region, agency, and even department within some agencies will have a different approach to the details of deployment and operations agreements. However, agreements generally revolve around one or more of four basic concepts:

- **Shared Deployment** – Where agencies/parties are seeking to deploy a common system or group of systems that they will both utilize.
• **Shared Operations** – Where agencies/parties are defining integrated or cooperative approaches to operations and the use of systems.

• **Shared Maintenance &/or Funding** – Where agencies/parties identify maintenance responsibilities for a system in terms of both funding and internal resources.

• **Common Standards and Guidelines** – Where parties agree to utilize the same standards or approaches in their deployment of systems to simplify integration efforts and promote economies of scale.

### 5.3 Current Examples of ITS Agreements in the Region

Currently very few formal operational or maintenance agreements are in place for ITS projects in the San Diego region. Two notable examples of agreements already in place are:

• **Mission Valley Event Traffic Management & Operations Procedure (ETMOP)** – Somewhat different than a formal interagency “agreement,” ETMOP is an operational procedures document that outlines event based actions and responsibilities for different agencies and parties involved with event management at Qualcomm Stadium. The focus of the ETMOP is on the types of actions that should be taken and which party should undertake them given different situations. In addition, it allows for the shared use of some field devices (CCTV cameras and changeable message signs) between the City of San Diego and Caltrans D11. The shared use of these devices is managed and controlled with the ITS project tools being deployed. Whether or not the City and Caltrans will seek a more formal agreement is unknown at this time. A more formal agreement may not be necessary as the City and Caltrans will continue to be responsible for their own equipment and all of the operating stakeholders have agreed to follow the ETMOP procedures which already fit within their current agency operating guidelines.

• **College, Federal, Broadway Traffic Signal Interconnect Memorandum of Understanding (MOU)** – This was a multi-agency MOU or agreement entered into by Caltrans and the cities of La Mesa, Lemon Grove, and San Diego. Effectively, the agreement outlined responsibilities in terms of deployment, maintenance, and operations for an interconnected traffic control system on three roadways. The MOU has been implemented, but the gestation period was very lengthy mostly due to differing interpretations of legal council from the various agencies involved. A desired change by one agency would cause a new round of review for all of the other agencies. In the end, problems in completing the agreement did not focus on technical issues as much as on legal wording and liability concerns. It is likely that many of these concerns were overblown given the project being deployed.

Caltrans D11 is currently undertaking an effort to define guidelines for dealing with outside agency use of the regional communications resources managed by the District. In several cases, the fiber optic communications resources that have been deployed by Caltrans along portions of the freeway network are planned to act as a communications backbone for other agencies. Other agencies, such as local cities and transit agencies, want to make use of this regional communications resource to both communicate with other agencies and to reach other departments and geographic areas within their own jurisdiction. Caltrans D11 is working towards establishing common procedures and templates for agreements for agencies that wish to make use of the fiber optic network. The initial coordination efforts include:

• **City of San Diego Mission Valley ATMIS project communications** – The City of San Diego is working with Caltrans D11 to establish communications between the Qualcomm Stadium Event Management Center and the regional TMC. This will allow the sharing of data, video, and CMS information and control between the City of San Diego and the District consistent with the guidelines outlined in the ETMOP agreement.
- Metropolitan Transit Development Board (MTDB) communications between the Imperial Avenue and the Kearny Mesa bus yards - MTDB is working with Caltrans D11 to utilize Caltrans fiber optics for communications between two of their bus yards. In addition, communications plans being developed by the transit agencies in the region include the use of near- and long-term Caltrans fiber optic communications to support regional transit communications needs.

### 5.4 General Types of ITS Agreements

As discussed previously, agreements can be necessary for a number of reasons ranging from defining operational procedures to outlining shared funds from multiple agencies for a common system. It is not possible at this point to define the specific agreements that would be required for each ITS project that is being planned and deployed in the San Diego region. Instead this architecture identifies several types of agreements that agencies may want to consider and notes which types may be most applicable to the major ITS program areas. These categories are shown in Figure 5-1 along with the relative time and complexity of achieving each level of agreement. The categories include:

- **Operational Prerogative** – Many systems, or portions of systems, may not require any formal agreement. Each agency already has a defined set of operating guidelines and clearly defined responsibilities. Many ITS projects are focused on simplifying or increasing the reliability of shared information and functionality between agencies that already have responsibilities for sharing information and functionality with others. For example, a traffic agency may already have responsibility for reporting major incidents to impacted local jurisdictions and emergency services. If a system simply automates or increases the effectiveness of this exchange, then a formal agreement may not be required and the operation of the system is well within each agency's own prerogative. This of course assumes that the system does not require any agreements for shared funding of communications or maintenance. Operational prerogative can be supported internally by agencies or between agencies if they cooperatively create and adopt guidelines for operations of the system. This establishes a common ground at a technical and operational level without need for higher level formalized agreements. Operational prerogative requires the least amount of time in terms of the defined “agreement categories” in this architecture.

**Figure 5-1. Categories of Agreements by Complexity and Time to Acceptance**
• **Bilateral Letter of Agreement** – Somewhat more complex and time consuming than operational prerogative, a bilateral letter of agreement can be established between two agencies where more defined operational, funding or maintenance responsibilities are required. This type of agreement should remain very simple and focused only on those concepts requiring formal agreement, and some legal review is likely to be required along with signatures from agency managers. Several agencies can use multiple bilateral agreements to establish the necessary institutional foundation for a broader system or ITS project. For example, an advanced signal timing project involving one major and two minor partners may make use of two bilateral letters of agreement (one from each minor to the major partner). This avoids the “merry-go-round” review that can occur when minor yet separate changes are requested by the different agencies involved.

• **Multi-Agency Letter of Agreement** – Significantly more time consuming and somewhat more complex than bilateral agreements, multi-agency agreements involve more than two agencies where there are one or more major partners in the agreement. Legal review will be necessary and often the signature of agency executive officers or a board of directors will be required. Multi-agency agreements may be appropriate where significant liability or the need for significant shared financial responsibility is an issue.

• **Regional Consensus/Policy** – Many of the necessary ITS agreements can be established as a matter of regional policy or consensus. For example, the region could determine to fund the development or operation of an ITS project involving multiple agencies. This in effective eliminates some of the requirements that would otherwise be required between the individual agencies to support this ITS project. An example of this level of agreement would be an action by the SANDAG to the common communications elements linking two agencies. On another level, a region can adopt a series of common standards either through a political body or a technical group which would become a matter of regional consensus or policy as ITS projects are deployed. An example situation could be where the San Diego Traffic Engineers Council (SANTEC) adopts some common standards which could be utilized by all local cities. Reaching regional consensus or establishing regional policy is often time consuming and complex, but it can be dealt with within the established institutional structure in the San Diego region.

• **Regional Memorandum of Understanding** – The ultimate level of agreement that has been discussed in the San Diego region during ITS deployment efforts is a regional MOU. This MOU would be adopted by each of the ITS stakeholders in the region in support of ITS deployment or in support of large-scale regional deployment and operations efforts. Achieving a regional MOU should be seen as a longer term goal as additional ITS projects come on-line, as this level of MOU would be very time consuming and difficult to achieve even at a relatively broad level.

5.5 **Examples of Regional Versus Local Responsibilities**

Most of the larger ITS projects involve several agencies across the region each with potentially different levels of participation and responsibility. The goal of most of the projects focuses on enhancing the efficiency and functional capabilities of the various transportation management agencies rather than increasing their responsibilities in terms of operational demands. However, the development of systems means that some agency or group of agencies must take responsibility for maintaining the system. Because of this it is important to distinguish between:

• **Regional responsibilities** – These generally occur where two or more agencies interact, and may include communications between systems as well as the systems themselves in some situations. Some form of agreement, regional consensus, or policy is generally required for all areas involving regional responsibilities.
• **Local responsibilities** – These occur where an agency is the “owning” agency of certain system components and is the primary user of those components. Examples could include ITS equipment in the field such as CCTV cameras, Highway Advisory Radio (HAR), Changeable Message Signs (CMS), etc. The fact that a system or a device lies within local responsibilities does not necessarily preclude the need for involving other agencies in helping to pay for deployment or maintenance costs, but it does make the need for formal agreements as discussed in this architecture less likely.

**Figure 5-2** displays some suggested divisions of regional and local responsibilities within the San Diego region for some of the major systems being deployed.

**Figure 5-2. Examples of Divisions Between Regional and Local Responsibilities**

**Figure 5-3** displays a matrix of the majority of transportation responsible agencies within the San Diego region, indicating what information and functionality is likely to be shared between the agencies and what regional ITS project would be the primary resource for the exchange of information and functionality. The matrix is an attempt to estimate what may occur as deployment of the regional ITS projects is accomplished throughout the region, but it is not necessarily comprehensive.

As part of complying with the regional architecture, all local agencies developing an ITS system that integrates with the regional IMTMS Network and/or has an intertie or “seed” to interface with the network, must be prepared to take the following actions:

- Provide any Interface Definition Language (IDL), eXtensible Markup Language (XML), or object definitions they develop for their system to other agencies on the IMTMS Network for purposes of use and development. These components are key to the regional integration effort, and as
agencies integrate their systems to the regional network, other agencies in the region should be able to utilize these components without additional costs.

- Develop contracts that ensure agencies retain rights for development and use purposes, as well as providing the above mentioned components to other agencies on the IMTMS Network.
- Provide upgrades or updates to regional intertie components to agencies on the IMTMS Network as they occur.
- Work with the regional configuration management group (contact SANDAG for further information) on their regional integration efforts.

These actions should not require formal agreements in that they are part of each agencies ITS system development effort, and part of regional configuration management efforts.

5.6 Recommendations for Operations Policies Approaches

- **Advanced Transportation Management System – Intermodal (ATMSi)** – One of the primary purposes of developing ATMSi is to allow the exchange of information and functionality with other agencies in the San Diego region. While data on ATMSi will be shared with many systems, functionality of the Caltrans field devices controlled by ATMSi at this time will only be shared with external agencies using some version of the IWS.
  
  o **Incident data** – Incident data from ATMSi should generally be free of non-transportation related sensitive data, so policies should allow for the sharing of all ATMSi incident data through the regional IMTMS Network and the IWS.
  
  o **Changeable Message Signs (CMS)** – CMS represent a somewhat special case. Coordination between Caltrans D11 and the City of San Diego has lead to shared control of CMS signs relevant to special events management near Qualcomm Stadium. The prerequisite is that the ability to share control of the signs is limited to a predetermine package of potential messages agreed to by both agencies. Across the broader region, it would probably be advisable to follow a similar pattern as shared use of CMS tends to revolve around special events. Caltrans should develop a standard set of messages that they feel comfortable with under shared control situations.
  
  o **Video/CCTV** – The goal for video/CCTV data and control from ATMSi should be shared viewing and control for all ATMSi camera locations through IWS. However, video feeds for traveler information should be dealt with separately and with greater restrictions.
  
  o **Vehicle Location Information** – At this time, the need for shared viewing of incident response vehicles through ATMSi seems limited. Should this information be desired by other systems, it could be more easily obtained from RAVL.

Overall, the recommendations for approach operational policies and agreements for ATMSi is as follows:

- Caltrans D11 should develop a standard agreement (most likely a bi-lateral letter of agreement) template for sharing information with agencies operating IWS.
- Caltrans D11, as the operating agency of ATMS, should manage and coordinate any policy agreements relating to ATMSi.
- Operational procedures (falling within the operational prerogative of each agency) should be developed as a cooperative effort between Caltrans and partner agencies where major special events management is a concern.
**FIGURE 5.3. INTERAGENCY TRANSPORTATION OPERATIONAL & DATA SHARING AGREEMENTS MATRIX (TRAFFIC & INCIDENT DATA)**

| Agency | California Highway Patrol | Caltrans HQ | Caltrans, District 11 | Carlsbad, City of | Chula Vista, City of | Del Mar, City of | Encinitas, City of | Imperial Beach, City of | La Mesa, City of | MTS (MTDB, SDTC, SDTI, etc.) | National City | National City | Port of San Diego | San Diego, City of | San Marcos, City of | Solana Beach, City of | Vista, City of |
|--------|---------------------------|-------------|----------------------|------------------|-------------------|-----------------|-----------------|----------------------|-----------------|------------------------|---------------|---------------|----------------|----------------|----------------|-----------------|----------------|--------|
|        |                           |             |                      |                  |                   |                 |                 |                      |                 |                        |               |               |               |               |                 |                 |         |        |
| **Primary ITS Systems which Agreements Relate To:** |                           |             |                      |                  |                   |                 |                 |                      |                 |                        |               |               |               |               |                 |                 |         |        |
| CCTV   | Traffic management video images. | CCTV, IR     | Incident A/I event information. | RAMS (IWS Only) | Regional Arterial Management System (RAMS - Includes Tier 1 & 2) - Cities, County, & Caltrans | Regional Changeable Message Sign (CMS) status & messages | RAMS (IWS) | Regional Changeable Message Sign (CMS) status & messages | RAMS | Regional Automatic Vehicle Location (AVL) System - Freeway Service Patrol & Traffic Management Team | Advanced Traffic management video images. | Advanced Traffic management video images. | RAMS | RAMS (IWS Only) | RAMS (IWS) | RAMS | RAMS | RAMS | RAMS |
| IR     | RAMS (IWS Only) | CCTV, IR     | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) |
| CMS    | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) |
| Sиг.   | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) | RAMS (IWS Only) |

**Note:** Bold Letters Indicate that Shared Control MAY Be Part of the Interagency Agreement. Specifics of Shared Control Situations are Discussed Separately from this Table.

2/3/03 DRAFT Agreements.xls
• **Regional Arterial Management System (RAMS)** – The RAMS project consists of two basic tiers which should be thought of separately.
  
  o **Tier 1 – Interjurisdictional Signal Coordination** – The Traffic Systems Subgroup has indicated a preference for operating within the operational prerogative of each agency. This is consistent with the concept of “regional timing plans” that would be jointly developed by all involved agencies with the owning agency maintaining ultimate control of signal operations in all situations. Where some form of agreement is thought necessary, the preference is for a bi-lateral letter of agreement specific to the corridor and agencies concerned. Where three agencies are involved, one larger and two smaller, experience has indicated that it is more expedient to use two separate bi-lateral letters of agreement through the larger agency to establish the necessary operational policies. It is important for matters of continuity in the face of sometimes frequent agency staff turnover that all agreements (even those within operational prerogative) be documented in some fashion. In the case of operational prerogative, this documentation serves a historical purpose rather than a binding one.

  o **Tier 2 – Integrated Workstation (IWS) Local ATMS Functions** – Perhaps the most appropriate approach for operational agreements involving the IWS, is for all agencies operating the IWS to utilize a standard bilateral letter of agreement regarding with Caltrans D11 allowing the use of data and device functionality on the regional IMTMS Network, with ATMSi, and with other agencies on the IWS. Ultimate control would always be maintained by the owning agency. This presumes no performance requirements on the part of participating agencies which could require more complex operational agreements. Sensitive devices which could result in interagency operational disagreements could be left out of the IWS pool. Security features could control access in a good faith operation to limit functionality to those agencies that are likely to require it. Sharing of data should not be limited. General operational guidelines should be developed for the IWS that each agency can internally adopt through their own review and institutional processes. Any violation of an agencies guidelines by its employees could be dealt with internally. This is somewhat similar to how other regions have chosen to operate such as Atlanta and Georgia DOT.

• **Regional Automatic Vehicle Location System (RAVL) & Regional Transit Management System (RTMS)** – RAVL and RTMS collectively encompass all of the currently envisioned major transit and fleet management systems. Both systems have already adopted a common approach for dealing with integration to the IMTMS Network. This simplifies operational concerns. RTMS is the much larger system and combines most operations for MTDB and NCTD allowing most agreements to become unnecessary or internal only issues. There are two aspects that are already understood from the technical side that should also be understood from the operational perspective.

  o **Emergency Situations** – Data (location, status, etc.) of vehicle activating an emergency alarm will send this information to the RAMS IWS. This will allow for other transportation agencies and emergency and law enforcement services to receive this information and will aide in response. However, any formal emergency response agreements should be dealt with separately between the appropriate transit agency and emergency service. This situation can exist within the operational prerogative of the agencies (excepting any other agreements).

  o **Other Transit Information** – Both RTMS and RAVL will provide transit schedule, schedule adherence, and related transit information to the IMTMS Network, as well as
possibly regional performance monitoring systems. This should not require formal agreements assuming that the networking and communications issues are covered.

- **Advanced Transportation Information Management System (ATIMS)** – Provision of information by any system to ATIMS should be simply a part of any agreement of providing information to systems on the IMTMS Network.
  - **Planning Data** – Provision of planning data is already part of adopted standard practice and a matter of policy in the 2030 Mobility RTP, and no formal agreements should be required for provision of this data. Video feeds are a separate matter and should be handled on a case by case basis and limited to a pre-selected series of cameras and/or locations.
  - **Traveler Information User Data** – Provision of data from ATIMS to any private sector entity should be controlled by a separate and formal bi-lateral or multi-party letter of agreement between the owning agency or agencies and the private entity. This agreement should define what data will and will not be provided and should not “promise” data reliability unless the responsible agencies directly participate in the agreement.

- **Regional IMTMS Network** – The regional IMTMS Network is effectively two separate systems for purposes of operational agreements:
  - **Communications** – The communications that comprise the IMTMS Network are a mixture of leased and private (public agency owned) communications resources, including the Caltrans D11 fiber being deployed along the freeway system. Currently development and funding of the communications system has been a matter of regional consensus and policy. It is hoped this approach will continue. Specific agreements for participation in the IMTMS Network should utilize bi-lateral letters of agreement (if required) with either Caltrans (in the case of the Caltrans fiber network) or SANDAG (in the case of leased services) being responsible for coordinating and possibly participating in the agreements.
  - **Network Configuration** – Network configuration is a matter for standards development, and should be adopted as a regional consensus and matter of policy by all agencies developing ITS systems in the region. Formal recognition of standards can be conducted through the SANDAG Board of Directors, and day-to-day configuration activities would be currently controlled by the IMTMS Task Force until such time that a different configuration management group is identified.
6.0 FUNCTIONAL REQUIREMENTS

High-level Functional Requirements for the San Diego Regional Architecture are derived from the National ITS Architecture and its artifacts of Equipment Packages, the building blocks of the Physical Architecture subsystems. These subsystems are shown generically in Figure 6-1. Section 7 provides graphical representations of the San Diego Region physical architecture subsystems. Equipment Packages group like processes (or functions) of a particular subsystem together into an “implementable” package of hardware and/or software. For purposes of the San Diego Region architecture development, Equipment Packages will be considered equivalent to high-level functions. Since Equipment Packages represent the functionality needed to implement Market Packages (and are shown in Market Packages), they provide a link between the interface-oriented physical architecture definition and the deployment-oriented Market Packages.

Figure 6-1: Overview of Physical Architecture Subsystems

Tailored Market Packages showing high-level data flows to support regional project development are also shown in Section 7 of this Architecture. In the following paragraphs, each Subsystem from the National ITS Architecture that will be implemented within the scope of the San Diego Regional ITS Strategic Deployment Plan is briefly described, followed by a listing of high-level functions that already exist or are most likely to be implemented. Projects that will implement new functions are listed for cross-referencing. Functional additions or changes are bracketed and italicized in the Functional Description field – if no corresponding project designation is listed, these sub-functions are not planned for near-term implementation.

6.1 Emergency Management Subsystem

The San Diego Emergency Management Subsystem is distributed among various public safety communications centers operated by the CHP Border Division (referred to as Border Communications...
Center, or BOCC), San Diego County Sheriff Department Communications Center, various City Communications Centers, Regional Fire Communications Authorities (North County Fire and Heartland), the California Division of Forestry and Fire Protection who acts as the San Diego County Fire Coordinator, and the U.S. Navy's Federal Fire Department. This subsystem will interface with other Emergency Management Subsystems to support coordinated emergency response involving multiple agencies. This subsystem will track emergency response vehicle status to facilitate coordinated response. The subsystem will track and manage emergency vehicle fleets using automated vehicle location technology (selected agencies and units only) and two-way radio communications with the vehicle fleet (all agencies). Real-time traffic information received from traffic management subsystems will be used to further assist the emergency dispatcher in selecting the emergency vehicle(s) and routes that will provide the timeliest response. Interface with the Traffic Management Subsystem will allows strategic coordination in tailoring traffic control to support en-route emergency vehicles and to keep unnecessary traffic away from areas affected by the incident. Interface with the Transit Management Subsystem will allow coordinated use of transit vehicles to facilitate response to major emergencies and timely notification of transit-related incidents requiring emergency management response. Table 6.1 lists the functions for Emergency Management.

<table>
<thead>
<tr>
<th>Function</th>
<th>Functional Description</th>
<th>Project X-Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergency Call Taking</td>
<td>This Function supports the emergency call-taker, collecting available information about the caller and the reported emergency, and forwarding this information to other functions that formulate and manage the emergency response. This function receives wireline and wireless 9-1-1, 7-digit local access, and motorist call-box calls and interfaces to other agencies to assist in the verification and assessment of the emergency and to forward the emergency information to the appropriate response agency.</td>
<td>Existing in public safety communications centers</td>
</tr>
<tr>
<td>Emergency Data Collection</td>
<td>This function collects and stores emergency information (e.g. CAD incident records) that is collected in the course of operations by the Emergency Management Subsystem. This data can be used directly by operations personnel [or made available to other data users and archives in the region].</td>
<td>Partially existing in public safety communications centers</td>
</tr>
<tr>
<td>Emergency Dispatch</td>
<td>This Function supports efficient dispatch of emergency vehicles. It tracks emergency vehicles, dispatches these vehicles to an incident, [and provides safe and efficient routes based on real-time traffic information].</td>
<td>Partially existing in public safety communications centers</td>
</tr>
<tr>
<td>Emergency Response Coordination</td>
<td>[This Function develops and stores emergency response plans and manages overall coordinated response to emergencies. It tracks the availability of resources and assists in the appropriate allocation of these resources for a particular emergency response. This Function provides coordination between multiple allied agencies before and during emergencies to implement emergency response plans and track progress through the incident. It provides vital communications linkages that provide real-time information to emergency response personnel in the field. This function is often implemented in Emergency Operations Centers].</td>
<td>Partially implemented in InterCAD project (cancelled in June 2002).</td>
</tr>
<tr>
<td>Incident Coordination</td>
<td>This function provides traffic-related information from freeway and arterial TMC’s to the transit dispatcher and other transit positions. Information includes congestion data, event data, CMS sign messages displayed, CCTV video and camera control. This function also handles the passing of selected RAVL RTMS RAMS Tier 2</td>
<td></td>
</tr>
</tbody>
</table>
### Table 6.1: Emergency Management Functional Descriptions

<table>
<thead>
<tr>
<th>Function</th>
<th>Functional Description</th>
<th>Project X-Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>transit incident and bus status data to public safety agencies in real-time for coordinating incident response (hi-jacking, crime in progress, medical emergency, etc.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mayday Support</td>
<td>This Function receives Mayday messages, determines an appropriate response, and either uses internal resources or contacts an “allied” agency to provide that response. The nature of the emergency is determined based on the information in the mayday message as well as other inputs. This package effectively serves as an interface between Telematics Service Providers (TSP’s) and the local public safety answering point for messages that require a public safety response.</td>
<td>Exists, or will exist in selected public safety agencies. Not supported by IMTMS.</td>
</tr>
</tbody>
</table>

### 6.2 Emergency Vehicle Subsystem

This subsystem resides in emergency vehicles operated within the San Diego County region and provides the sensory, processing, storage, and communications functions necessary to support safe and efficient emergency response. Emergency vehicles are taken to mean CHP units, Sheriff and City PD patrol vehicles, fire apparatus and EMS vehicles. FSP and Traffic Management Team vehicles are not considered to be part of the Emergency Vehicle Subsystem. The Emergency Vehicle Subsystem includes two-way communications to appropriate communications centers and other emergency vehicles. The primary means to support these communications in San Diego is the Regional Communications System (RCS). Some emergency vehicles (generally fire and EMS) are equipped with automated vehicle location capability for monitoring by vehicle tracking and fleet management functions in the Emergency Management Subsystem. Using these capabilities, the appropriate emergency vehicle to respond to each emergency is determined. Route guidance capabilities within the vehicle (GPS-based displays) enable safe and efficient routing to the emergency. In addition, the emergency vehicle may be equipped to support signal preemption through communications with the roadside subsystem. **Table 6.2** lists the functions for the Emergency Vehicle subsystem.

### Table 6.2: Emergency Vehicle Functional Descriptions

<table>
<thead>
<tr>
<th>Function</th>
<th>Functional Description</th>
<th>Project X-Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-Board EV Enroute Support</td>
<td>This Function provides capabilities that support safe and expedient arrival on the incident scene. This package provides dispatch and routing information, tracks the vehicle, [and preempts signals via short-range communication directly with traffic signal control equipment at the roadside].</td>
<td>P/S agencies implement varying levels of this function</td>
</tr>
<tr>
<td>On-Board EV Incident Management Communications</td>
<td>This Function provides a direct interface between the emergency vehicle and incident management personnel.</td>
<td>Implemented by agencies that use Mobile Computer Terminals</td>
</tr>
</tbody>
</table>

### 6.3 Traffic Management Subsystem

The Traffic Management Subsystem operates within a Caltrans or local agency traffic management center or other fixed location. This subsystem communicates with the Roadway Subsystem to monitor and manage traffic flow. Incidents are detected and verified and incident information is provided to the Emergency Management Subsystem, travelers (through Roadway Subsystem Highway Advisory Radio
and Dynamic Message Signs), and to third party information service providers. The subsystem supports HOV lane management and coordination, road pricing, and other demand management policies that can alleviate congestion and influence mode selection. The subsystem monitors and manages maintenance work and disseminates maintenance work schedules and road closures. The subsystem also manages reversible lane facilities, and processes probe vehicle information. The subsystem communicates with other Traffic Management Subsystems to coordinate traffic information and control strategies in neighboring jurisdictions. This can be Caltrans-to-local agency or local agency-to-local agency. It also coordinates with rail operations to support safer and more efficient highway traffic management at highway-rail intersections. Table 6.3 lists the functions for Traffic Management.

<table>
<thead>
<tr>
<th>Function</th>
<th>Functional Description</th>
<th>Project X-Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collect Traffic Surveillance</td>
<td>This Function collects, stores, [and provides electronic access to the traffic surveillance data].</td>
<td>Caltrans ATMS2, UC PEMS</td>
</tr>
<tr>
<td>Highway-Rail Interface Traffic Management</td>
<td>This function monitors highway-rail intersection (HRI) equipment at the roadside which manages highway traffic. Various levels of roadside equipment may be interfaced to, and supported by, this function to include standard speed active warning systems and high speed systems which provide additional information on approaching trains and detect and report on obstructions in the HRI. This function remotely monitors and reports the status of this roadside equipment. A two way interface supports explicitly status requests or remote control plan updates to be generated by this function. Status may also be received periodically in the absence of a request or asynchronously in the event of a detected failure or other unsafe condition at the intersection.</td>
<td>RAMS Tier 1</td>
</tr>
<tr>
<td>TMC Freeway Management</td>
<td>Control system for efficient freeway management including integration of surveillance information with freeway road geometry and vehicle control such as ramp metering and CMS. Interface to ATIS-related subsystems such as CMS and HAR for information dissemination to the public.</td>
<td>Caltrans ATMS2</td>
</tr>
<tr>
<td>TMC Incident Detection</td>
<td>This Function provides the capability to traffic managers to detect and verify incidents and includes detectors and ATMS algorithms. [This capability includes analyzing and reducing the collected data from traffic surveillance equipment, including planned incidents, adverse weather and other hazardous conditions].</td>
<td>Caltrans ATMS2</td>
</tr>
<tr>
<td>Incident Dispatch Coordination and Communications</td>
<td>This Function provides the capability for incident response planning to minimize secondary incidents and other adverse traffic impacts. This function recommends resources required for incident management including proposing and facilitating the dispatch of emergency response and service vehicles as well as coordinating response with all appropriate cooperating agencies.</td>
<td>RAVL (FSP/TMT)</td>
</tr>
<tr>
<td>TMC Multi-Modal Coordination</td>
<td>This Function provides the capability of signal control at the traffic management subsystem to provide signal priority for transit vehicles.</td>
<td>RAVL (Transit), RTMS, RAMS Tier 1</td>
</tr>
</tbody>
</table>
### Table 6.3: Traffic Management Functional Descriptions

<table>
<thead>
<tr>
<th>Function</th>
<th>Functional Description</th>
<th>Project X-Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMC Regional Traffic Control</td>
<td>This Function provides capabilities in addition to those provided by the TMC Basic Signal Control Function for analyzing, controlling, and optimizing area-wide traffic flow. [These capabilities provide for wide area optimization integrating control of a network signal system with control of freeway, considering current demand as well as expected demand with a goal of providing the capability for real-time traffic adaptive control while balancing inter-jurisdictional control issues to achieve regional solutions. These capabilities are best provided using a Traffic Management Center (TMC) to monitor and manage freeway ramp meters and intersection traffic signals and software to process traffic information and implement traffic management measures (e.g., ramp metering, signalization, and traffic coordination between both local and regional jurisdiction). The TMC shall be able to communicate with other TMCs in order to receive and transmit traffic information on other jurisdictions within the region].</td>
<td>Caltrans ATMSi RAMS Tier 1 RAMS Tier 2</td>
</tr>
<tr>
<td>TMC Road Weather Monitoring</td>
<td>This function assimilates current and forecast road conditions and weather information using a combination of weather service information and an array of environmental sensors deployed on and about the roadway. The collected road weather information is monitored and analyzed to detect and forecast environmental hazards such as icy road conditions and dense fog. This information can be used to more effectively deploy road maintenance resources, issue general traveler advisories, and support location specific warnings to drivers.</td>
<td>Caltrans ESS</td>
</tr>
<tr>
<td>TMC Signal Control</td>
<td>This Function provides the capability for traffic managers to monitor and manage the traffic flow at signalized intersections. This capability includes analyzing and reducing the collected data from traffic surveillance equipment and developing and implementing control plans for signalized intersections. Control plans may be developed and implemented that coordinate signals at many intersections under the domain of a single traffic management subsystem. [In advanced implementations, this package collects route planning information and integrates and uses this information in predicting future traffic conditions and optimizing the traffic control strategy for these conditions. These capabilities are achieved through real-time communication of logged routes from an Information Service Provider. The planned control strategies can be passed back to the Information Service Provider so that the intended strategies can be reflected in future route planning.]</td>
<td>RAMS Tier 1</td>
</tr>
<tr>
<td>TMC Traffic Information Dissemination</td>
<td>This Function provides the capability to disseminate incident related information to travelers, potential travelers, and private information service providers. [These capabilities shall be provided using a workstation type processor within a facility connected to traveler information providers by utilizing existing wireline links.]</td>
<td>IMTMS Network RAMS Tier 2 ATIMS</td>
</tr>
</tbody>
</table>
Table 6.3: Traffic Management Functional Descriptions

<table>
<thead>
<tr>
<th>Function</th>
<th>Functional Description</th>
<th>Project X-Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMC Traffic Network</td>
<td>[This Function provides the capability to predict travel demand patterns to support traffic flow optimization, demand management, and incident management. This Function requires the data collected by surveillance Functions as well as input from other management subsystems including the ISP Subsystem, Transit Management Subsystem.]</td>
<td>PEMS</td>
</tr>
<tr>
<td>Performance Evaluation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traffic Data Collection</td>
<td>[This function collects and stores traffic information that is collected in the course of traffic operations performed by the Traffic Management Subsystem. This data can be used directly by operations personnel or it can be made available to other data users and archives in the region.]</td>
<td>PEMS</td>
</tr>
<tr>
<td>Traffic Maintenance</td>
<td>[This Function provides monitoring and remote diagnostics of field equipment to detect field equipment failures, issues problem reports, and tracks the repair or replacement of the failed equipment.]</td>
<td>Limited capability in CT ATMS2</td>
</tr>
<tr>
<td>Rail Operations Coordination</td>
<td>[This equipment package provides strategic coordination between rail operations and traffic management centers. It receives train schedules, maintenance schedules, and any other forecast events that will result in highway-rail intersection (HRI) closures from Rail Operations. The provided information is used to develop forecast HRI closure times and durations that may be applied in advanced traffic control strategies or delivered as enhanced traveler information. This equipment package includes the processing and algorithms necessary to derive HRI closure times and the communications capabilities necessary to communicate with rail operations and interface to the traffic control and information distribution capabilities included in other Traffic Management Subsystem equipment packages.]</td>
<td>JTOC</td>
</tr>
</tbody>
</table>

6.4 Transit Management Subsystem

The transit management subsystem manages transit vehicle fleets and coordinates with other modes and transportation services. It provides operations, maintenance, customer information, planning and management functions for the transit property. It spans distinct central dispatch and garage management systems and supports the spectrum of fixed route, flexible route, and paratransit services. The subsystem's interfaces allow for communication between transit departments and with other operating entities such as emergency response services and traffic management systems. This subsystem receives special event and real-time incident data from the traffic management subsystem. It provides current transit operations data to other center subsystems. The Transit Management Subsystem collects and stores accurate ridership levels and implements corresponding fare structures. It collects operational and maintenance data from transit vehicles, manages vehicle service histories, and assigns drivers and maintenance personnel to vehicles and routes. The Transit Management Subsystem also provides the capability for automated planning and scheduling of public transit operations. It furnishes travelers with real-time travel information, continuously updated schedules, schedule adherence information, transfer options, and transit routes and fares. In addition, the monitoring of key transit locations with both video and audio systems is provided with automatic alerting of operators and police of potential incidents including support for traveler activated alarms.

San Diego has an interim transit management project (Regional AVL, or RAVL) that provides transit management services for selected contract operator routes in the region. A longer term project is
also being planned and procured (Regional Transit Management System, RTMS). Table 6.4 lists the functions for Transit Management.

Table 6.4: Transit Management Functional Descriptions

<table>
<thead>
<tr>
<th>Function</th>
<th>Functional Description</th>
<th>Project X-Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transit Center Fixed Route Operations</td>
<td>This Function enhances the planning and scheduling associated with fixed route transit services. The package allows fixed-route services to develop, print and disseminate schedules and automatically updates customer service operator systems with the most current schedule information. Current vehicle schedule adherence and optimum scenarios for schedule adjustment shall also be provided.</td>
<td>RAVL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RTMS</td>
</tr>
<tr>
<td>Transit Center Information Services</td>
<td>This function collects the latest available information for a transit service and makes it available to transit customers and to Information Service Providers for further distribution. Customers are provided information at transit stops and other public transportation areas before they embark and on-board the transit vehicle once they are enroute. Information provided can include the latest available information on transit routes, schedules, transfer options, fares, real-time schedule adherence, current incidents, weather conditions, and special events. In addition to general service information, tailored information (e.g., itineraries) are provided to individual transit users.</td>
<td>RTMS</td>
</tr>
<tr>
<td>Transit Center Multi-Modal Coordination</td>
<td>This Function provides the transit management subsystem the capability to determine the need for transit priority on routes and at certain intersections and request transit vehicle priority at these locations. It also supports schedule coordination between transit properties and coordinates with other surface and air transportation modes.</td>
<td>RTMS</td>
</tr>
<tr>
<td>Transit Center Paratransit Operations</td>
<td>[This Function provides the capability to automate the planning and scheduling, allowing improvements in paratransit routes and services to develop, printing and disseminating schedules, and automatically updating customer service operator systems with the most current schedule. In addition, this Function provides the capability to assign drivers to routes in a fair manner while minimizing labor and overtime services, including driver preferences and qualifications, and automatically tracking and validating the number of work hours performed by each individual driver. These capabilities shall be provided through the utilization of dispatch and fleet management software running on a workstation type processor.]</td>
<td></td>
</tr>
<tr>
<td>Transit Center Security</td>
<td>[This Function provides the capability to monitor key transit locations and transit vehicles with both video and audio systems automatically alerting operators and police of potential incidents and supporting traveler-activated alarms. The monitoring equipment shall also include capabilities to assist in responding to terrorist incidents.]</td>
<td></td>
</tr>
</tbody>
</table>
### Table 6.4: Transit Management Functional Descriptions

<table>
<thead>
<tr>
<th>Function</th>
<th>Functional Description</th>
<th>Project X-Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transit Center Tracking and Dispatch</td>
<td>This Function provides the capabilities for monitoring transit vehicle locations and determining vehicle schedule adherence. The Function shall also furnish users with real-time travel related information, continuously updated with real-time information from each transit system within the local area of jurisdiction, inclusive of all transportation modes, from all providers of transportation services, and provide users with the latest available information on transit routes, schedules, transfer options, fares, real-time schedule adherence, current incidents conditions, weather conditions, and special events. This Function also supports the capability for two-way voice communication between the transit vehicle driver and a facility, two-way data communication between the transit vehicles and a facility.</td>
<td>RAVL RTMS</td>
</tr>
<tr>
<td>Transit Garage Operations</td>
<td>This Function automates and supports the assignment of transit vehicles and drivers to enhance the daily operation of a transit service. It provides the capability to assign drivers to routes or service areas in a fair manner while minimizing labor and overtime services, considering driver preferences and qualifications, and automatically tracking and validating the number of work hours performed by each individual driver.</td>
<td>RTMS</td>
</tr>
<tr>
<td>Transit Data Collection</td>
<td>This function collects and stores transit information that is collected in the course of transit operations performed by the Transit Management Subsystem. This data can be used directly by operations personnel or it can be made available to other data users and archives in the region.</td>
<td>RAVL RTMS</td>
</tr>
<tr>
<td>Transit Load and Fare Management</td>
<td>[This function provides the capability to accept collected data required to determine accurate ridership levels and implement variable and flexible fare structures. Support shall be provided for the traveler for use of a fare medium for all applicable surface transportation services, to pay without stopping, have payment media automatically identified as void and/or invalid and eligibility verified, and allow for third party payment. In addition, capability to provide expansion into other uses for payment medium such as retail and telephone and for off-line billing for fares paid by agencies shall be supported. This function also supports the capability for two-way voice communication between the transit vehicle driver and a facility, two-way data communication between the transit vehicles and a facility, sensor data to be transmitted from the transit vehicles to a facility, and data transmission from individual facilities to a central facility for processing/analysis if desired. These capabilities shall be provided through a workstation type processor with GUI, high capacity storage, ride share software housed in a building with dialup lines and wireline telephone and require integration with an existing Transit Center Tracking and Dispatch function.]</td>
<td>Selected units under RTMS Regional Fare Card System</td>
</tr>
</tbody>
</table>

### 6.5 Transit Vehicle Subsystem

This subsystem resides in a transit vehicle and provides the sensory, processing, storage, and communications functions necessary to support safe and efficient movement of passengers. The
Transit Vehicle Subsystem collects accurate ridership levels and supports electronic fare collection. An optional traffic signal prioritization function communicates with the roadside subsystem to improve on-schedule performance. Automated vehicle location functions enhance the information available to the Transit Management Subsystem enabling more efficient operations. On-board sensors support transit vehicle maintenance. The Transit Vehicle Subsystem also furnishes travelers with real-time travel information, continuously updated schedules, transfer options, routes, and fares. Table 6.5 lists the functions for the Transit Vehicle Subsystem.

Table 6.5: Transit Vehicle Functional Descriptions

<table>
<thead>
<tr>
<th>Function</th>
<th>Functional Description</th>
<th>Project X-Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-Board Fixed Route Schedule Management</td>
<td>This Function provides the capabilities for automated planning and scheduling, by collecting data for schedule generation. Capability shall also be provided to automatically determine optimum scenarios for schedule adjustment. This Function also supports the capability for two-way voice communication between the transit vehicle driver and a facility, two-way data communication between the transit vehicles and a facility, on-board safety sensor data to be transmitted from the transit vehicles to a facility, and data transmission from individual facilities to a central facility for processing/analysis if desired.</td>
<td>RTMS</td>
</tr>
<tr>
<td>On-Board Maintenance</td>
<td>This Function provides the capability to use transit vehicle mileage data to automatically generate preventative maintenance schedules for each specific bus by utilizing vehicle tracking data and storing with a trip computer. It also provides the capability for real-time condition monitoring on board the vehicle, and transmission of this information via two-way communication to the management center.</td>
<td>RTMS</td>
</tr>
<tr>
<td>On-Board Paratransit Operations</td>
<td>[This function forwards paratransit dispatch requests to the driver and forwards acknowledgements to the center. It coordinates with, and assists the driver in managing multi-stop runs associated with demand responsive, flexibly routed transit services.]</td>
<td></td>
</tr>
<tr>
<td>On-Board Transit Information Services</td>
<td>The Function furnishes enroute transit users with real-time travel-related information. Current information that can be provided to transit users includes transit routes, schedules, transfer options, fares, real-time schedule adherence, current incidents, weather conditions, and special events are provided. In addition to tailored information for individual transit users, this function also supports general annunciation and/or display of general schedule information, imminent arrival information, and other information of general interest to transit users.</td>
<td>RAVL, RTMS</td>
</tr>
<tr>
<td>On-Board Transit Security</td>
<td>This Function provides the capability to monitor the safety of transit vehicles using on-board safety sensors, processors and communications from the prerequisite On-board Trip Monitoring Function.</td>
<td>RTMS</td>
</tr>
<tr>
<td>On-Board Transit Priority</td>
<td>This Function provides the capability for transit vehicles to request signal priority through short range communication directly with traffic control equipment at the roadside.</td>
<td>RAMS Tier 1</td>
</tr>
</tbody>
</table>
### Table 6.5: Transit Vehicle Functional Descriptions

<table>
<thead>
<tr>
<th>Function</th>
<th>Functional Description</th>
<th>Project X-Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-Board Transit Trip Monitoring</td>
<td>This Function provides the capabilities to support fleet management with automatic vehicle location and automated mileage and fuel reporting and auditing. This package may also record other special events resulting from communication with roadside equipment. This includes only the equipment on board the vehicle to support this function including the vehicle location devices such as GPS equipment, communication interfaces, a processor to record trip length, and the sensors/actuators/interfaces necessary to record mileage and fuel usage.</td>
<td>RTMS</td>
</tr>
</tbody>
</table>

### 6.6 Information Service Provider Subsystem

This subsystem collects, processes, stores, and disseminates transportation information to system operators and the traveling public. The subsystem can play several different roles in an integrated ITS. In one role, the ISP provides a general data warehousing function, collecting information from transportation system operators and redistributing this information to other system operators in the region and other ISPs. In this information redistribution role, the ISP provides a bridge between the various transportation systems that produce the information and the other ISPs and their subscribers that use the information. The second role of an ISP is focused on delivery of traveler information to subscribers and the public at large. Information provided includes basic advisories, real time traffic condition and transit schedule information, yellow pages information, ride matching information, and parking information. The subsystem also provides the capability to provide specific directions to travelers by receiving origin and destination requests from travelers, generating route plans, and returning the calculated plans to the users. In addition to general route planning for travelers, the ISP also supports specialized route planning for vehicle fleets. In this third role, the ISP function may be dedicated to, or even embedded within, the dispatch system. Reservation services are also provided in advanced implementations. The information is provided to the traveler through the Personal Information Access Subsystem, Remote Traveler Support Subsystem, and various Vehicle Subsystems through available communications links. Both basic one-way (broadcast) and personalized two-way information provision is supported. The subsystem provides the capability for an informational infrastructure to connect providers and consumers, and gather that market information needed to assist in the planning of service improvements and in maintenance of operations. **Table 6.6** lists the functions for the Information Service Provider.
### Table 6.6: Information Service Provider Functional Descriptions

<table>
<thead>
<tr>
<th>Function</th>
<th>Functional Description</th>
<th>Project X-Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Information Broadcast</td>
<td>This Function provides the capabilities to collect, process, store, bill, and disseminate traveler information including traveler, transit, ride matching, traffic, and parking information. The traveler information shall include maintaining a database of local area services available to travelers with up-to-the-minute information and providing an interactive connectivity between sponsors and providers of services. The transit information shall include the latest available information on transit routes and schedules, transit transfer options, transit fares, and real-time schedule adherence. The traffic information shall include latest available information on traffic and highway conditions, and current situation information in real-time including incidents, road construction, recommended routes, current speeds on specific routes, current parking conditions in key areas, schedules for any current or soon to start events, and current weather situations. [This Function shall also provide users with real-time travel related information while they are traveling, and disseminate to assist the travelers in making decisions about transfers and modification of trips. These capabilities shall be provided using equipment such as a fixed facility with a communications system such as a data Subcarrier multiplexing device.]</td>
<td>Regional ATIS ATIMS</td>
</tr>
<tr>
<td>ISP Data Collection</td>
<td>[This function collects and stores traveler information that is collected in the course of operation of the ISP subsystem. This data can be used directly by operations personnel or it can be made available to other data users and archives in the region.]</td>
<td>Regional ATIS</td>
</tr>
<tr>
<td>Interactive Infrastructure Information</td>
<td>[This Function shall have as prerequisite the capabilities of the Basic Information Broadcast Function. This Function augments the Basic Information Broadcast Function by providing the capabilities for interactive traveler information.]</td>
<td>Regional ATIS</td>
</tr>
<tr>
<td>Infrastructure Provided Yellow Pages and Reservations</td>
<td>[This Function shall have as prerequisite the capabilities of the Interactive Infrastructure Information Function. In addition, this Function provides the capability to provide specific traveler information, such as Yellow Pages information, with reservation capabilities.]</td>
<td>Regional ATIS</td>
</tr>
<tr>
<td>Infrastructure Provided Route Guidance</td>
<td>[This Function shall have as prerequisite the capabilities of the Interactive Infrastructure Information Function. In addition, this Function provides the capability to provide specific directions to travelers by receiving origin and destination requests from travelers, generating route plans, returning the calculated plans to the users, and then potentially logging the route plans with Traffic Management Subsystem. This additional capability shall be provided using equipment such as a workstation type processor and software for route planning and traffic measurements along with additional communications capabilities including dialup lines, PCS telephones, and wireless data transceivers.]</td>
<td>Regional ATIS</td>
</tr>
</tbody>
</table>
6.7 Personal Information Access Subsystem

This subsystem provides the capability for travelers to receive formatted traffic advisories from their homes, place of work, major trip generation sites, personal portable devices, and over multiple types of electronic media. These capabilities shall also provide basic routing information and allow users to select those transportation modes that allow them to avoid congestion, or more advanced capabilities to allow users to specify those transportation parameters that are unique to their individual needs and receive travel information. This subsystem shall provide capabilities to receive route planning from the infrastructure at fixed locations such as in their homes, their place of work, and at mobile locations such as from personal portable devices and in the vehicle or perform the route planning process at a mobile information access location. This subsystem shall also provide the capability to initiate a distress signal and cancel a prior issued manual request for help. Table 6.7 lists the functions for Personal Information Access.

### Table 6.7: Personal Information Access Functional Descriptions

<table>
<thead>
<tr>
<th>Function</th>
<th>Functional Description</th>
<th>Project X-Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Basic Information Reception</td>
<td>This Function shall provide the capability for travelers to interface with the ISP Subsystem Basic Information Broadcast Function and receive formatted traffic advisories including accurate traveling information concerning available travel options and their availability, and congestion information from their Personal Information Access Subsystem to include their homes, place of work, major trip generation sites, personal portable devices, and over multiple types of electronic media such as facsimile machines, portable AM/FM radios, and a pager processor.</td>
<td>Private Sector Provided</td>
</tr>
<tr>
<td>Personal Interactive Information Reception</td>
<td>This Function shall provide the capability for travelers to interface with the ISP Subsystem Infrastructure Functions including the Interactive Infrastructure Information Function, and the Infrastructure Provided Route Selection, Yellow Pages and Reservation, and Dynamic Ridesharing Functions. These capabilities shall be provided using the Personal Information Access Subsystem equipment such as cellular telephone, interactive TV, Personal Computer, and pager with alpha display using communication medium and equipment such as two-way radio, CATV, and wireless data transceivers.</td>
<td>Private sector Provided</td>
</tr>
<tr>
<td>Personal Location Determination</td>
<td>This function determines current location information and provides this information to other functions that use the location information to provide various ITS services.</td>
<td>Private Sector Provided</td>
</tr>
<tr>
<td>Personal Mayday Interface</td>
<td>This Function shall provide the capability to initiate a distress signal and cancel a prior issued manual request for help using the Personal Information Access Subsystem. This capability shall be provided using equipment such as a processor to automatically dial the Emergency Management Subsystem and provide location.</td>
<td>Private Sector Provided (but interface to regional 9-1-1 centers not yet implemented)</td>
</tr>
<tr>
<td>Personal provider-Based Route Guidance</td>
<td>[This Function coordinates with an ISP-Based route planning service to select a suggested route plan that is tailored to the traveler’s preferences. Coordination may continue during the trip so that the route plan can be modified to account for new information. Many equipment configurations are possible including systems that provide a basic route plan to the traveler as well as more sophisticated systems that can provide transition by transition guidance to the traveler along a multi-modal route plan.]</td>
<td>To be Private Sector Provided (Telematics Service Providers)</td>
</tr>
</tbody>
</table>
### Table 6.7: Personal Information Access Functional Descriptions

<table>
<thead>
<tr>
<th>Function</th>
<th>Functional Description</th>
<th>Project X-Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Autonomous Route Guidance</td>
<td>This Function provides multi-modal route planning and transition by route guidance. It provides autonomous route guidance in the absence of real-time information or factors information provided by the infrastructure into its route selection and guidance algorithms. The function also includes those truly autonomous systems that are not configured to receive or process any external data.</td>
<td>Private Sector Provided</td>
</tr>
</tbody>
</table>

### 6.8 Remote Traveler Support Subsystem

This subsystem provides access to traveler information at transit stations, transit stops, other fixed sites along travel routes, and at major trip generation locations such as special event centers, hotels, office complexes, amusement parks, and theaters. Traveler information access points include kiosks and informational displays supporting varied levels of interaction and information access. At transit stops, simple displays providing schedule information and imminent arrival signals can be provided. This basic information may be extended to include multi-modal information including traffic conditions and transit schedules along with yellow pages information to support mode and route selection at major trip generation sites. Personalized route planning and route guidance information can also be provided based on criteria supplied by the traveler. In addition to traveler information provision, this subsystem also supports public safety monitoring using CCTV cameras or other surveillance equipment and emergency notification within these public areas. Fare card maintenance, and other features which enhance traveler convenience may also be provided at the discretion of the deploying agency. Table 6.8 lists the functions for Remote Traveler Support.

### Table 6.8: Remote Traveler Support Functional Descriptions

<table>
<thead>
<tr>
<th>Function</th>
<th>Functional Description</th>
<th>Project X-Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remote Basic Information Reception</td>
<td>This Function shall provide the capability for travelers to interface with the ISP Subsystem Basic Information Broadcast Function and receive formatted traffic advisories including accurate traveling information concerning available travel options and their availability, and congestion information at the Remote Traveler Support Subsystem.</td>
<td>Regional ATIS</td>
</tr>
<tr>
<td>Remote Interactive Information Reception</td>
<td>This Function shall provide the capability for travelers to interface with the ISP Subsystem Infrastructure Functions including the Interactive Infrastructure Information Function, the Infrastructure Provided Route Selection, Yellow Pages and Reservation, and Dynamic Ridesharing Functions. These capabilities shall be provided using the Remote Traveler Support Subsystem equipment such as interactive TV and kiosk using communication medium and equipment such as CATV and wireline and wireless data transceivers.</td>
<td>Regional ATIS</td>
</tr>
<tr>
<td>Remote Mayday Interface</td>
<td>This Function provides the capability to report an emergency and summons assistance. The equipment includes a traveler interface that facilitates generation of a distress signal under duress and wireline communications that carries this distress signal and allows follow-up verification and determination of the nature of the emergency and the required response. This function notifies either the Emergency Management or Transit Management Subsystem depending on the implementation.</td>
<td>Private Sector Provided</td>
</tr>
</tbody>
</table>
### Table 6.8: Remote Traveler Support Functional Descriptions

| Function                          | Functional Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Project X-Ref |
|----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Remote Transit Information Services | The Function furnishes transit users with real-time travel-related information at transit stops, multi-modal transfer points, and other public transportation areas. It provides transit users with the latest available information on transit routes, schedules, transfer options, fares, real-time schedule adherence, current incidents, weather conditions, and special events. In addition to tailored information for individual transit users, this function supports general annunciation and/or display of imminent arrival information and other information of general interest to transit users.                                                                                     | RTMS          |
| Secure Area Monitoring           | [This Function provides the capability to monitor the safety of transit users at Remote Traveler Subsystem locations. It collects surveillance images and data and relays this information back to the Transit Management Subsystem.]                                                                                                                                                                                                                                                                  | MTDB Project  |

### 6.9 Roadway Subsystem

This subsystem includes the equipment distributed on and along the roadway which monitors and controls traffic. Equipment includes highway advisory radios, dynamic message signs, cellular call boxes, CCTV cameras and video image processing systems for incident detection and verification, vehicle detectors, traffic signals, grade crossing warning systems, and freeway ramp metering systems. This subsystem also provides the capability for emissions and environmental condition monitoring including weather sensors, pavement icing sensors, fog etc. HOV lane management and reversible lane management functions are also available. Intersection collision avoidance, curve warning and speed warning functions are provided by determining the onset or existence of hazardous conditions and sending appropriate warnings and/or control actions to the approaching vehicles. Table 6.9 lists the functions for the Roadway Subsystem.

### Table 6.9: Roadway Functional Descriptions

| Function                          | Functional Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Project X-Ref |
|----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Roadside Data Collection         | [This function collects traffic, road, and environmental conditions information for use in transportation planning, research, and other off-line applications where data quality and completeness take precedence over real-time performance. This function includes the sensors, supporting roadside infrastructure, and communications equipment that collects and transfers information to a center for archival.]                                                                                                                                       | PEMS          |
| Roadside Signal Priority         | This Function shall provide the capability to receive vehicle signal priority requests and control roadside signals accordingly.                                                                                                                                                                                                                                                                                                                                                                          | RAMS Tier 1   |
| Roadway Basic Surveillance       | This Function provides the capabilities to monitor traffic flow in major intersections and on main highways for urban areas and to monitor road conditions using fixed equipment such as loop detectors and wireline communication.                                                                                                                                                                                                                                                             | ATMS          |
|                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | RAMS          |
### Table 6.9: Roadway Functional Descriptions

<table>
<thead>
<tr>
<th>Function</th>
<th>Functional Description</th>
<th>Project X-Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roadway Environmental Monitoring</td>
<td>This Function measures environmental conditions and communicates the collected information back to a center where it can be monitored and analyzed. A broad array of general weather and road surface information may be collected. Weather conditions that may be measured include temperature, wind, humidity, precipitation, and visibility. Surface and sub-surface sensors can measure road surface temperature, moisture, icing, salinity, and other measures. Air quality monitoring can include point monitoring of individual vehicles as well as general monitoring of standard air quality measures.</td>
<td>Caltrans Existing</td>
</tr>
<tr>
<td>Roadway Freeway Control</td>
<td>Ramp meters, CMS and other freeway control devices that will control traffic on freeways.</td>
<td>ATMS</td>
</tr>
<tr>
<td>Roadway Incident Detection</td>
<td>[This Function provides incident detection capability to reside at the roadside. For example, advanced CCTV's with built-in incident detection algorithms would allow the actual detection function to be roadside rather than transmitting images to a center for visual or automated detection.]</td>
<td>ATMS</td>
</tr>
<tr>
<td>Roadway Intersection Collision Warning</td>
<td>[This Function provides the capability to determine the probability of a collision in the intersection and send appropriate warnings and/or control actions to the approaching vehicles using a short-range interface. This Function also provides the capability that the traffic control signals provide signal indication information to the vehicles using a short-range interface and the vehicle performs the determination of the probability of collision in the intersection. This package covers intersections between vehicles and railroad at grade crossings.]</td>
<td></td>
</tr>
<tr>
<td>Roadway Signal Control</td>
<td>This Function provides the capabilities to control traffic signals at major intersections and on main highways for urban areas. This Function is generally constrained to a single jurisdiction.</td>
<td>Various RAMS Tier 1</td>
</tr>
<tr>
<td>Roadway Hazard Warning System</td>
<td>[This Function provides the capability to detect the existence or onset of a hazardous condition in the roadway or by vehicles traveling the roadway and sends appropriate signals to a static or dynamic sign to inform motorists of the hazardous condition in real-time.]</td>
<td>ATMS</td>
</tr>
<tr>
<td>Roadway Traffic Information Dissemination</td>
<td>This Function provides the roadside elements of traffic information dissemination including DMS and HAR.</td>
<td>ATMS RAMS Mission Valley</td>
</tr>
</tbody>
</table>
Table 6.9: Roadway Functional Descriptions

<table>
<thead>
<tr>
<th>Function</th>
<th>Functional Description</th>
<th>Project X-Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Rail Crossing</td>
<td>This Function manages highway traffic at highway-rail intersections (HRIs) where operational requirements do not dictate advanced features (e.g., where rail operational speeds are less than 80 miles per hour). Either passive (e.g., the crossbuck sign) or active warning systems (e.g., flashing lights and gates) are supported depending on the specific requirements for each intersection. These traditional HRI warning systems may also be augmented with other standard traffic management devices. The warning systems are activated on notification by interfaced wayside equipment of an approaching train. The equipment at the HRI may also be interconnected with adjacent signalized intersections so that local control can be adapted to highway-rail intersection activities. Health monitoring of the HRI equipment and interfaces is performed; detected abnormalities are reported through interfaces to the wayside interface equipment and the traffic management subsystem.</td>
<td>RAMS</td>
</tr>
<tr>
<td>Advanced Rail Crossing</td>
<td>[This function manages highway traffic at highway-rail intersections (HRIs) where operational requirements demand advanced features (e.g., where rail operational speeds are greater than 80 miles per hour). It includes all capabilities from the Standard Rail Crossing function and augments these with additional safety features. The active warning systems supported by this market package includes positive barrier systems that preclude entrance into the intersection when the barriers are activated. Like the Standard package, the HRI equipment is activated on notification by wayside interface equipment that detects, or communicates with the approaching train. In this function, the wayside interface equipment also provides additional information about the arriving train so that the train's direction of travel, its estimated time of arrival, and the estimated duration of closure may be derived. This enhanced information may be conveyed to the driver prior to, or in context with, warning system activation. This function also includes detection capabilities that enable it to detect an entrapped or otherwise immobilized vehicle within the HRI and provide an immediate notification to the wayside interface equipment and traffic management.]</td>
<td></td>
</tr>
</tbody>
</table>

6.10 Archived Data Management Subsystem

The Archived Data Management Subsystem collects, archives, manages, and distributes data generated from ITS sources for use in transportation administration, policy evaluation, safety, planning, performance monitoring, program assessment, operations, and research applications. The data received is formatted, tagged with attributes that define the data source, conditions under which it was collected, data transformations, and other information (i.e. meta data) necessary to interpret the data. The subsystem can fuse ITS generated data with data from non-ITS sources and other archives to generate information products utilizing data from multiple functional areas, modes, and jurisdictions. The subsystem prepares data products that can serve as inputs to Federal, State, and local data reporting systems. This subsystem may be implemented in many different ways. It may reside within an operational center and provide focused access to a particular agency's data archives. Alternatively, it
may operate as a distinct center that collects data from multiple agencies and sources and provides a general data warehouse service for a region. **Table 6.10** lists the functions for Archived Data Management.

**Table 6.10: Archived Data Management Functional Descriptions**

<table>
<thead>
<tr>
<th>Function</th>
<th>Functional Description</th>
<th>Project X-Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITS Data Repository</td>
<td><strong>[This equipment package collects data and data catalogs from one or more data sources and stores the data in a focused repository that is suited to a particular set of ITS data users. This equipment package includes capabilities for performing quality checks on the incoming data, error notification, and archive to archive coordination. This equipment package supports a broad range of implementations, ranging from simple data marts that collect a focused set of data and serve a particular user community to large-scale data warehouses that collect, integrate, and summarize transportation data from multiple sources and serve a broad array of users within a region.]</strong> PEMS</td>
<td></td>
</tr>
<tr>
<td>Traffic and Roadside Data Archival</td>
<td><strong>[This equipment package collects and archives traffic, roadway, and environmental information for use in off-line planning, research, and analysis. The equipment package controls and collects information directly from equipment at the roadside, reflecting the deployment of traffic detectors that are used primarily for traffic monitoring and planning purposes rather than for traffic management.]</strong> PEMS</td>
<td></td>
</tr>
<tr>
<td>Virtual Data Warehouse Services</td>
<td><strong>[This equipment package provides capabilities to access &quot;in-place&quot; data from geographically dispersed archives and coordinate information exchange with a local data warehouse. While many of the functions performed by this equipment package are similar to the functions inherent in other archived data management subsystem equipment packages (e.g. data management, fusion, analysis) this equipment package also provides the specialized publishing, directory services, and transaction management functions associated with coordinating remote archives. In addition, this equipment package performs functions on an as-needed basis, thereby negating the need to maintain the comprehensive set of data from the remote archives in the local data warehouse.]</strong> PEMS</td>
<td></td>
</tr>
</tbody>
</table>
7.0 INFORMATION FLOWS & INTERFACE REQUIREMENTS

In the context of the San Diego ITS architecture, information flows will be interpreted as "architecture flows" as defined in the National ITS Architecture. These flows are high-level data exchange requirements between physical elements of the architecture, i.e. the architecture subsystems. As shown in the previous section, these subsystems include the major functional areas of Management Centers, Roadway Devices, Vehicles and Personal Access. The data in these flows is carried by the architecture interconnects, or communications networks supporting ITS. These have been established as:

- **Wireline networks** – networks supporting fixed elements of the architecture (centers and roadway devices). These networks include the Internet, public agency-owned fiber optic networks, signal interconnect networks, and the like. In San Diego these include the Caltrans TOSNET, MTDB's fiber network and the City of San Diego's fiber network as well as leased services.

- **Wide Area Wireless networks** – public and private networks that support both fixed and mobile elements of the architecture. These networks can support mobile access to the Internet. Wide area wireless networks also include "private" radio systems (as seen by the Federal Communications Commission) such as law enforcement trunked radio systems, transit fleet radio systems, etc. In San Diego this includes the Regional Communications System (RCS) and a new transit radio service among others.

- **Dedicated Short-Range Communications networks** – networks primarily serving communications between roadway devices and vehicles. These networks include, for example, emergency vehicle preemption and transit vehicle signal priority treatments through direct vehicle to signal controller communications. DSRC is not implemented or planned in San Diego.

- **Vehicle-to-Vehicle networks** – networks that support advanced vehicle control applications such as the Automated Highway System. San Diego operates the AHS test bed on the I-15 Reversible Lane facility.

Other communications systems that support ITS applications include local area networks (LAN's) that are typically used within modal management centers, such as a freeway management system running in a Caltrans TMC. These internal networks typically support single systems like Advanced Traffic Management Systems (ATMS) that include components such as applications servers, database servers and operator workstations.

Connectivity between physical architecture subsystems is greatly facilitated by the use of standard interfaces, or means of connecting to a network on one side, and to physical components on the other side. One of the best known interface standards is the RS-232C standard for connecting low data rate computing elements to communications devices such as modems. The RS-232C standard includes such mundane details as the electrical signal format (how "1’s" and "0’s" are formed), pin-out definitions for standard 9-pin and 25-pin connectors, and the meaning of signals on each pin (communications protocol). Other standard interfaces run the gamut from the means to encode analog video signals into a digital signal to the means to exchange high level data between dissimilar transportation management centers (e.g. a freeway management center and a transit management center). In Section 8, the subject of standards and their use in ITS applications is covered in detail.

7.1 Information Flows

In the San Diego ITS architecture, information flows will be considered equivalent to architecture flows in the National ITS Architecture, therefore the artifact of Market Packages will be used to express the flows needed to support projected ITS applications in San Diego. Market Packages are defined as
deployable combinations of equipment, functions and communications interconnects that support ITS User Services. Market Packages consist of physical elements (subsystems) within the architecture, connected by high-level data flows. The physical elements contain Equipment Packages that we have previously defined in Section 6 as high-level functions. For the San Diego architecture development, standard National ITS Architecture Market Packages have been adapted, tailored and combined to form templates for five (5) major functional areas within this regional architecture. These 5 functional areas include the following:

- Incident Management
- Traffic Management
- Transit Management
- Traveler Information Management (3 Market Package combinations)
- Archive Data Management

**Figure 7-1** provides high-level overview of the information that will be exchanged within the San Diego IMTMS project that forms the backbone of the San Diego regional ITS architecture. **Figures 7-2 through 7-8** provide the San Diego-tailored Market Package diagrams corresponding to the 5 major functional areas listed above.

### 7.2 Interface Requirements

#### 7.2.1 Communications Systems

**Figure 7-9** provides a tailored architecture interconnect diagram for San Diego ITS applications. This diagram provides a high-level view of the communications systems needed to connect various systems and projects in the San Diego region. The fundamental requirement for virtually all of the projects under development in the San Diego region is increased reliance upon wide area wireline communications for implementing local signal interconnects, local “interties” (multi-jurisdictional shared viewing and/or control), “smart” corridors and connectivity between major transportation nodes in the region. The regional IMTMS Network that provides the physical project linkage in San Diego consists of a combination of agency-owned fiber networks and leased facilities. Over time, the leased facilities will give way to the increased use of agency networks. For example, in the Mission Valley Event Management project, Caltrans District 11 and the City of San Diego were able to connect their respective fiber networks to form a data and video link to support major events at Qualcomm Stadium. On the other hand, the Regional AVL project will initially rely on leased facilities to connect the participating transit centers.

#### 7.2.2 Interface Architecture

**Figure 7-10** shows the high-level architecture for the connectivity between freeway, arterial, transit and traveler information systems in the region. **Figure 7-11** provides a detailed example on how a particular mode (in this case transit) will connect to the regional network. The generic name for this interface is a “Seed”. The means for connecting other modes and centers will be similar in concept. The figure refers to both Hardware Configuration Items (HCI’s) and Software Configuration Items (SCI’s, or sometimes referred to as Computer Software Configuration Items, or CSCI’s). These are the items that will be tracked through the regional configuration management system and include items such as Integrated Workstations (HCI), Intertie Servers (HCI) and the various Bridges and Factories (SCI’s) needed to interface to legacy systems and create either CORBA or XML objects. Each Factory SCI creates a set of objects that can be defined by an artifact known as an Interface Definition Language, or IDL. In the case of XML, the data objects are defined somewhat differently but achieve the same purpose, i.e. to define a standard set of data objects for the region. These data objects will also be under configuration
management. A particular “Seed” interfaces to a single legacy system (e.g. a QuickNet 4 Seed) but may contain one or more Bridges and Factories depending on the data needed from the legacy system. For example, the QuicNet 4 Seed will likely contain Bridges for detector data, controller data, and timing plan data. Each of these data elements will have a corresponding object definition and therefore a unique Factory to generate these objects.

7.2.3 **WEB SERVICES ARCHITECTURE**

The San Diego region anticipates implementing some Web Services that will support web browser-based interfacing to the regional network. Figure 7-12 illustrates how the web services will fit into the regional architecture and how they are derived from the CORBA architecture. The Advanced Traveler Information Management System (ATIMS) Server will host the software functions that convert CORBA IDL to XML as necessary and the Web Services applications that serve various “thin client” workstations throughout the region.

7.2.4 **INTERFACE SUMMARY**

Table 7.1 provides a summary of the major interface artifacts in the San Diego architecture, including the type of configuration item, location(s) and function of the artifact.

<table>
<thead>
<tr>
<th>Artifact</th>
<th>Configuration Item</th>
<th>Location</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intertie Server</td>
<td>Hardware</td>
<td>In any agency that has field elements or sources of data</td>
<td>Hosts Bridges and Factories</td>
</tr>
<tr>
<td>Integrated Workstation</td>
<td>Hardware</td>
<td>All participating agencies in the SD region</td>
<td>Provides operator map-based display of regional traffic and event data</td>
</tr>
<tr>
<td>Bridge</td>
<td>Software</td>
<td>Intertie Server</td>
<td>Interfaces to legacy system (system dependent)</td>
</tr>
<tr>
<td>Factory</td>
<td>Software</td>
<td>Intertie Server</td>
<td>Creates object types (bus, route, event, etc. – system independent)</td>
</tr>
<tr>
<td>Web Service</td>
<td>Software</td>
<td>ATIMS Server (could be multiple CPU’s)</td>
<td>Creates an application that can be accessed by standard Internet browsers</td>
</tr>
<tr>
<td>CORBA Client</td>
<td>Software</td>
<td>Integrated Workstations (in some agencies, co-resident with Intertie Server)</td>
<td>Software application residing on an Integrated Workstation that accesses one or more Factories to provide data to the workstation operator</td>
</tr>
<tr>
<td>Thin client</td>
<td>Software</td>
<td>Integrated Workstation</td>
<td>Map-based browser</td>
</tr>
</tbody>
</table>
Figure 7-1: San Diego Region High-Level Logical Architecture
SAN DIEGO REGIONAL ARCHITECTURE

Figure 7-2: Incident Management Market Packages
Figure 7-3: Integrated Traffic Management Market Packages
Figure 7-4: Transit Management Market Packages
Figure 7-5: Transit Traveler Information and Basic ATIS Market Packages
Figure 7-6: Longer Term ATIS Market Packages
Figure 7-7: ATIS “Convenience” Market Packages
Anyone of the following ITS data sources can be the source for an ITS Data Mart. The Caltrans District 11 ATMSi is shown as an example.

Potential Data Sources:
- CHP Border Division
- National Weather Service/NOAA
- Caltrans VDS/ramp meter system
- Caltrans Count Station Data
- Caltrans D11 TMC ATMS reporting**
- CHP Incident Reporting
- RAMS Archived Traffic Data
- MTDB Management Service Reports
- NC Transit Service Reports
- Information Service Provider Reports
- Caltrans/Local Agency Road Closure Logs
- Other Data Sources
- Government Reporting Systems

Figure 7-8: Archived Data Market Packages
Figure 7-9: San Diego Region Physical ITS Architecture
**Figure 7-10 San Diego High Level Intermodal Connectivity.**
Transit Seed:
Bridges are vendor-unique
Factories produce standard IDL

The transit world's window on traffic management and its relationship to transit data (configuration is part of regional CM)

IDL is part of regional architecture

Figure 7-11. San Diego “Seed” Architecture for Modal System Interfaces
Overlaying XML/Internet Technology on IMTMS CORBA Network

Figure 7-12. San Diego Web Services Architecture.
8.0 IDENTIFICATION OF DESIRED STANDARDS

This section will provide a brief overview of the current ITS standards issues that are relevant to the San Diego Regional Architecture. ITS standards are considered essential both for enhanced local, regional, and national interoperability and operational application. Led by the Federal Highway Administration (FHWA) in conjunction with the American Association of State Highway and Transportation Officials (AASHTO) and the Institute of Transportation Engineers (ITE), the National Electrical Manufacturers Association (NEMA) has been developing standards for the National Transportation Communications for ITS Protocol (NTCIP). NTCIP will provide a communications standard that ensures the interoperability and interchangeability of ITS devices and transportation centers. This spearheaded the development of a number of standards related to the identification, transfer, and dissemination of transportation information. The various Standards Development Organizations (SDO’s) including the International Standards Organization (ISO) are actively developing critical interfacing standards including data dictionaries, message sets, and communications protocols. These SDO’s are briefly described below.

8.1 Standards Development Organizations (SDO’s)

The following paragraphs describe the various SDO’s that are currently involved in some aspect of ITS standards development. Each of the underlined headings is a link to that organization’s website where further background information and details can be found. The overall responsibility for the ITS standards development program rests with the U.S. Department of Transportation, ITS Joint Program Office. The ITS Standards web page can be found at http://www.its-standards.net/. Management and technical support for this effort is provided by ITS America (http://www.itsa.org).

**American Association of State Highway and Transportation Officials (AASHTO):** AASHTO, teamed with the National Electrical Manufacturers Association (NEMA) and the Institute of Transportation Engineers (ITE), is the lead organization for the National Transportation Communications for ITS Protocol (NTCIP). (Also see the NTCIP SDO description below.)

**American National Standards Institute (ANSI):** The American National Standards Institute (ANSI), the U.S. administrator and coordinator of private sector voluntary standardization, does not itself develop standards. An ANSI committee [the Accredited Standards Committee (ASC) X12] was chartered to develop standards to facilitate electronic data interchange (EDI) for business transactions. This committee is in the process of developing ITS-related standards involving commercial vehicle operations (CVO).

**American Society for Testing & Materials (ASTM):** ASTM provides a forum for producers, users, consumers, and others who have interest in standard test methods, specifications, practices, guides, classifications, and terminology. ASTM leads efforts in ITS standards concerning dedicated short-range communications (DSRC).

**Commercial Vehicle Information Systems Network (CVISN – US DOT sponsored program):** The scope of commercial vehicle operations, of which CVISN is a part, includes the operations and regulations associated with moving goods and passengers via commercial vehicles. It includes activities related to safety assurance, commercial vehicle credentials and tax administration, roadside operations, freight and fleet management, and vehicle operation.
Consumer Electronics Manufacturers Association (CEMA): CEMA is a sector of the Electronic Industries Alliance (EIA). Two ITS standards have been developed under the auspices of CEMA, both having to do with traveler information radio and FM subcarrier systems.

Data Interchange Standards Association (DISA): DISA was chartered by the American National Standards Institute (ANSI) to provide its Accredited Standards Committee (ASC) X12 with administrative support. Some commercial vehicle operations (CVO) related standards are available for purchase at this site.

Institute of Electrical and Electronics Engineers (IEEE): The IEEE develops and disseminates voluntary, consensus-based industry standards involving all types of electrotechnology. ITS-related standards being developed by IEEE include message sets and data dictionaries.

Institute of Transportation Engineers (ITE): The Institute of Transportation Engineers (ITE) is one of the largest professional transportation organizations in the world. ITE members include traffic engineers, transportation planners, and other professionals who are responsible for planning, designing, implementing, operating and maintaining surface transportation systems worldwide. ITE is involved in the development of NTCIP, TCIP, and other ITS standards.

ITS America (ITSA): The Intelligent Transportation Society of America fosters public/private partnerships to increase the safety and efficiency of surface transportation through the application of advanced technologies. This site contains many excellent resources for basic information on ITS and related topics.

National Electrical Manufacturers Association (NEMA): NEMA is one of the largest standards development organizations (SDOs) in the nation and represents over 600 member organizations. NEMA is a member organization of NTCIP and acts as the publisher of NTCIP standards.

National Transportation Communications for ITS Protocol (NTCIP): The primary objective of the NTCIP is to provide communication standards that ensure the interoperability and interchangeability of traffic control and intelligent transportation systems (ITS) devices. The NTCIP is the first protocol for the transportation industry that provides a communications interface between disparate hardware and software products.

Oak Ridge National Laboratory (ORNL): Oak Ridge National Laboratory's Intelligent Transportation Systems (ITS) Research Program provides technical assistance and program support to the FHWA in the following subject areas: traffic simulation, signal optimization, real-time control, human factors, automation and systems engineering, operations research, traffic models, and management information systems.

Security Industry Association (SIA): The SIA was formed in 1969 to promote growth and expansion in the access control, auto security, biometrics, burglar alarm, CCTV, lock hardware, monitoring, outdoor protection, perimeter protection, personal response systems and personal security product industries. SIA has recently begun to investigate the need for ITS-related standards.

Society of Automotive Engineers (SAE): This organization is made up of more than 75,000 engineers, business executives, educators, and students who share information and exchange ideas for advancing the engineering of mobility systems. Information about SAE’s ITS standards
activities can be found within the "Technical Committee" section of this Web site. SAE has developed several ITS standards related to in-vehicle electronics architectures and advanced traveler information systems.

**Telecommunications Industry Association** (TIA): TIA is a national trade organization that provides communications and information technology products, materials, systems, distribution services and professional services. The association's member companies manufacture or supply most of the products used in global communication networks.

**Transit Communications Interface Profiles** (TCIP): The TCIP is a family of ITS standards for transit communications. These new standards provide the interfaces among transit applications that will allow data to be shared by transit departments and other operating entities such as emergency response services and regional traffic management centers.

**Transit Standards Consortium** (TSC): The Transit Standards Consortium is a public/private, non-profit organization that facilitates the development, testing, maintenance, education, and training related to transit standards. The organization includes transit agencies, standards bodies, vendors, and other interested parties.

**Volpe National Transportation Systems Center**: The John A. Volpe National Transportation Systems Center (Volpe Center), located in Cambridge, MA, is an organization of the Federal Government whose principal role is to serve as a national center of transportation and logistics expertise. As such, it provides research, analytic, management, and engineering support to the U.S. Department of Transportation, other Federal agencies, and state and local governments.

### 8.2 Standards Elements

A number of key elements make up a standard or set of standards. These include Data Dictionaries, Message Sets, Object Definitions and Communications Protocol. Each of these will be described in more detail below.

#### 8.2.1 DATA DICTIONARY

Data Dictionaries provide the definition and format of individual data elements that are then grouped into individual messages. In other words, messages are the sentences and data elements are the individual words.

Two good examples of data dictionaries are the Traffic Management Data Dictionary (TMDD) developed by the Institute of Transportation Engineers (ITE) and the Advanced Traveler Information Systems (ATIS) Data Dictionary developed by SAE.

#### 8.2.2 MESSAGE SET

Message Sets (MS) are an essential component in the design and operation of modern computer based systems. They provide the basic information flows (generally described as messages) upon which communications between systems depend. Specifically, a message set provides the information definition (semantics) and format (syntax) to handle individual informational exchanges on specific topics. Thus, agreed upon message sets with unambiguous message definitions is one of the essential characteristics of standards required for information exchange between individual traffic management systems. Message sets are also important for communications between traffic management systems and other ITS users and/or suppliers of traffic related information. An example of a currently implemented Message Set is Location Reference Message Specification (LRMS). This specification standard was developed at Oak
Ridge National Laboratory. The LRMS establishes standard formats for individual messages used within message sets to convey locations. The design of the LRMS is based on three fundamental concepts. First, the transfer of a location is a message in itself. Second, the use of multiple location message options (termed profiles) is used within an expandable framework. Finally, the use of a set of well-known ground control points (referred to as “datums”) is used to permit registration of different map databases to one another so that locations transferred can be understood with minimal ambiguity. Message Sets work in hand-in-hand with Data Dictionaries and Communications Protocol.

8.2.3 Object Definitions

The analogy to message sets in the world of object oriented software is object definitions. Under the Common Object Request Broker Architecture (CORBA) protocol, object definitions are expressed as Interface Definition Language, or IDL. Objects are intuitive in nature – for example bus objects, traffic signal objects, vehicle detector objects, incident objects, etc. Each defined object has attributes, or characteristics and methods that act upon it. For example, a bus object contains attributes of <driver ID>, <bus number>, <passenger capacity>, <wheelchair compatible>, and so on. A bus object can be created, removed or stored – these are examples of its methods. Object definitions will gradually evolve as more and more object oriented systems are deployed. One major shortcoming of defining object-oriented architectures is that the National ITS Architecture is not yet object oriented. However, this does not necessarily lessen the value of the National Architecture in the definition of a regional architecture containing object-oriented systems.

8.2.4 Communications Protocol

Communications protocol is the set of data exchange rules that tie together the message set and data dictionary definitions. One could imagine having a word vocabulary and sentence structure but no grammar. This would be the situation if no communications protocol existed to allow interoperation between transportation management centers, for example. One of the more critical developments affecting a regional ITS architecture has been the evolving process of the NTCIP Application Profiles, formerly known as the NTCIP Class E or Center-to-Center standards. Currently, there are five NTCIP Application Profiles: 2301 (Simple Transportation Management Framework), 2302 (Trivial File Transfer Protocol), 2303 (File Transfer protocol), 2304 (Data Exchange ASN.1, also known as DATEX) and 2305 (Common Object Request broker Architecture – CORBA). We will concern ourselves with only the 2304 and 2305 standards at this point. Center-to-Center communications encompasses the exchange of information between domain-specific systems such as freeway management systems, transit management systems, emergency management systems, information service provider systems, traffic signal systems, and commercial vehicle systems. Because it is the fundamental standard used to interconnect management systems across modes, the C2C standard is crucial to the development of a regional architecture.

The Center-to-Center (C2C) Working Group of the NTCIP is developing the CORBA and DATEX-ASN protocols to provide optional paths for inter-system communications. These protocols complement each other and together provide a convenient means for any type of system to join a data exchange network. Through the proper use of these two protocols, the ITS industry will be able to more readily integrate disparate systems. Some specific details of CORBA are provided as an example of how center-to-center protocol might be implemented in the real world. It should be noted that the California Alliance for Advanced Transportation Systems (CAATS) Statewide ITS Architecture recognizes the existence of both CORBA and DATEX and provides for their interconnection.
CORBA uses object-oriented technologies to provide advanced data exchange services. All of the data available for data exchange are registered with the local object request broker (ORB). Each center implements an ORB and related CORBA services software, comprising the CORBA system. This software is commercially available. At the simplest level, when a remote data item (such as an externally generated incident) is required to perform an action, the CORBA system is then responsible for negotiating the data exchange with the various brokers. As a result, from the programmer's perspective, all data on the network appear to be locally available. This simplifies computer code and allows a very modular design of software.

CORBA provides several features to support networks connecting object oriented systems, and assuming sufficient processing power and communications bandwidth are provided, it could be used for all applications between such systems. The DATEX protocol uses a mature message set with a less mature protocol and currently a lesser availability of commercial development tools. Conversely, CORBA uses less mature object models with a more mature protocol. Over time, as a standardized reference model emerges, new object-oriented systems come on line, and processing and communications resources are upgraded, more and more systems will use the CORBA protocol. Non-object-oriented “legacy” (pre-existing) systems may connect to a CORBA network through the Legacy Bridge function. The operation of this Legacy Bridge function in the case of transit data is illustrated in Figure 8-1. The proper operation of a Legacy Bridge assumes that a standard set of object definitions exists for a specific regional architecture.

![Figure 8-1: Converting Legacy Data into Standard CORBA-Compatible Object Definitions](image)

*Figure 8-2* shows how all of these standards inter-relate. For each system interface in the architecture, there must be a formal definition of (1) how the data will be exchanged (protocol), (2) the data message structure (message sets), and (3) data element definitions (data dictionary).
The IEEE Data Dictionary Standard (IEEE P1489, Box 1a in Figure 8.2) documents the basic building block used to define ITS data elements and other data concepts. The Message Set Template Standard (IEEE P1488, Box 2a) defines the format used to combine individual data elements together in order to form ITS messages. ITS messages provide a description of what to transfer, but not the details of how the information is transferred.

Functional area data dictionaries (Box 1b) and message sets (Box 2b) use the above formats to define their requirements. As mentioned previously, these standards include the Traffic Management Data Dictionary (TMDD) for ATMS systems, the Transit Communications Interface Profiles (TCIP) for transit systems, and the SAE J-Series standards for ATIS and in-vehicle devices, among others. Local agencies should also use these formats when specifying project-specific data and messages. This will allow future integration efforts to readily understand the design of the local system and allow maximum reuse of computer code.

ITS messages can be readily transmitted using the DATEX-ASN protocol (Box 3a). Alternatively, the information and functionality contained within the ITS messages can be mapped to an object-oriented data model (Box 1c) and reference model (Box 2c) according to the rules defined by Object Management Group (OMG) standards (Box 2d). These object-oriented data and reference models, described in terms of a notation scheme called Unified Modeling Language (UML) and a data specification called Interface Definition Language (IDL), can then be used as the basis for exchanging data using the Common Object Request Broker Architecture (CORBA) protocols (Box 3b). An emerging alternative for this layer of standardization is the use of the eXtensible Markup Language, or XML. XML data standards
and exchange protocol are governed by the World Wide Web Consortium, W3C. XML itself is a data format standard and it must be combined with one or more data exchange protocol to form a useful communications tool. For the San Diego regional architecture, CORBA and XML will be used for tightly-coupled and loosely-coupled applications respectively. Regardless of the application-specific protocol used (e.g. transportation applications), the Internet protocols (Transmission Control Protocol-TCP, User Datagram Protocol-UDP, and Internet Protocol-IP) are normally used for sending data over the network. This is consistent with the requirements of the NTCIP 2305 CORBA Application Profile.

In a more specific context, Figure 8-3 shows where certain standards fit into a typical transportation system ATMS/ATIS architecture containing field elements, multiple transportation management centers and a traveler information system with numerous means of dissemination. A diagram similar to Figure 8-3 could be constructed for transit management, substituting the NTCIP 1400 Series standards for the SAE standards. Virtually all field device and data collection activity is covered by one of the many NTCIP standards. Center-to-center data exchanges are covered by the NTCIP 2305 CORBA or 2304 DATEX-ASN (Data Exchange – American Standard Notation). For the San Diego regional architecture, the 2305 CORBA will be used since current experience in Southern California provides a knowledge base and minimizes technical risk of future project implementation. Dissemination and location referencing to end users is covered by several of the SAE J-Series standards.

Specific standards that are most likely to be implemented in the San Diego region over time are summarized in Table 8.1. The detailed application of these standards is specific to individual projects and should be addressed in Requirements Definition and High Level Design as

**Figure 8-3: Operational Use of Standards in the San Diego Region Architecture**
applicable for each project. Moreover, local and regional agencies should require these standards be implemented as appropriate when ITS software and hardware systems are procured as part of project delivery. For example, if a project required control sharing through an “Intertie” communications network, the standards application would follow the pattern shown in Figure 8-4.

<table>
<thead>
<tr>
<th>Standard</th>
<th>Functional Area</th>
<th>Maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td>NTCIP 1201, 1202, 1203, 1204, 1205, 1206, 1207, 1208, 1209, 1210, 1211</td>
<td>Global, Actuated Signal Controller, DMS, ESS, CCTV, Data Collection, Ramp Meter, Video Switches, Sensor Objects, Signal Systems Master, Signal Control Priority object definitions</td>
<td>Various levels (Global, Actuated Signal Controllers, DMS, ESS Approved, others Pre-ballot).</td>
</tr>
<tr>
<td>1301</td>
<td>Weather Report messages</td>
<td>Pre-ballot.</td>
</tr>
<tr>
<td>NTCIP 2304</td>
<td>Center to Center Application Profiles (DATEX)</td>
<td>Approved.</td>
</tr>
<tr>
<td>NTCIP 2305</td>
<td>Center to Center Application Profiles (CORBA)</td>
<td>Pre-ballot. Object definitions need more work. Southern CA Showcase object definitions will be the basis.</td>
</tr>
<tr>
<td>SAE TIML (XML)</td>
<td>Traffic Information dissemination to ISP sites (public and private)</td>
<td>In development. This is an extension of the SAE J2353/J2354/J2369 ATIS standards.</td>
</tr>
<tr>
<td>TMDD (TM 1.03, TM 2.01)</td>
<td>Traffic Management Data Dictionary, TMC Message Sets</td>
<td>Being revised.</td>
</tr>
<tr>
<td>NTCIP 1401-1408</td>
<td>Transit Management</td>
<td>Former TCIP standards. 1401-1407 Approved, 1408 (Fare Collection) Pre-ballot.</td>
</tr>
<tr>
<td>SAE J1708</td>
<td>Transit Vehicle Equipment Interface</td>
<td>Approved.</td>
</tr>
<tr>
<td>NTCIP 2001, 2101-2104, 2201-2203</td>
<td>Various Communications Protocol</td>
<td>Approved.</td>
</tr>
</tbody>
</table>
8.3 Why Standards?

Why are national ITS standards important and how do they support the San Diego regional architecture? The San Diego regional ITS architecture “regionalizes” the National ITS Architecture by tailoring it to fit regional conditions. The National ITS Architecture includes all relevant ITS standards that for the most part carry over into regional architectures. As long as the San Diego regional architecture adheres to an agreed set of ITS standards, any system within this region can interoperate with any other system in the region or elsewhere in Southern California as appropriate. This will allow the San Diego Region to adopt a flexible architecture that supports current and planned ITS projects in the region.
9.0 PROJECT DEPLOYMENT SEQUENCING

The San Diego Region is somewhat unique from many regions around the nation that have recently developed or are currently developing their regional ITS system architecture due to two primary factors:

1. **Regional Approach to ITS Project Deployment** – Most of the ITS deployment efforts in the region center around a handful of larger scale regional deployment efforts. A good example of this is the Regional Transit Management System (RTMS) project where the major transit agencies are cooperating in a regional deployment of an advanced communications and transit scheduling, CAD, and fleet management solution. This project will eventually encompass the large majority, if not all transit operators desiring to deploy this type of ITS system. This means that unlike any area that may have to deploy many different smaller transit management systems, the San Diego region is focused on a single system limiting concerns about project sequencing.

2. **Advanced Character of On-Going Project Deployment Efforts** – In addition, most of the regional ITS deployment efforts in the region have been in conceptual development, design, and/or early deployment for the last couple of years. This means that the concepts, scope of effort, and timelines for the regional ITS projects are well advanced. As a part of this architecture and the San Diego region’s approach to a coordinated and efficient deployment effort, agencies are strongly encouraged to participate and/or utilize the work that has been developed for the regional ITS project in their particular area of interest. For example, a city wishing to deploy local ATMS functions such as camera video and control and changeable message signs is encouraged to utilize the Integrated Workstation (IWS) being developed as a part of RAMS Tier 2 and to add functionality to their benefit and the benefit of the region as it suits their needs.

Taken together these two factors mean that the typical approach to project sequencing which focuses on the logical sequence of deployment for ITS project subsystems or market packages is not very useful to the San Diego region. Agencies desiring to approach a ITS project development effort totally independent of the regional deployment efforts would at a minimum be encouraged to make use of the requirements, design, and procurement documents that have bee prepared for the regional efforts.

9.1 Importance Of Overall Project Sequencing to San Diego ITS Development

While the typical project sequencing information may be of limited use to the region, the overall sequencing of each regional project and its integration components for tying into the regional IMTMS Network are very important. The sequencing of regional systems and integration of each regional system indicates when the functionality and information from that modal system will become available to other systems on the IMTMS Network.

**Figure 9-1** displays the general sequencing relationship true for all of the region’s ITS systems. Basically, the field sensing infrastructure (loops, cameras, AVL, etc.) with the associated communications is essential to the operation of any system. Each regional modal system operates independently with its own internal system communications. These internal communications usually serve to link multiple dispatch locations to the modal system. Finally, the intermodal management systems bring together the functionality and information of the various modal systems, both in terms of software applications and system to system.
communications. A breakdown or missing link in a lower level of this dependency pyramid will impact the next levels up, and each piece of the picture is interrelated.

**Figure 9-1. Overall Deployment Sequencing Considerations**

This points out the importance of each level of the regional ITS deployment effort. Individual agencies will usually be focused on the development of the middle layer, modal management systems, but must be cognizant of the state of their field infrastructure. In addition, agencies must consider what role their system plays in the larger regional picture and how they will tie into the regional intermodal management systems. This can generally be accomplished through one of two approaches:

1. **Utilizing the regionally development management systems tools** – For example, an agency that utilizes the regional IWS, RTMS, or RAVL systems will already be working with a system that meets regional integration needs.

2. **Separately develop an interface to the regional IMTMS Network** – For example, an agency that is deploying a new functionality not covered under the existing regional deployment efforts will need to review this system architecture document with special attention being paid to what standards they will utilize with the understanding that they will need to coordinate their efforts through the IMTMS Task Force.

### 9.2 Overall Major Regional Its Project Sequencing

**Figure 9-2** displays the overall project sequencing for the major regional IMTMS deployment efforts. These timelines should be seen as estimates and schedules are likely to change over time. In addition, the extent of deployment for each regional system is planned to grow over time. For example, a regional system may be operational for one or two agencies early in the overall regional deployment sequence with agencies being added to the system over time. This means that the extent of information and functionality available from each system will grow over time with the core system being established up front and expansion following to each participating agency as they become ready to deploy and operate their piece of the regional system.
<table>
<thead>
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<th>ID</th>
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<td>Q2</td>
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<td>ATMS- Intermodal</td>
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<tr>
<td>2</td>
<td>Design</td>
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<td>4</td>
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<td>RAMS Tier 1 QN4+</td>
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<td>7</td>
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<tr>
<td>22</td>
<td>Deployment</td>
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</tbody>
</table>

Figure 9-2. Overall Regional ITS Deployment Timeline & Sequencing
9.3 Sequencing & Schedule for Major IMTMS Integration Efforts

Somewhat separate yet interrelated to the development of each regional modal system is the development of the IMTMS communications and intertie systems that allow for the intermodal operability of the overall regional IMTMS. Many of the regional intertie development efforts are closely tied to the development of the ATMSi which serves as a conceptual “hub” for deployment of the region’s transportation management capabilities. Currently, ATMS version 2 is operational with Caltrans. Figure 9-3 displays the anticipated timelines for development of key components of the regional IMTMS Network functionality. This timeline should be considered an estimate, and agencies interested should discuss the most current information available with the IMTMS Task Force. Key components of the IMTMS integration effort include:

- **TrMS/FSP/TMT seed or intertie** – which provides the basis of integration for the RAVL and RTMS systems.
- **ATIMS** – which provides the public sector data portal to private traveler information service providers.
- **RAMS Tier 1/QuicNet 4 seed or intertie** – which provides the basis for integrating the RAMS Tier 1 QuicNet 4+ system to the regional IMTMS Network and therefore to the RAMS Tier 2 IWS.

RAMS Tier 2 is being developed already compliant with the regional IMTMS Network standards, this means that integration sequencing issues with the IWS are more focused on the provision of physical communications.
Figure 9-3. Regional IMTMS Network & ATMSi Sequencing