DEVELOPMENT OF THE REGIONAL INTELLIGENT TRANSPORTATION SYSTEMS ARCHITECTURE FOR THE SAN JUAN METROPOLITAN AREA

by

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ABSTRACT

Several regions around the United States and Puerto Rico have been facing increasingly complex problems related to their transportation systems. In many cases, the use of advanced technology and strategies collectively known as Intelligent Transportation Systems (ITS) have helped to substantially improve their transportation systems. The integration of all the ITS components in a framework is called the ITS system architecture and has usually been an important part of the success in improving the transportation system.

This work presents the methodology followed to develop the regional ITS architecture for the San Juan Metropolitan Area. Initially, the region is described including the stakeholders group and identified needs. A description of user services, operational concepts and functional requirements is then presented. These steps lead to the presentation of the system architecture based upon the National ITS Architecture. At the end, the implications of the architecture in terms of planning and project development are discussed.

RESUMEN

Muchas regiones alrededor de los Estados Unidos y Puerto Rico enfrentan problemas crecientemente complejos relacionados a sus sistemas de transportación. En muchos casos, el uso de tecnología avanzada y estrategias conocidas colectivamente como Sistemas Inteligentes de Transportación (SIT) han ayudado a mejorar sustancialmente sus sistemas de transportación. La integración de todos los componentes de SIT en un marco, es llamada la arquitectura de SIT y usualmente ha sido parte importante del éxito.

Este trabajo presenta la metodología seguida para desarrollar la arquitectura regional de SIT para el Área Metropolitana de San Juan. Inicialmente, la región es descrita incluyendo el grupo de constituyentes y necesidades identificadas. Una descripción de servicios a los usuarios, conceptos operacionales y requerimientos funcionales es presentada luego. Estos pasos nos llevan a la presentación de la arquitectura basada en la Arquitectura Nacional de SIT. Finalmente, las implicaciones de la arquitectura en términos de planificación y desarrollo de proyectos son discutidas.

To my family . . .

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List of Acronyms

Term	Definition
AVL	Automatic Vehicle Locator
CAD	Computer Aided Dispatch
CCTV	Close Circuit Television – generic term often used to refer to many different types of camera systems
DMS	Dynamic Message Signs
GIS	Geographic Information Systems – digital maps
HAR	Highway Advisory Radio – mechanism for broadcasting traveler information to motorists
ITS Architecture	Intelligent Transportation Systems Architecture -A framework for ensuring institutional agreement and technical integration of technologies for the implementation of projects under ITS strategy
MBA	Metropolitan Bus Authority
MCO	Maintenance and Construction Operations
PRHTA	Puerto Rico Highway and Transportation Authority
Rule / Policy	Abbreviated reference to Department of Transportation 23 CFR Parts 655 and 940, January 8th 2001 that provides policies and procedures for implementing section 5206(e) of the Transportation Equity Act for the 21st Century (TEA-21).
SDO	Standard Development Organization
SJMA	San Juan Metropolitan Areas
TMC	Transportation Management Center
TTC	Temporary Traffic Control

1 Introduction

1.1 Purpose

The purpose of this project is to develop a regional Intelligent Transportation Systems (ITS) Architecture for the San Juan Metropolitan Area (SJMA), based on stakeholders' interviews, to gather information on existing and planned ITS infrastructure, services, and information sharing arrangements.

Developing a regional ITS architecture for the San Juan Metropolitan Area is important for several reasons, including:

- To achieve interoperability between ITS deployments.
- To reduce the cost of ITS deployments.
- To document the current and future information sharing relationships between existing and planned ITS elements.
- To meet the Federal TEA-21 Section 5206(e) requirements on Architecture Conformity as interpreted in the USDOTs *Interim Guidance on Conformity with the National ITS Architecture and Standard.*
- To map each ITS element in the SJMA to one or more National ITS Architecture entities.

1.2 Definition

In engineering, a systems architecture is related to some aspects of the structure of a system. There is no strict definition of which aspects constitute a systems architecture, and various organizations define it in different ways (*Wikipedia, 2006*), including:

- *"The fundamental organization of a system, embodied in its component, their relationships to each other and the environment, and the principles governing its design and evolution."* From American National Standards Institute (ANSI) / Institute of Electrical and Electronic Engineers (IEEE) 1471-2000.

- *"It defines the (system) components or building blocks…and provides a plan from which products can be procured, and systems developed, that will work together to implement the overall system."* From The Open Group Architecture Framework (TOGAF).

In the case of an ITS architecture, it describes interaction among physical components of the transportation systems including travelers, vehicles, roadside devices, and control centers. It also describes the information and communication systems requirements, how data should be shared and used, and the standards required to facilitate information sharing.

1.3 Background

Since the sixties, the Puerto Rico Department of Transportation and Public Works has been actively looking for and implementing innovative solutions to the ever increasing problem

of congestion on the highway system in the San Juan Metropolitan Area. Today, many of these solutions are widely recognized as basic elements of Intelligent Transportation Systems.

The most relevant applications and a brief description of ITS elements used in the San Juan Metropolitan Area are listed below.

- *Contra-flow bus lanes* – used by the Metropolitan Bus Authority (MBA) since the seventies, have been highly successful in efficiently moving transit and emergency vehicles. Today they are also used by Metrobus I, a privately operated high frequency bus service along one of the major arterials in San Juan.

- *Reversible lanes and movable barriers* – in freeways, arterials and collectors of the San Juan Metropolitan Area. These lanes have been successful in addressing significant changes in the directional distribution of traffic during peak hours.

- *Electronic Toll Collection System* – known as AutoExpreso, was inaugurated in 2005. Developed in response to various research efforts since the early nineties trying to improve the efficiency of toll collection systems in the expressways of Puerto Rico. Today 35 percent of all toll transactions are made using AutoExpreso, over 45 percent during peak hours.

- *Traffic Management Center, Regata 2000* – Intelligent Transportation Systems were used to enhance mobility and safety of the users of the transportation system during this

special event. A Traffic Management Center (TMC) was created to receive information and respond to varying traffic conditions. Among the ITS elements integrated to this center were:

- Closed-circuit television for detection and supervision,
- Dynamic Message Signs (DMS),
- Coordinated traffic signals along arterials,
- Reversible lanes,
- Short-range radio equipment to allow communication between control centers,
- Real time parking lot information,
- Pre-trip information through the Internet,
- En-route traveler information through Highway Advisory Radio (HAR), and
- Service patrol to provide immediate incident assistance.

All these elements were used in monitoring, traffic management and information distribution in the whole area of influence created by the special event. All of the above illustrate what efforts have been done in Puerto Rico in terms of ITS. Still in many places in the United States ITS architectures have been developed to address transportation related problems. Some examples are the Regional ITS Architecture for Metropolitan Boston (*Commonwealth of Massachusetts, 2005*), the Kansas City Regional ITS Architecture (*Mid-America Regional Council*), the Central Ohio Regional ITS Architecture (*Mid-Ohio Regional Planning Commission, 2004*) and the Southern California Regional ITS Architecture Final Version 6.0 (*Southern California Association of Governors).*

1.4 Scope

The San Juan Metropolitan Area (SJMA), as defined by the 2000 Census, consists of 30 municipalities. Of these municipalities, only six municipalities were chosen for the development of this Regional ITS Architecture on the basis of population and land area. These represent the geographic scope of the architecture. These municipalities are Bayamón, Caguas, Carolina, Guaynabo, San Juan and Toa Baja. The combined population of these cities is 1,181,088 people and the combined area is 247.3 square miles. This represents 31 percent of the population of Puerto Rico and 7.22 percent of its area.

The functional scope of the architecture, that is, the services to be included in the regional ITS architecture are mostly related to incident management and traffic management. A detailed discussion of these services is provided in following chapters.

In Puerto Rico, a financially constrained statewide plan is developed with a timeframe of at least 20 years. Projects are classified into short term, medium term and long term projects. Needs are identified and projects are proposed considering certain financial constraints.

In Puerto Rico, as in the mainland, a Transportation Improvement Plan (TIP) with a proposed project sequencing is developed by regional planning organizations; in this case a Public Policy Committee of the Metropolitan Planning Organization (MPO). This committee is formed by city mayors and other agencies that play a part in the decision making process in regards to project sequencing. A summary of the TIPs turns into the Statewide Transportation

Improvement Program (STIP). The STIP is formally adopted in an MPO meeting presided by the Secretary of the Department of (FHWA) and Federal Transit Administration (FTA). The STIP is revised every 5 years to keep it current. The SJMA Regional ITS Architecture has a timeframe consistent with the STIP, that is, 5 years into the future.

It is important to make a distinction between the planning process and the regional ITS architecture in terms of project cost analysis. Although the architecture is an important tool for use in transportation planning, it is not part of the planning process therefore costs associated with projects, although part of the planning process, are not within the scope of the architecture.

1.5 Organization

This work presents the methodology (described in Chapter 2) followed to develop the regional ITS architecture for the San Juan Metropolitan Area. In Chapters 3 and 4 the region is described including the stakeholders group and identified needs. Chapters 5 through 8 present a description of user services, operational concepts and functional requirements. These steps lead to the presentation in Chapter 9 of the system architecture based upon the National ITS Architecture. Chapters 10 through 12 present a sequence of projects that will flow from the architecture and the elements that will guide their implementation such as standards and agreements between stakeholders. Chapter 13 discusses the implications of the architecture in terms of planning and project implementation. In Chapter 14 a maintenance plan for the architecture is described. In the end, Chapters 15 and 16 present conclusions gathered from the development of the architecture followed by recommendations for future work.

2 Methodology

The *Regional ITS Architecture Guidance* of the National ITS Architecture Team of the Federal Highway Administration suggests that the following process, presented in Figure 2-1, be followed when developing a regional ITS architecture.

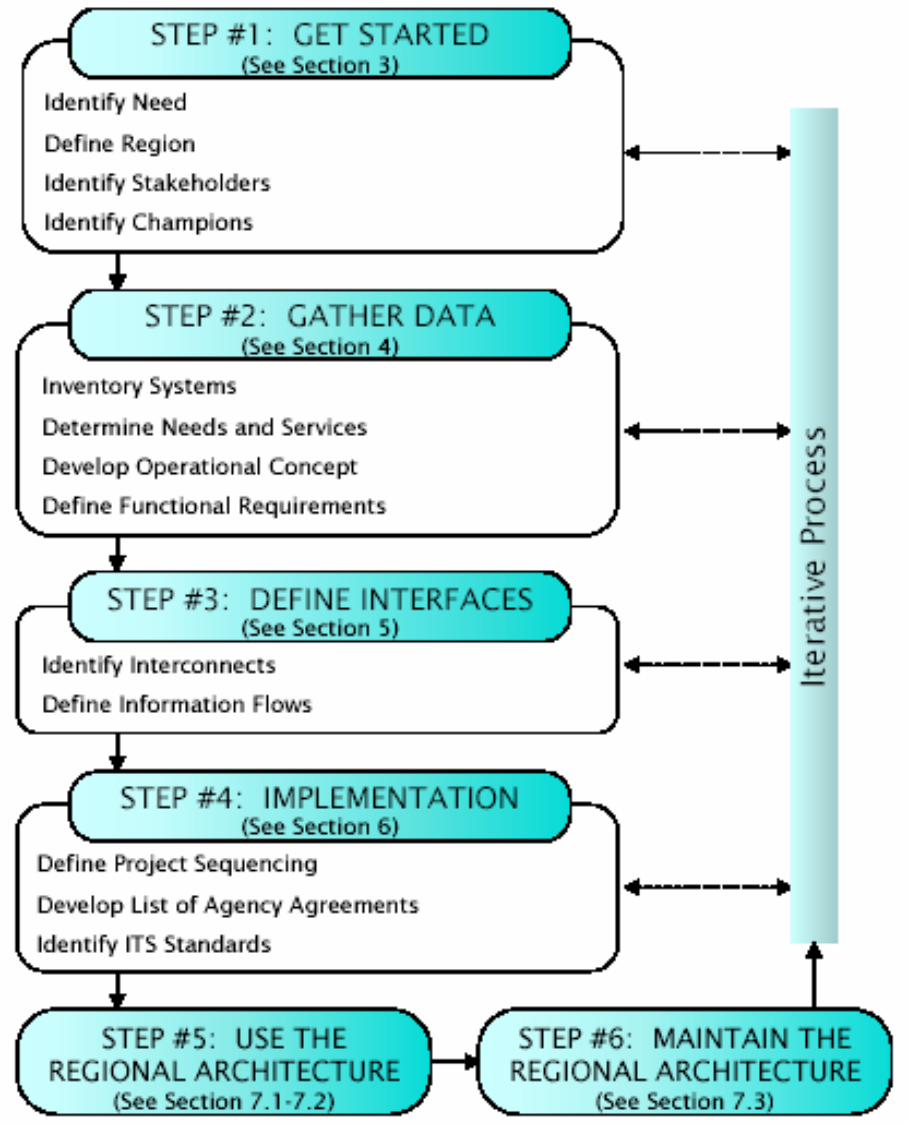

Figure 2-1: Process of developing a Regional ITS Architecture

In the first step, Get Started, the focus is on the institutions and people involved in the architecture. Based on the scope of the region, the relevant stakeholders and one or more champions are identified, and the overall development effort is planned. This step is fully developed in Chapters 3 and 4. In Chapter 3 a description of the region, the transportation problems in the SJMA, the major roadways and transit services along with the cities included in the architecture are presented. Chapter 4 describes the process of selecting and gathering pertinent information from stakeholders.

In the second step, Gather Data, the existing and planned ITS systems in the region are inventoried, the roles and responsibilities of each stakeholder in developing, operating, and maintaining these ITS systems are defined, the ITS services that should be provided in the region are identified, and the contribution (in terms of functionality) that each system will make to provide these ITS services is documented. Chapters 5 through 8 present the process described in this step. Chapter 5 presents an inventory of ITS elements planned or existing in the San Juan Metropolitan Area. In Chapter 6 the needs and services for the SJMA are identified. In Chapter 7 a concept of operations is defined which documents the roles and responsibilities of the stakeholders. It also defines the stakeholders' responsibilities in the implementation and operation of the system. Market Packages are then assigned to address the needs defined in Chapter 6. Finally in Chapter 8, Functional Requirements, the activities that will be performed by the systems are identified.

In the next step, Define Interfaces, the connections ("Interconnects") between systems are identified, and the information that will be exchanged on each of the interfaces is defined.

Chapter 9 presents a high level conceptual diagram with the SJMA ITS architecture subsystems ("sausage diagram") showing potential connectivity between subsystems. Also customized market packages are presented to illustrate information flows among elements.

In the following step, Implementation, products can be defined that will guide implementation of the projects that will flow from the regional ITS architecture. These include a sequence of projects, a list of needed agency agreements, and a list of standards that can be considered for project implementation. Chapters 10 through 12 present respectively a list of proposed ITS projects in the SJMA; some of the agreements necessary to accomplish the implementation of the regional ITS architecture; and relevant standards to facilitate the deployment of ITS projects in the region.

The fifth step: Use the Regional ITS Architecture, is where the benefits of developing an architecture are realized. Once a regional ITS architecture is created, it can be used by stakeholders in planning their ITS projects to support regional goals. It can also be used to maximize appropriate integration of projects identified by the planning process. Chapter 13 describes how the SJMA Regional ITS Architecture will be used to support both the planning process and project implementation process.

In the sixth and final step of the process, Maintain the Regional ITS Architecture, a maintenance plan is put in place to guide controlled updates to the regional ITS architecture baseline so that it continues to accurately reflect the region's existing ITS capabilities and future plans. Chapter 14 describes the maintenance plan for the SJMA Regional ITS Architecture.

3 Regional Description

3.1 Introduction

This section provides the context for the development of the SJMA Regional ITS Architecture. It is important to consider the general demographic and geographic characteristics of the area and the existing transportation systems.

Puerto Rico is part of the Greater Antilles in the Caribbean Sea. Puerto Rico is located east of the Dominican Republic and east of Miami, Florida; southeast of New York City, New York; northeast of Central America and north of Caracas, Venezuela. The island has a land area of approximately 3,425 square miles (8,406 km^2), and a population of 3,808,610 persons according to the 2000 U.S. Census for a population density of 1,112 persons per square mile.

Puerto Rico is divided into 78 municipalities that vary widely in terms of their population and land area. The SJMA is the principal center of population, employment and government activities in Puerto Rico. As defined by the 2000 Census, the SJMA has 30 municipalities covering most of the north and east of Puerto Rico. Figure 3-1 presents a map of Puerto Rico with its metropolitan areas as defined by the 2000 Census. However, for simplification purposes, the SJMA is defined here as in the 1990 Census consisting of thirteen municipalities: Bayamón, Canóvanas, Carolina, Cataño, Dorado, Guaynabo, Loíza, Naranjito, Río Grande, San Juan, Toa Alta, Toa Baja, and Trujillo Alto. This definition of the SJMA has a land area of 404 square miles (1,036 km^2) and a population of 1,400,320 persons according to the 2000 Census for a population density of 3,464 persons per square miles.

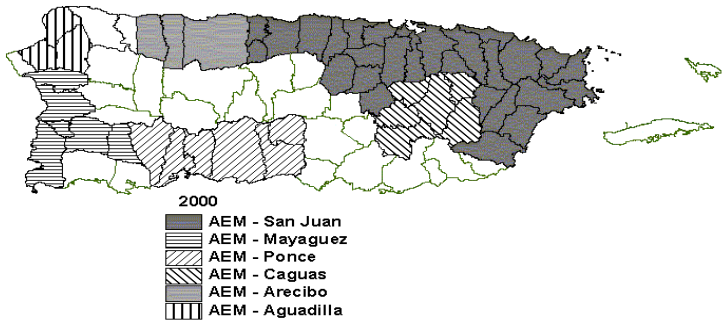

Figure 3-2: Metropolitan Areas as defined by the 2000 Census.

From 1960 to 2000 the SJMA population increased by 84.2 percent. By 2010, the population for this area is expected to grow by an additional 10 percent to 1.55 million people. One-third of the SJMA population resides in San Juan and another third is concentrated in Bayamón and Carolina. This general distribution of the region's population is expected to continue through the year 2010.

In line with the population, regional employment is heavily concentrated along the north–south and east–west metropolitan spines. According to 2000 U.S. Department of Labor estimates, San Juan supports 63 percent of the region's total employment of approximately 410,000 jobs; another 26 percent is concentrated in Bayamón, Carolina, and Guaynabo.

In 2000, more than 90 percent of all trips between home and the workplace were made in private vehicles. The density of vehicles per kilometer of paved road in the SJMA is three times higher than on the United States mainland, and one of the highest of all metropolitan areas in the world. Gridlock traffic conditions result, along with extended peak period congestion and delay throughout the region, particularly in central San Juan, including Santurce and Hato Rey.

3.2 Transportation Problems in the SJMA

An assessment of average daily traffic volumes and levels of service on the major roadways was performed using the 1992 Highway Performance Monitoring System (HPMS). This indicates that numerous roadway segments are opening at, or above, capacity. Of the 90 roadway segments in the SJMA for which data are available, 36 segments are operating above capacity throughout the day, 7 segments are operating at 80 percent of capacity or more, and another 19 segments are operating between 60 and 80 percent of capacity. Only 28 segments are operating at below 60 percent of their capacity.

Given that these capacity statistics reflect average daily traffic volumes, it can be expected for the congestion to increase during peak periods when most roadway segments operate at or above capacity. The acute levels of congestion result from the following conditions:

- Concentrated population and employment densities and centralized development patterns,
- High and increasing travel demand,
- Limited capacity of the network of highways and arterial streets in the SJMA,
- Inadequate public transportation service,
- Lack of inter modal connections, and
- Constrained mobility for low–income families.

The congestion and delays that characterize much of the region's transportation system have also intensified other social and environmental problems such as productivity losses, wasted energy, degraded air quality, and increased vehicular accidents (*Colucci, Valdés, Torres 2001*).

3.3 The need for ITS in the SJMA

As stated before, San Juan's transportation systems are facing significant challenges. The 1.4 million SJMA residents generate 3.4 million trips per day. These daily trips are expected to increase to 4.6 million by 2010, which represents an increase of 35 percent. This will happen as a result of a 10 percent growth in population and employment and a 10 percent increase in per capita trip making.

To meet these challenges, San Juan has recognized the need to find innovative solutions to save travelers time through enhanced traffic management, traveler information and transit services. Lives will also be saved with improved safety measures. Moreover an impact on the economic side is expected by reducing operating expenses and leveraging limited transportation funds. Advanced information and communications technologies, also known as Intelligent Transportation Systems (ITS) are among the tools necessary to meet San Juan's transportation challenges.

3.4 Major Roadways

Puerto Rico Highway and Transportation Authority (PRHTA) operates and manages the expressway system in the SJMA. The total length of these highways is approximately 426 km. Table 3-1 introduces the most important roadways in SJMA.

Table 3-1. SJMA Major Roadways

Roadways	Description
PR-22	• 21.7 km • Includes the municipalities of San Juan, Guaynabo, Cataño, Bayamón and Toa Baja. • Two toll stations • Three to four lanes in each direction • Approximate AADT of 242,000 (June 2, 2002).
PR-18	• 6 km • Includes the municipality of San Juan • Three to four lanes in each direction • Approximate AADT of 270,000 (June 1, 2002).
PR-52	• 13.8 km • Includes the municipalities of San Juan and Caguas • One toll station • Three to four lanes in each direction • Approximate AADT of 166,000 (April 30, 2003).
PR-26	• 15.0 km • Includes the municipalities of San Juan and Carolina • Approximate AADT of 160,000 (April 11, 2002).

3.5 Transit

SJMA provides bus and rail transit services. The local bus system in the SJMA is made up of the Metropolitan Bus Authority (MBA) and Metrobus I. The MBA has a fixed route, fixed schedule regular bus service and a demand responsive service. Metrobus I is a contract service with the Puerto Rico Highway and Transportation Authority. There is also the "público system", a type of paratransit service that serves the general public throughout Puerto Rico. To

enhance the transit system, a metro line was recently inaugurated. This metro system is known as “Tren Urbano”. A brief description of these public transit systems follows.

Metropolitan Bus Authority (MBA)

The MBA bus system has 30 routes providing regular service in the SJMA including the municipalities of San Juan, Bayamón, Guaynabo, Cataño, Carolina, Toa Baja and Trujillo Alto. The MBA vehicle fleet in 2000, according to the statistics from the National Transit Database, consisted of 301 regular full size buses that were available for maximum service with 196 operating in the regular routes. Recently, the MBA route structure was modified to integrate its service with Tren Urbano.

The regular bus system is complemented by a dial-a-ride paratransit system that provides an alternative to the elderly and handicapped. This system is a scheduled service that provides transportation from home to any destination in the MBA area of service. The vehicle fleet for this demand responsive service consists of 36 vehicles available for maximum service.

Metrobus I

Metrobus I is a privately operated bus route that provides a high frequency service from Old San Juan to Río Piedras along a high density corridor using in part exclusive contra-flow lanes. The vehicle-fleet consists of 30 low-floor full size buses that are available for maximum service.

"Público" System

The "público" system is a type of paratransit service that serves the general public throughout Puerto Rico. The "público" includes four distinct types of sevice:

- *Local* – unscheduled municipal level coverage connecting the downtown area to major residential and activity centers and nearby communities. It operates with fixed routes but without a fixed scheduled since they respond to the passenger's demand.
- *Inter-municipalities* – unscheduled service between municipalities usually to and from centrally located terminals and using primary state highways. It operates with fixed routes with minor route deviations to serve activity centers.
- *"Linea"* – scheduled door to door service between cities with reservations taken by phone.
- *"Urbano"* – a special service in the municipality of Mayaguez similar to a shared-ride taxi following no fixed route and no fixed stops and operates with and without door to door service entirely within the city limits.

Outside the SJMA they are the only type of public transportation available. In the SJMA the "público" system service area covers mainly Río Piedras and Bayamón. Statistics from the National Transit Database indicate that ridership within the SJMA on the "público" system is larger than the MBA and Metrobus I combined. There are over 1,500 "público" vehicles operated in maximum service. Therefore, they are an important component of the SJMA public transportation system.

"Tren Urbano"

The "Tren Urbano" transports passengers in San Juan and the surrounding urban areas. The initial phase serves three central municipalities of the SJMA: Bayamón, Guaynabo, and San Juan. The first phase of the system consists of 17.2 km of dual track heavy rail. The "Tren Urbano" alignment has 16 stations across the whole route from Bayamón to Santurce as presented in Figure 3-2. The system is composed of grade sections, elevated sections, and an underground section at Río Piedras. The yard and control center is located between the stations of Martínez Nadal and Las Lomas.

Future phases of the "Tren Urbano" are already in the process of public discussion about their construction. One will serve the Municipality of Santurce to Minillas. Two future phases will originate from Minillas, one to the east to the International Airport Luis Muñoz Marin in the Municipality of Carolina, and the other to the west to Old San Juan.

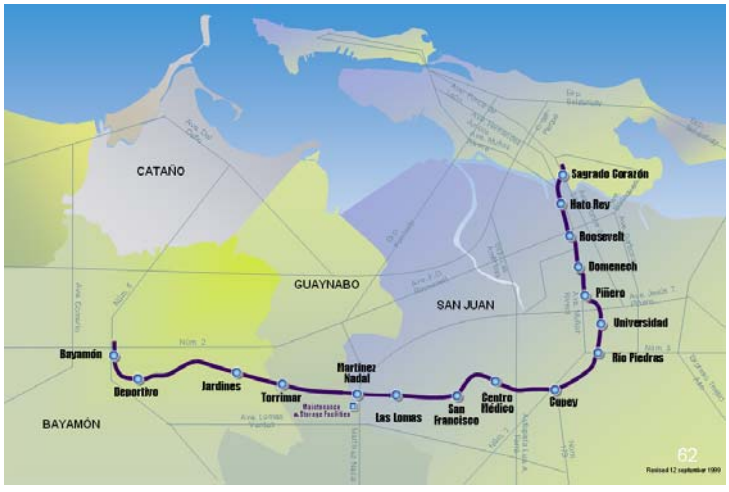

Figure 3-2: "Tren Urbano" route

3.6 SJMA Cities

Although there are thirteen cities in the SJMA, as defined in this document, only six are to be considered in the development of the Regional ITS Architecture for the SJMA. These cities were chosen because of their great concentration of population as well as employment in the region. These elements combined generate a lot of traffic and congestion that can be alleviated using advanced technologies such as ITS. Also the most important corridors in the SJMA, including the Tren Urbano, pass through these municipalities. Moreover the transit services in the SJMA have many routes serving these cities. All of the above present a clear picture as to why these municipalities were included in the development of the architecture. Table 3-2 provides information about the population and size of these six cities according to the 2000 Census. Figure 3-3 highlights the cities included to show their relative location and size to each other.

Table 3-2: SJMA Cities Description

Name	Population	Size (Square Miles)
Bayamón	224,044	44.4
Caguas	140,502	58.7
Carolina	186,076	45.3
Guaynabo	100,053	27.1
San Juan	434,374	47.8
Toa Baja	96,039	24
TOTAL	1,181,088	247.3

In terms of advanced technology, most of these cities have centers, either existing or planned, outfitted with video equipment to be used as a tool in the management of public safety.

These centers operate in coordination with the police department and other emergency management agencies. In addition, the equipment has the capability to be used in transportation related issues, such as incident management on roadways.

This chapter provided a comprehensive understanding of the region in terms of its geographic and demographic characteristics as well as its transportation problems, major roadways, transit services, and cities included in the architecture. The next chapter will provide a description of the stakeholders in the region and the efforts to gather information and support for the development of the architecture.

Figure 3-3: Cities included in the Regional ITS Architecture

4 Regional Stakeholders

The process of the ITS architecture development is, to a large degree, a process of consensus building. The participation and agreement of a diverse set of local stakeholders, is critical to the success of the SJMA Regional ITS Architecture. A group of agencies were identified, because of their transportation related management or vested interest in the SJMA, as stakeholders for the development of this regional architecture. Table 4-1 lists by agency the stakeholder group that was present during the project's final meeting. The following section describes briefly the main function of some of the stakeholders identified for the architecture. It is important to clarify that the majority of the stakeholders identified are public works agencies. In the case of the municipalities, the names listed represent, in most cases, departments having to do with strategic planning in each municipality.

Table 4-1: Stakeholder Group

Name	Agency	Email
Gabriel Alcaraz	Secretary Department of Transportation and Public Works	galcaraz@act.dtop.gov.pr
Fernando Vargas	Executive Director - Department of Transportation and Public Works	
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Máximo Ayala	Tren Urbano	MAyala@trenurbano.dtop.gov.pr
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Vicente Morales	Municipality - Bayamon	vicmoral2001@yahoo.com

Eddie Rivera	FHWA	eddie.rivera@fhwa.dot.gov
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Luis Cotto	Fire Department	
Alexis Novoa	Municipality - Guaynabo	anovoa@guaynabocity.gov.pr
Miguel E. Ortiz	Municipality - Guaynabo	mortiz@guaynabocity.gov.pr
Wilfredo Ramos	MBA	wramos@ama.gobierno.pr
Karen Méndez	Media (Univisión)	dmendez@univision.net
Wilfredo Velásquez	Medical Emergency Sertvices	
K. Maldonado	Police Department	kmaldonado@policiapr.com
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Miguel Torres	Tren Urbano	migueltorres@acipuertorico.com

4.1 Stakeholders Description

Puerto Rico Highway and Transportation Authority (PRHTA)

The PRHTA, under the Puerto Rico Department of Transportation and Public Works has a very complex organizational structure of its own. The PRHTA is mainly responsible for the construction and maintenance of the highway system and the Tren Urbano (metro system) in Puerto Rico. The PRHTA is also the key stakeholder in the development of the Regional ITS Architecture for the SJMA.

Metropolitan Bus Authority (MBA)

The MBA, under the Puerto Rico Department of Transportation and Public Works supervises, maintains and provides public bus transportation services for the SJMA.

Municipalities

The municipalities included in this project are Bayamon, Caguas, Carolina, Guaynabo, San Juan and Toa Baja. Although each municipality has its own organizational structure, their role in the development of the system is the same. These municipalities have as a short time goal the development of surveillance centers outfitted with video equipment. The main objective of these centers is to enhance public safety. At the same time these centers could contribute in incident management.

Local Emergency / Security Agencies

The Local Emergency / Security Agencies include the Fire Department, Emergency Medical Services, 911 and the Police Department. Within this group, the Police Department is the most important. The Police Department has the faculty by law to redirect traffic, implement strategies of traffic displacement, and other functions. Also it will have permanent presence in the PRHTA Transportation Management Center (TMC).

Research Groups

Within this group are included all agencies public and private with some access to the data archives collected by the PRHTA TMC. An example of these groups is the University of Puerto Rico.

At all stages of the architecture's development inputs and involvement were specifically encouraged and requested from stakeholders. Many tools were used to facilitate communication and expand the stakeholder outreach, such as: stakeholders' interviews, meetings and workshops.

Prior to the final meeting, the researchers conducted face-to-face interviews with several stakeholders for a completed and up to date ITS inventory, as well as the analysis of stakeholders' needs, vision, ideas and planned projects. The team used questionnaires based on the National ITS Architecture TurboArchitecture ^{TM} software package. These questions were related to commercial vehicle operations, emergency management, electronic tolling, freeway

management, maintenance and construction operations, public transportation, regional traveler information, and traffic management. Table 4-2 lists, in alphabetical order, the name of the person interviewed, the agency they represent and contact information. In many cases, the people interviewed in the early stages of the process are not the same listed in the table above. This is because as the process progressed people more relevant to the project was identified and approached. Please refer to Appendix A for a complete report of the information gathered during the interview process.

Table 4-2 Stakeholder Initial Interviews

Name	Agency	Contact Information
Carmen Sánchez	Medical Emergencies Services	csanchez@cem.gobierno.pr
Gabriel Calderón	Municipality of Toa Baja	(787) 261-0202
Luaida Oyola Mercado	Municipality of Toa Baja	(787) 261-0202 x. 2200
Gladys Rodriguez	911	grodriguez@e911.gobierno.pr
Heriberto Sauri	Municipality of San Juan	(787) 721-3048
Jorge Matos	Alternate Concepts	(787) 625-0395 x. 6308
José D. Echevarría	AEMEAD	(787) 724-0124 x. 2201
Rafael A. Díaz	Department of Transportation and Public Works	(787) 722-2929 x. 2054
Rubén Ramos	Police Department	(787) 793-1234
Wilfredo Ramos	MBA	wramos@ama.gov.pr

It is important to point out that since the beginning, the key stakeholder, the Puerto Rico Highway and Transportation Authority, was involved in the architecture development process. Also a champion from the same agency was established to lead in the development of the

architecture. The champion in this case is the Highway and Traffic Operation Division of the Puerto Rico Highway and Transportation Authority headed by Engineer Felipe Luyanda Andino.

At this point the region and the stakeholders for the architecture have been identified. In the next chapter the elements both existing and planned found to be relevant to the SJMA Regional ITS Architecture are presented.

5 ITS Inventory

The process of gathering information about the ITS inventory for the SJMA consisted of distributing questionnaires, exchanging phone calls, conducting meetings and workshops, and reviewing documents to establish existing ITS elements in the region. The questionnaires were based on the National ITS Architecture TurboArchitecture ™ software package. The following topics were addressed:

- Archived Data Management
- Emergency Management
- Electronic Tolling
- Freeway Management
- Maintenance and Construction Operations
- Public Transportation
- Regional Traveler Information
- Traffic Management

From this effort the following elements were determined to be relevant to the SJMA ITS Architecture. The subsystems and related elements pertaining to the SJMA ITS Architecture are presented in Table 5-1. For further information concerning the ITS Inventory, please refer to Appendix B, which contains the TurboArchitecture™ generated inventory report sorted by entity (subsystem) and by stakeholder.

Table 5-1. SJMA ITS Architecture Subsystems and Related Elements

Subsystem	Elements
Travelers	
Remote Traveler Support	• Remote Traveler Support
Personal Information Access	• PRHTA TMC • User Personal Computing Devices
Centers	
Archive Data Management	• PRHTA TMC
Traffic Management	• PRHTA TMC
Emergency Management	• Emergency Management System (Local Emergency / Security Agencies) • Surveillance Center
Toll Administration	• Toll Roads
Maintenance and Construction Management	• Toll Roads
Information Service Provider	• PRHTA TMC • Media (private and public agencies)
Transit Management	• Transit Management System
Vehicles	
Transit Vehicle	• Vehicles
Emergency Vehicle	• Vehicles
Maintenance and Construction Vehicle	• Vehicles
Vehicle	• Vehicles (including probe vehicles, maintenance and construction vehicles, and service patrol)
Field	
Roadway	• PRHTA TMC • Roadside Equipment
Security Monitoring	• Security Monitoring Field Equipment
Toll Collection	• Toll Roads

Having identified the elements relevant to the architecture the needs and services to be provided in the region should be considered. Chapter 6 presents the needs identified through meetings and interviews with the stakeholders in the region.

6 User Needs and Services

The identification of needs provides the essential framework for architectural development at the highest level. As established before, the San Juan Metropolitan Area has recognized the need to find solutions to save travelers time through enhanced traffic management, traveler information and transit services. A number of potential concerns regarding how to better address these needs were discussed with PRHTA. This analysis helped to identify the gaps between existing systems and future needs. The needs were identified through interviews, meetings and knowledge from the project's team. To help with organized project development, the needs were categorized by ITS User Services. The National ITS Architecture Version 5.0 grouped the ITS User Services into eight User Services Bundles for convenience. Some of these bundles and some of the needs associated with each bundle follow.

Service Bundle: *Travel and Traffic Management*

Related Needs:

- Specialized maintenance for Dynamic Message Signs, Closed Circuit TV and communication media such as fiber optics and central software system
- Provide system wide arterial management strategies
- Develop access management plans/strategies (signal spacing)
- Improve traffic flow monitoring
- Provide more widespread centralized computer control

- Improve or implement ability to remotely modify signal timing
- Reduce emergency vehicle delays at signals
- Improve inter-jurisdictional continuity
- Upgrade signal hardware
- Implement or improve signal coordination
- Better management periods of high traffic demand in poor roadway conditions
- Provide quality real time congestion related information
- Communicate with adjacent cities
- EVP/ITS and AVL/ITS interconnect

Service Bundle: *Public Transportation Management*

Related Needs:

- Improve regional trip planning
- Improve patron safety (in-vehicle and at stations)
- Provide transit priority at signals
- Enable dissemination/display of bus arrival times

Service Bundle: *Electronic Payment*

Related Needs:

- Capability for vehicle operators to pay tolls without stopping their vehicles
- Provide confirmation of the toll collection transaction to each customer
- Identify those vehicles and/or operators that violate the toll collection process

Service Bundle: *Emergency Management*

Related Needs:

- Automatic notification of declines in traffic flow
- Provide alternate route plans
- Increase broad understanding of existing incident management procedures
- Improve incidents response coordination between agencies
- Improve incidents detection
- Provide quality real time congestion information
- Improve traveler information during incidents
- Involve in decision process regarding potential diversion of traffic on or off the toll roads
- Notify public if tolls are waived/resumed
- Notify if completed or under-construction projects can be affected
- Real time info to review closures, congestion, incidents

Service Bundle: *Information Management*

Related Needs:

- Provide a Historical Data Archive system for ITS data
- Include a function to ensure integrity of operational data as received from field equipment or data collection devices
- Import ITS operational data from ITS Operational Repositories
- Import ITS Freeway Operations data including traffic flow surveillance data, visual and video surveillance data, freeway flow metrics, electronic toll collection data, etc.

Service Bundle: *Maintenance and Construction Operations*

Related Needs:

- Provide Automatic Vehicle Locator (AVL) for Maintenance and Construction Operations (MCO) vehicles
- Improve work zone Temporary Traffic Control (TTC)
- Improve detection and removal of dangerous trash barrier on roadways
- Improve coordination of constructions notification and information distribution
- Improve fleet information and management
- Coordinate traffic control plans between jurisdictions
- Increase use of portable control devices

- Provide real time congestion information
- Improve traveler information
- Need to both receive and disseminate advanced notice of construction and maintenance projects, closures and other issues that affect drivers
- Need to monitor weather and construction progress
- Ability to track maintenance vehicles
- Up to date (via web site) information to review closures, congestion, incidents, etc.

Service Bundle: *Regional Traveler Information*

Related Needs:

- Provide real time congestion information
- Expand traveler information delivery methods
- Use public cable TV to disseminate traffic information
- Improve procedure to obtain information
- Provide information to private information service providers
- Better road construction information
- Provide en-route traveler information
- Provide traveler information through Internet

The region, the stakeholders, the elements and the transportation related needs in the SJMA heve been identified at this point. The next chapter will define the market packages that can be assigned to address the needs defined in this chapter.

7 Operational Concept

The operational concept documents the current and future roles of the stakeholders. Moreover, it defines their responsibilities in the implementation and operation of the regional system.

Once the User Services have been defined, market packages can be assigned to address the needs defined previously. Within these market packages the roles and responsibilities of the stakeholders and/or the operational concept is defined.

7.1 Market Packages

The market packages provide an accessible, service-oriented perspective to the Regional ITS Architecture. They are tailored to fit, separately or in combination, real world transportation problems and needs that have previously been identified. 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. In other words, they identify the pieces of the physical architecture that are required to implement a particular transportation service.

Table 7-1 represents a listing of selected market packages from the National Architecture Version 5.0 as they apply to the SJMA Regional ITS Architecture. Appendix C presents the operational concept for the SJMA Regional ITS Architecture, that is, the roles and responsibilities of the stakeholders as related to the market packages. Please refer to Appendix D

for a complete report on role and responsibility areas sorted by stakeholders as an output of TurboArchitecture™.

Table 7-1: Market Packages Summary

Archived Data Management	
AD1	ITS Data Mart
AD2	ITS Data Warehouse
Transit Services	
APTS1	Transit Vehicle Tracking
APTS4	Transit Passenger and Fare Management
APTS5	Transit Security
APTS6	Transit Maintenance
APTS7	Multi-modal Coordination
APTS8	Transit Traveler Information
Traveler Information	
ATIS1	Broadcast Traveler Information
Freeway Management	
ATMS01	Network Surveillance
ATMS02	Probe Surveillance
ATMS06	Traffic Information Dissemination
ATMS07	Regional Traffic Control
ATMS18	Reversible Lane Management
ATMS19	Speed Monitoring
ATMS21	Roadway Closure Management
Surface Street Management	
ATMS01	Network Surveillance
ATMS03	Surface Street Control
ATMS06	Traffic Information Dissemination
ATMS07	Regional Traffic Control
Incident Management	

ATMS08	Traffic Incident Management System
ATMS09	Traffic Forecast and Demand Management
Electronic Toll Collection	
ATMS10	Electronic Toll Collection
Emergency Management	
EMS01	Emergency Call-Taking and Dispatch
EMS02	Emergency Routing
EMS03	Mayday Support
EMS04	Roadway Service Patrols
EMS05	Transportation Infrastructure Protection
EMS08	Disaster Response and Security
EMS10	Disaster Traveler Information
Maintenance and Construction Management	
MC01	Maintenance and Construction Vehicle and Equipment Tracking
MC02	Maintenance and Construction Vehicle Maintenance
MC07	Roadway Maintenance and Construction
MC08	Work Zone Management
MC10	Maintenance and Construction Activity Coordination

Once the roles and responsibilities of the stakeholders have been defined the next step in the process is to define the activities to be performed by the systems themselves. Chapter 8 presents input to the interfaces and information flows in the architecture.

8 Functional Requirements

The needs, services and market packages and the roles of the agencies have been identified in continuing to develop the Regional ITS Architecture for the SJMA. The next step of the process is to identify the activities that are performed by the systems themselves. This can be either the existing systems or those that are planned.

This section provides input to the identification of interfaces and information flows of the architecture, as well as a resource for project planners in defining activities and functional relationships of the systems that may be developed or upgraded to provide SJMA Regional ITS Architecture.

The following section lists the primary functional requirements for the major ITS elements in SJMA.

Stakeholder: Puerto Rico Highway and Transportation Authority

- System: *PRHTA TMC*

  This system shall:

  - Monitor, analyze, and store traffic sensor data and CCTV real time pictures collected from field elements under remote control of the center.

- Distribute road network conditions data based on collected and analyzed traffic sensor and surveillance data to other centers.
- Respond to control data from center personnel regarding sensor and surveillance data collection, analysis, storage and distribution.
- Remotely control changeable message signs for dissemination of traffic and other information to drivers.
- Remotely control driver information systems that communicate directly from a center to the vehicle radio (such as Highway Advisory Radios) for dissemination of traffic and other information to drivers.
- Collect operational status for the driver information systems equipment (Dynamic Message Signs, Highway Advisory Radio, etc.)
- Distribute traffic data to maintenance and construction centers, transit centers, emergency management centers, and traveler information providers.
- Distribute information to the media.
- Collect and store traffic flow and image data from the field equipment to detect and verify incident.
- Exchange incident and threat information with emergency management centers as well as maintenance and construction centers; including notification of existence of incidence and expected severity, location, time and nature of incident.
- Provide road network conditions and traffic images to emergency management centers to support the detection, verification, and classification of incidents.

- Provide road network conditions and traffic images to emergency management centers, maintenance and construction centers and traveler information service providers.

- System: *Emergency Vehicles (Service Patrol)*

  This system shall:

  - Send the vehicle's location and operational data to the center for emergency management and dispatch.
  - Receive incident details and a suggested route when dispatch to a scene.
  - Provide an interface with the center for emergency personnel to transmit information about the incident site such as the extent of injuries, identification of vehicles and people involved, hazardous materials, etc.

- System*: Roadside Equipment*

  This system shall:

  - Collect, process, estimate, digitize, and send traffic sensor data to the center for further analysis and storage, under center control.
  - Collect, process, and send traffic images to the center for further analysis and distribution.
  - Return sensor and CCTV system operational status to the controlling center.

- System: *Toll Roads*

This system shall:

- Manage toll transactions, including maintaining a log of all transactions and toll pricing structure information.
- Manage the details of toll payment violations based on tag information from the toll plaza, vehicle registration information from the Department of Motor Vehicles, and previous violations.
- Support wide-area alerts from emergency centers by passing in information to its toll plazas and the toll road operation center.
- Read data from vehicle toll tags to support payment of transactions.
- This system will also be in charge of maintenance and construction operations. In this capacity, this system shall:
    - Respond to requests from emergency management and traffic management centers for hazard removal, field equipment repair, and other roadway maintenance.
    - Exchange information with administrative systems to support the planning and scheduling of maintenance activities.
    - Provide emergency management and traffic management centers with information about scheduled maintenance and construction work activities.

- Dispatch and route maintenance and construction vehicle drivers and support them with route-specific environmental, incident, advisory, threat, alert, and traffic congestion information.
- Track the status of roadway maintenance and construction activities by monitoring collected data from the dispatched vehicles and equipment.
- Disseminate work zone information to other agencies and centers including traffic, transit, emergency management centers, other maintenance centers, traveler information providers, and the media.
- Control traffic in work zones by providing remote control of VMS and HAR systems located in or near the work zone.

Stakeholder: Local Emergency / Security Agencies

- System: Emergency Management Center

This system shall:

- Receive emergency call information from 911 services and present the possible incident information to the emergency system operator.
- Coordinate, correlate, and verify all emergency inputs and assign each a level of confidence.
- View CCTV systems within traffic management center in order to verify the reported incident.

- Update the incident information log once the emergency system operator has verified the incident.
- Forward the verified emergency information to the responding agency based on the location and nature of the emergency.
- Dispatch emergency vehicles to respond to verified emergencies and provide suggested routing under center personnel control.
- Store the current status of all emergency vehicles available for dispatch and those that have been dispatched.
- Relay location and incident details to the responding vehicles.
- Track the location and status of emergency vehicles responding to an emergency and update the incident status based on information from the emergency vehicle.
- Coordinate response to incidents with other Emergency Management centers to ensure appropriate resources are dispatched and utilized.
- Collect current traffic and road condition information from traffic management center for emergency vehicle route calculation.
- Receive inputs from traffic management and maintenance centers on the location and status of traffic control equipment and work zones along potential emergency routes.
- Track the availability of resources, request additional resources from traffic, maintenance, or other emergency centers if needed.
- Allocate the appropriate emergency services, resources, and vehicles to respond to incidents.
- Provide information to the media concerning the status of an emergency response.

Stakeholder: MBA, "Tren Urbano"

- System: Transit Management System

  This system shall:

  - Monitor the location of all transit vehicles within its network.
  - Determine adherence of transit vehicles to their assigned schedule.
  - Provide transit operational data to traveler information service providers.
  - Exchange information with maintenance and construction operations concerning work zones, roadway conditions, asset restrictions, work plans, etc.
  - Collect operational and maintenance data from transit vehicles.
  - Generate transit vehicle maintenance schedules, including what and when the maintenance or repair is to be performed.
  - Collect transit management data such as transit fares and passenger use, transit services, paratransit operations, transit vehicle maintenance data, etc.

- System: Remote Traveler Support

  This system shall:

  - Provide travelers using public transportation with traffic and advisory information upon request. Such information may include transit routes, schedules, transfer options, fares, real-timanded schedule adherence, etc.

- Exchange transit schedules, real-time arrival information, fare schedules, and general transit service information with other transit organizations to support transit traveler information services.

- System: Transit Vehicles

  This system shall:

  - Receive transit route information for its assigned route including transit service instructions, traffic information, road conditions, and other information for the operator.
  - Read data from the traveler card/payment instrument embarking travelers are carrying.

Stakeholder: Municipalities

- System: Emergency Services

  This system shall:

  - Receive emergency call information from 911 services and present the possible incident information to the emergency system operator.
  - Update the incident information log once the emergency system operator has verified the incident.
  - Dispatch emergency vehicles to respond to verified emergencies.

- Relay location and incident details to the responding vehicles.
- Receive traffic information, including closures, traffic conditions, etc. from traffic management center.
- Develop and coordinate with other agencies, to store emergency response plans.

This chapter presented the functions to be performed by each system as related to the stakeholders. In chapter 9 the connectivity and information flows between systems will be illustrated.

9 ITS Interconnects and Architecture Flows

In this step of the process it is possible to see the outline of a framework for integrating systems to finally gather the benefits of sharing data. The framework for integration is identified and the potential flows are examined. A high level conceptual diagram, usually called a "sausage diagram", depicts the physical systems that can be interconnected in a region. Figure 9-1 shows the "sausage diagram" for the SJMA ITS Architecture. The Figure shows the potential for connectivity among different subsystems. Figure 9-2 illustrates the existing general system of interconnects.

The National ITS Architecture discusses various alternatives to depict potential data flows between the systems. One of these alternatives is the use of customized market packages. Figures 9-3 through 9-33 illustrate the information flows among elements by Market Packages.

Another means of displaying interconnect information is through the use of the software tool TurboArchitecture™. Appendix E presents the interconnects between the various elements as an output of the afore mentioned software.

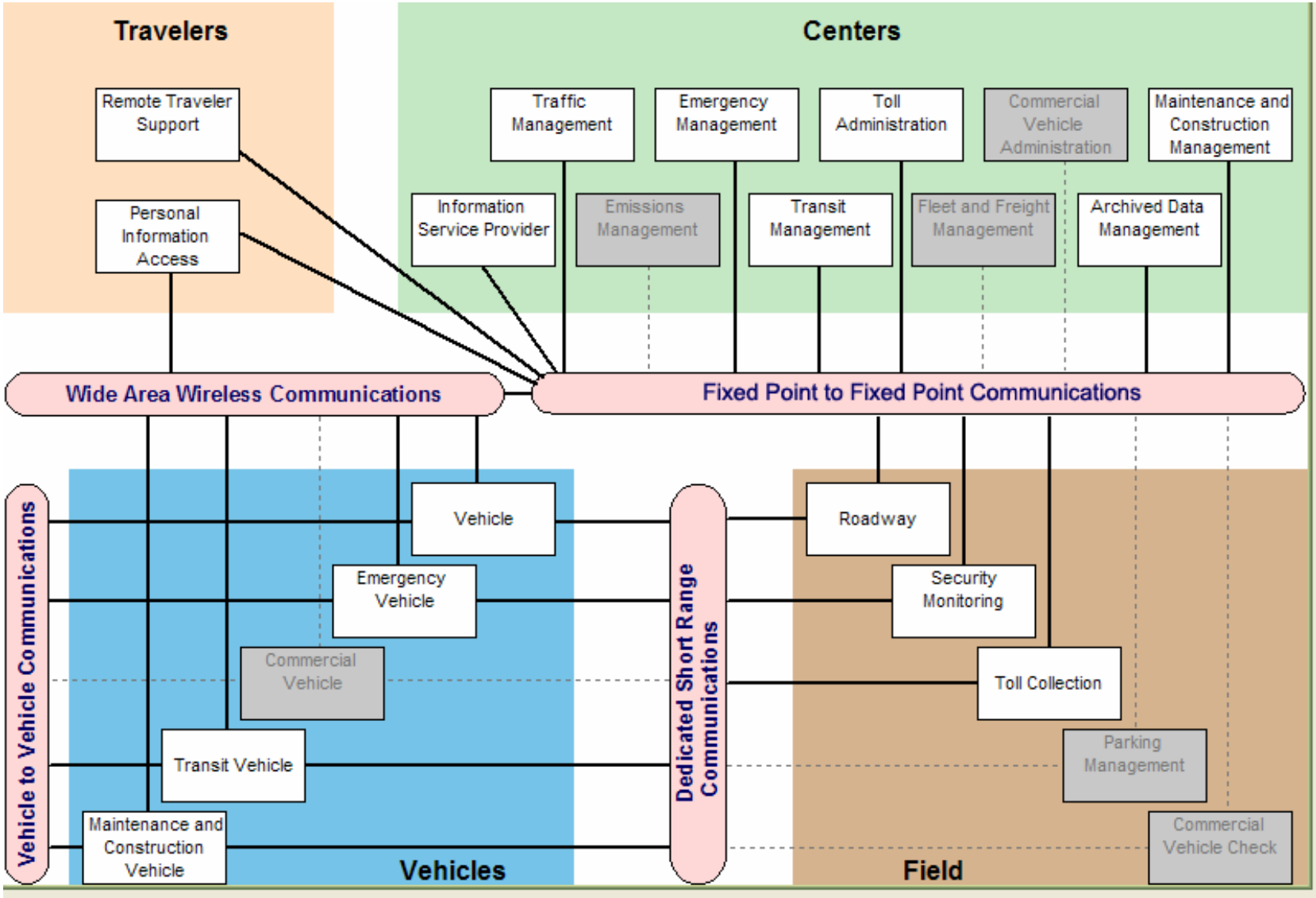

Figure 9-1 : Metropolitan ITS Architecture Subsystems

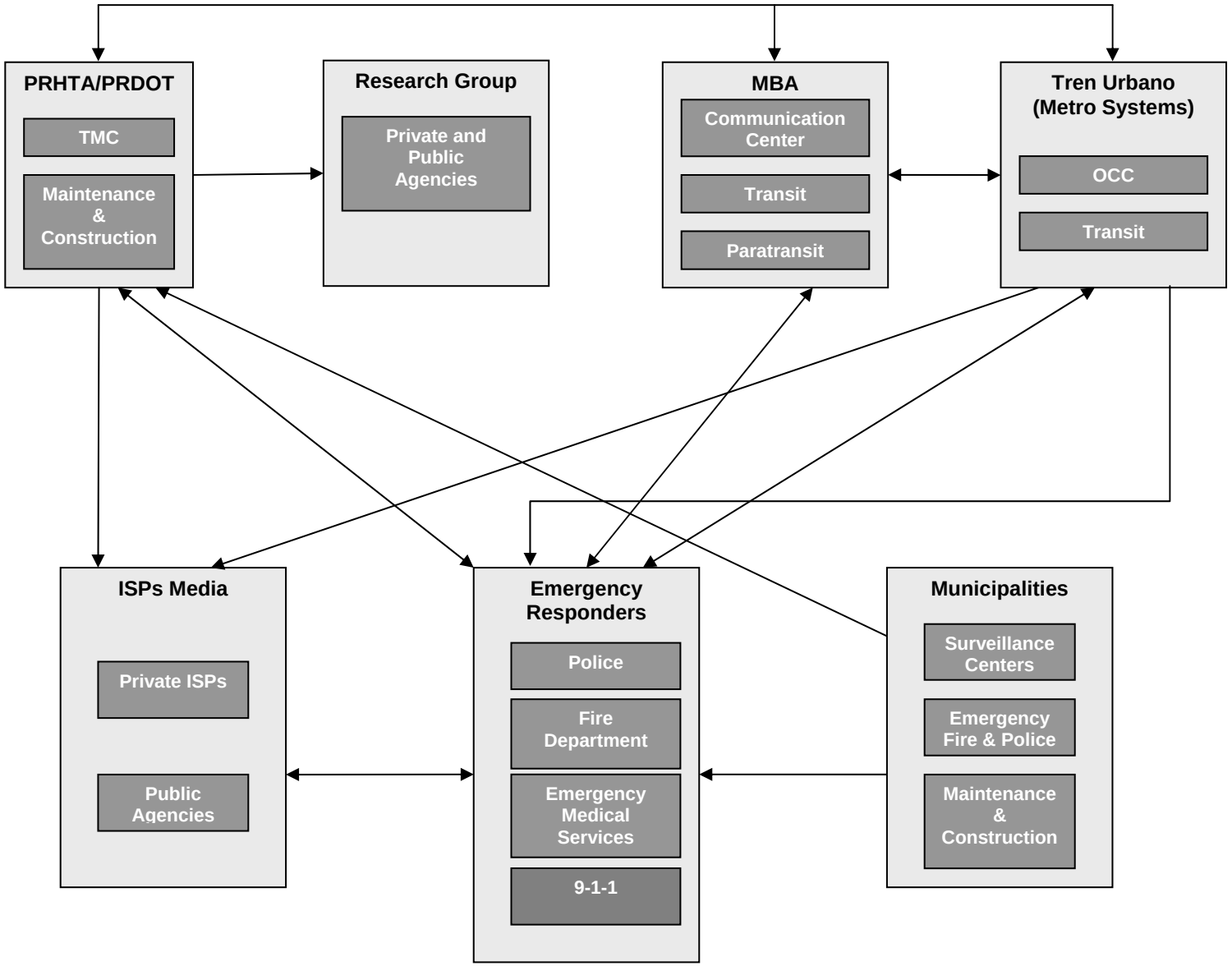

Figure 9-2: San Juan Metropolitan Area Interconnects.

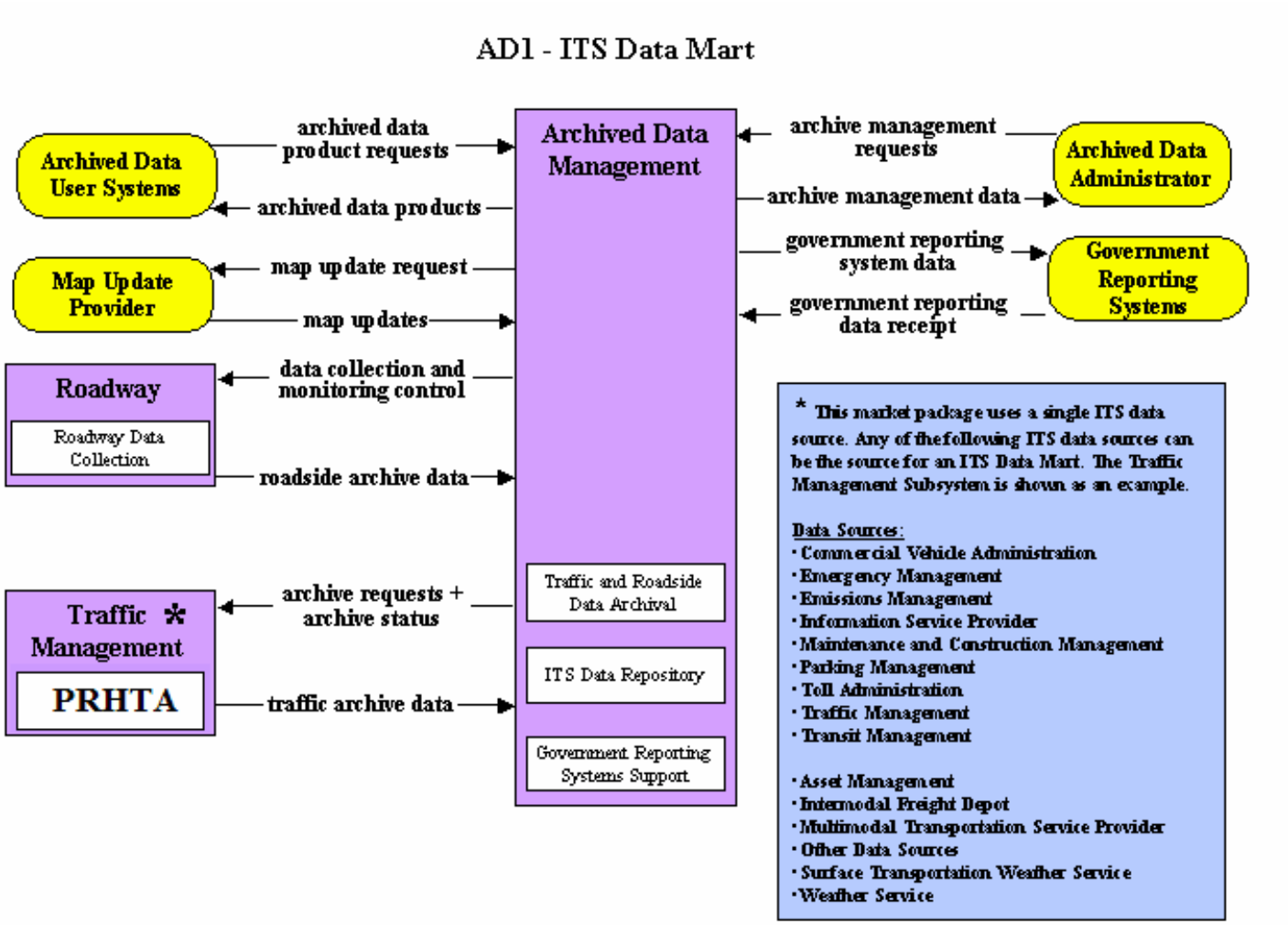

Figure 9-3: AD 1 – ITS Data Mart

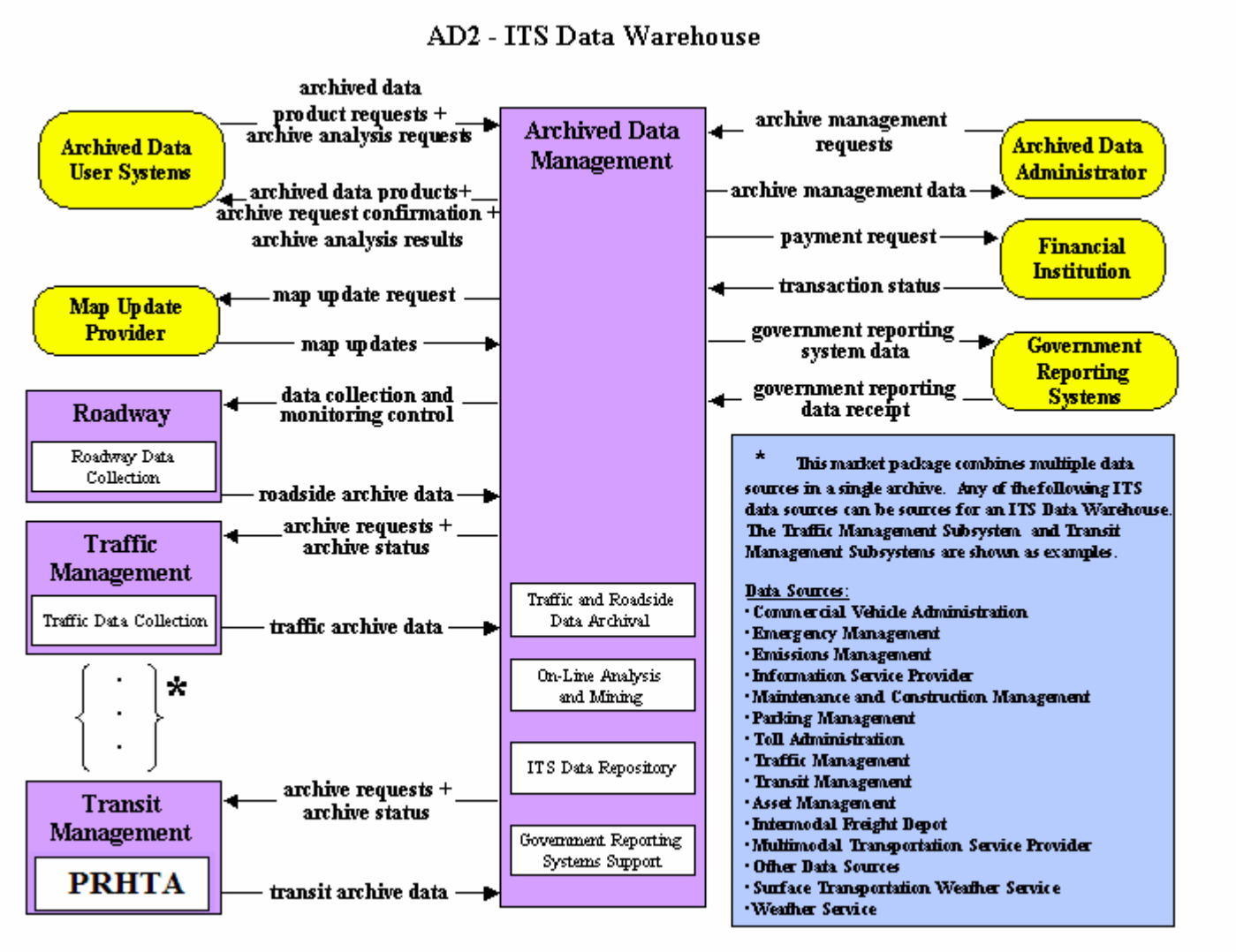

Figure 9-4: AD 2 – ITS Data Warehouse

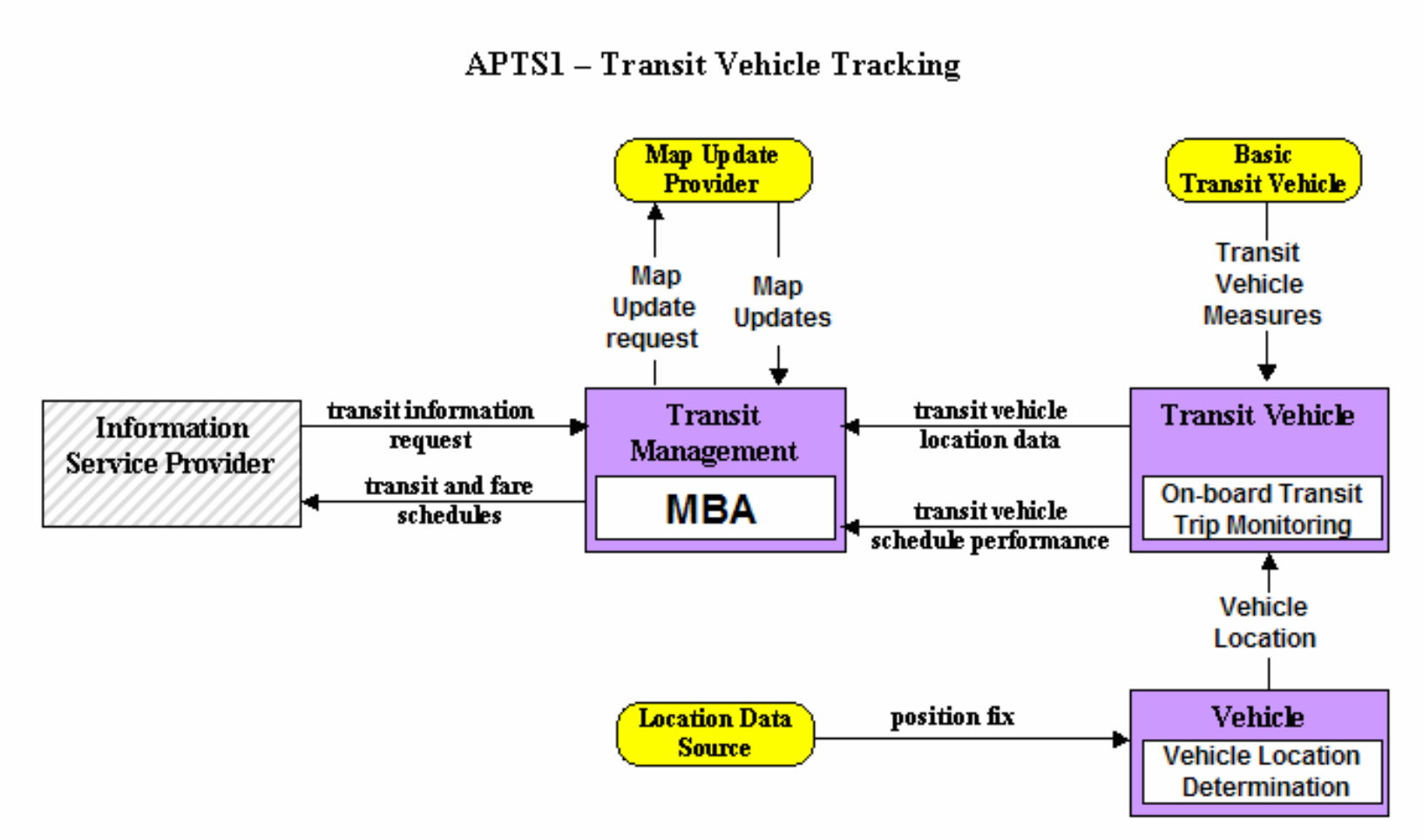

Figure 9-5: APTS 1 – Transit Vehicle Tracking

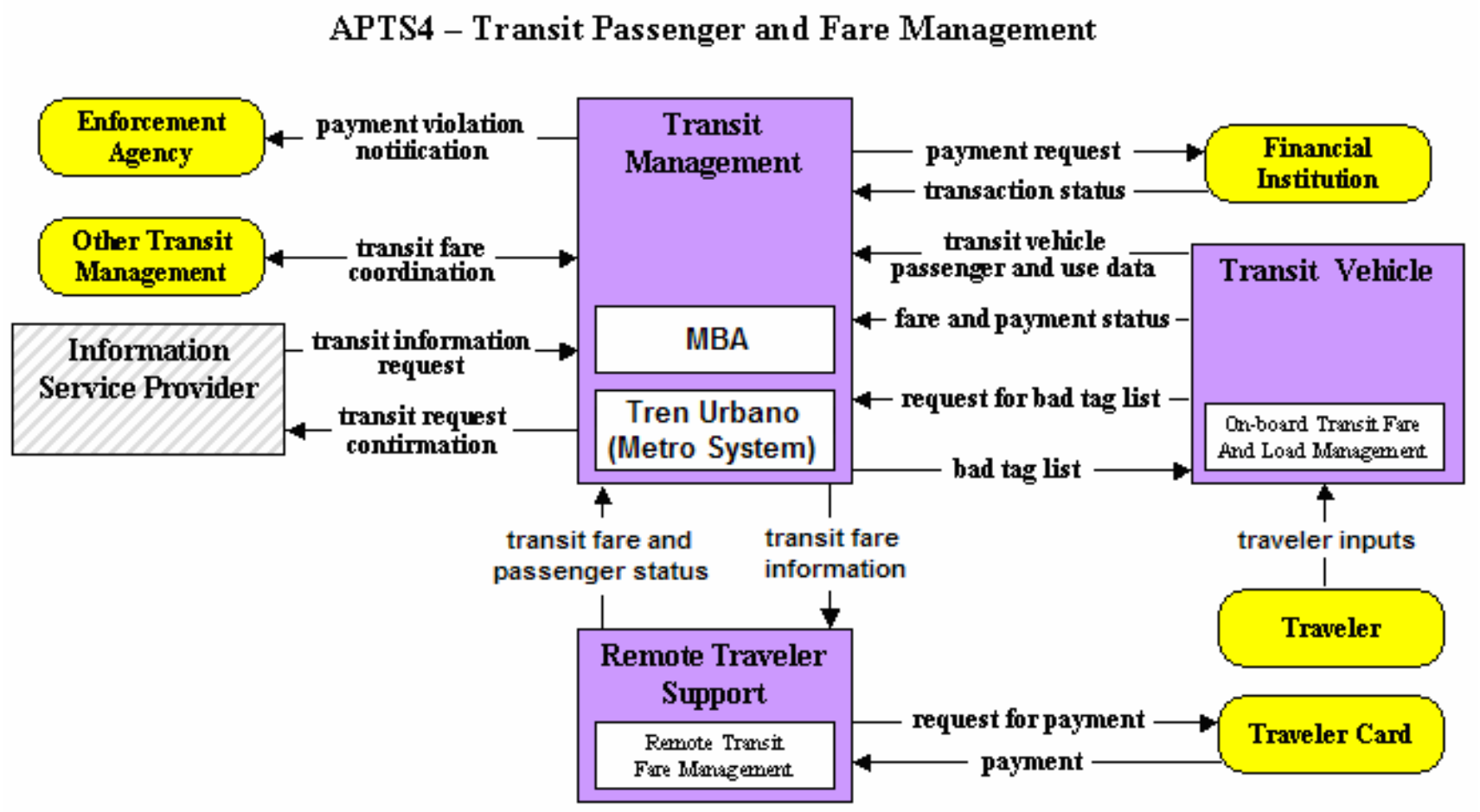

Figure 9-6: APTS 4 – Transit Passenger and Fare Management

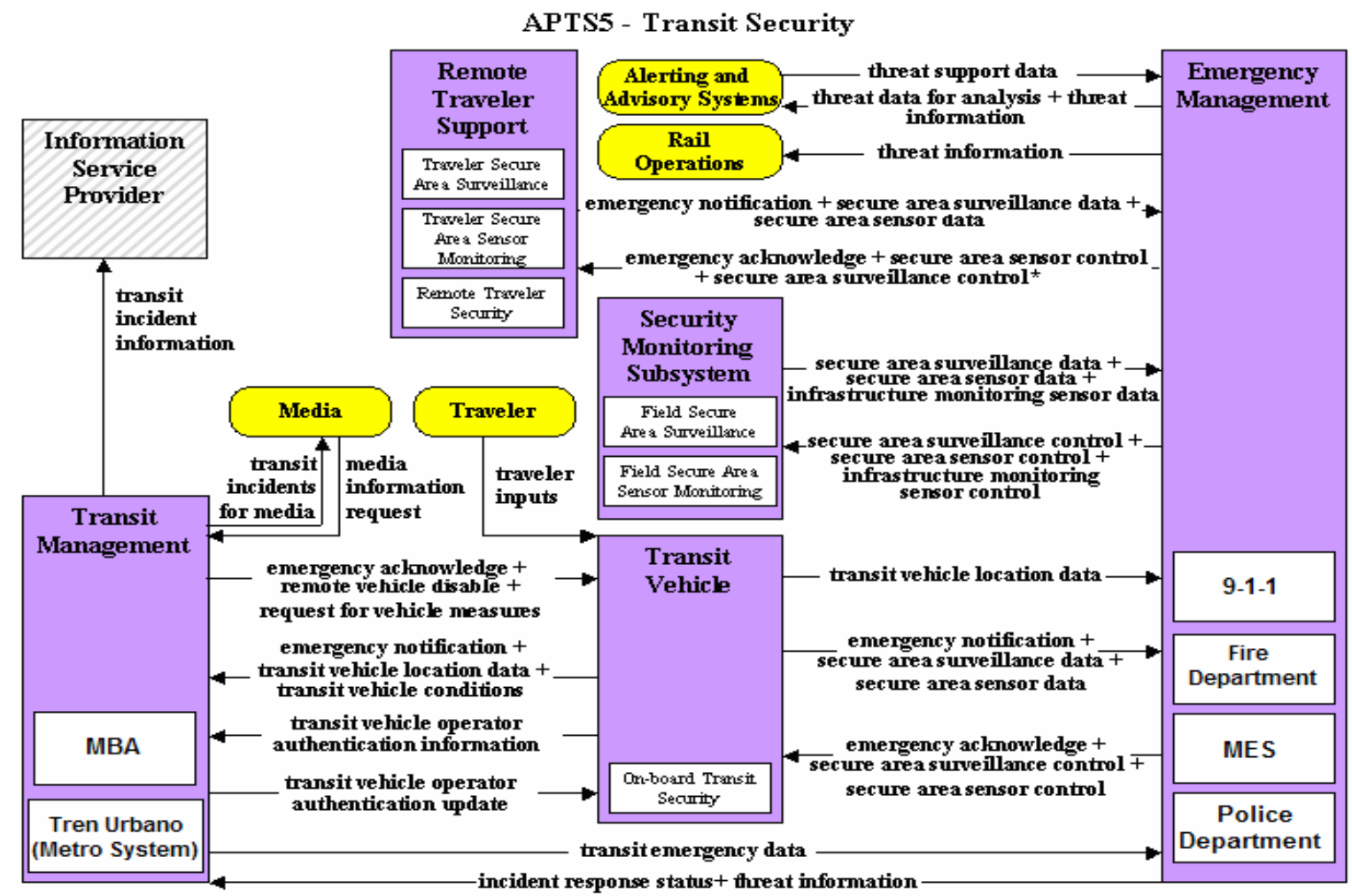

Figure 9-7: APTS 5 – Transit Security

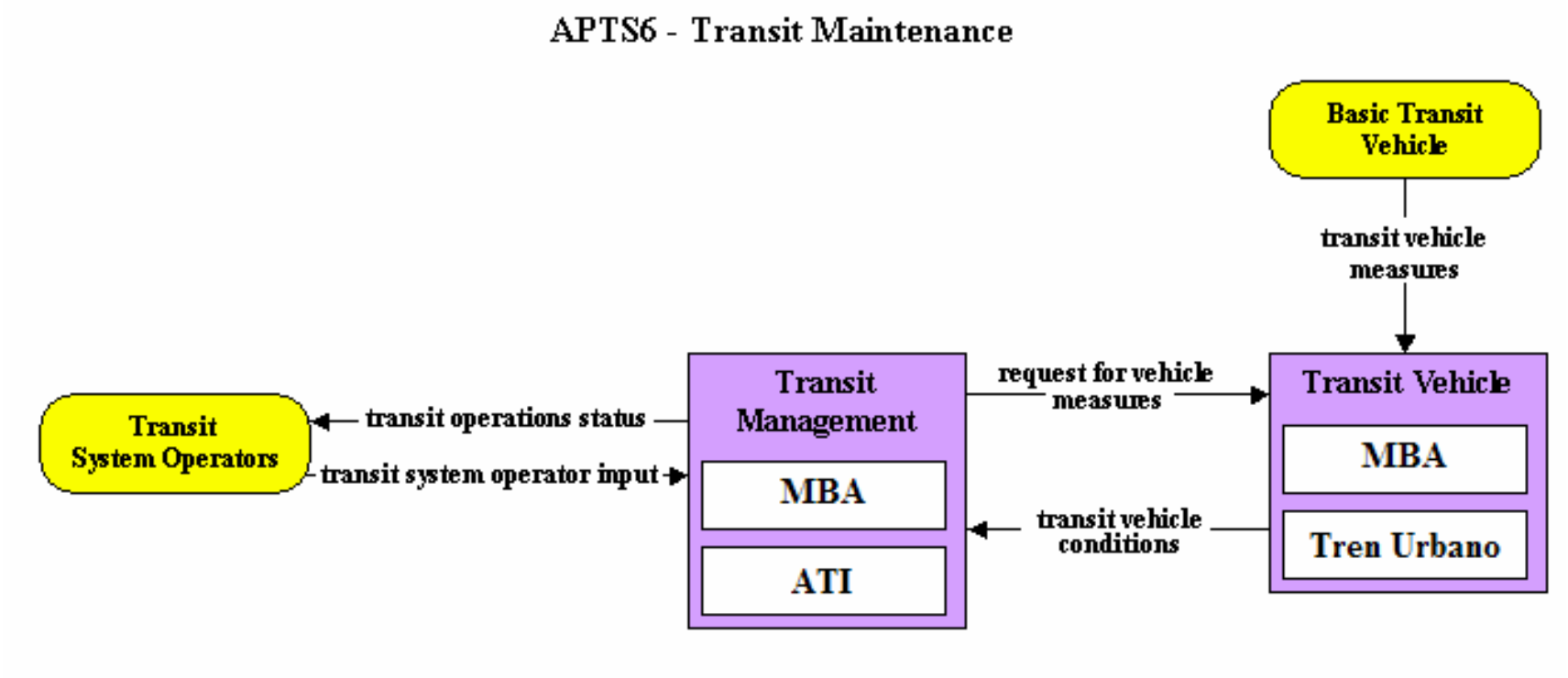

Figure 9-8: APTS 6 – Transit Maintenance

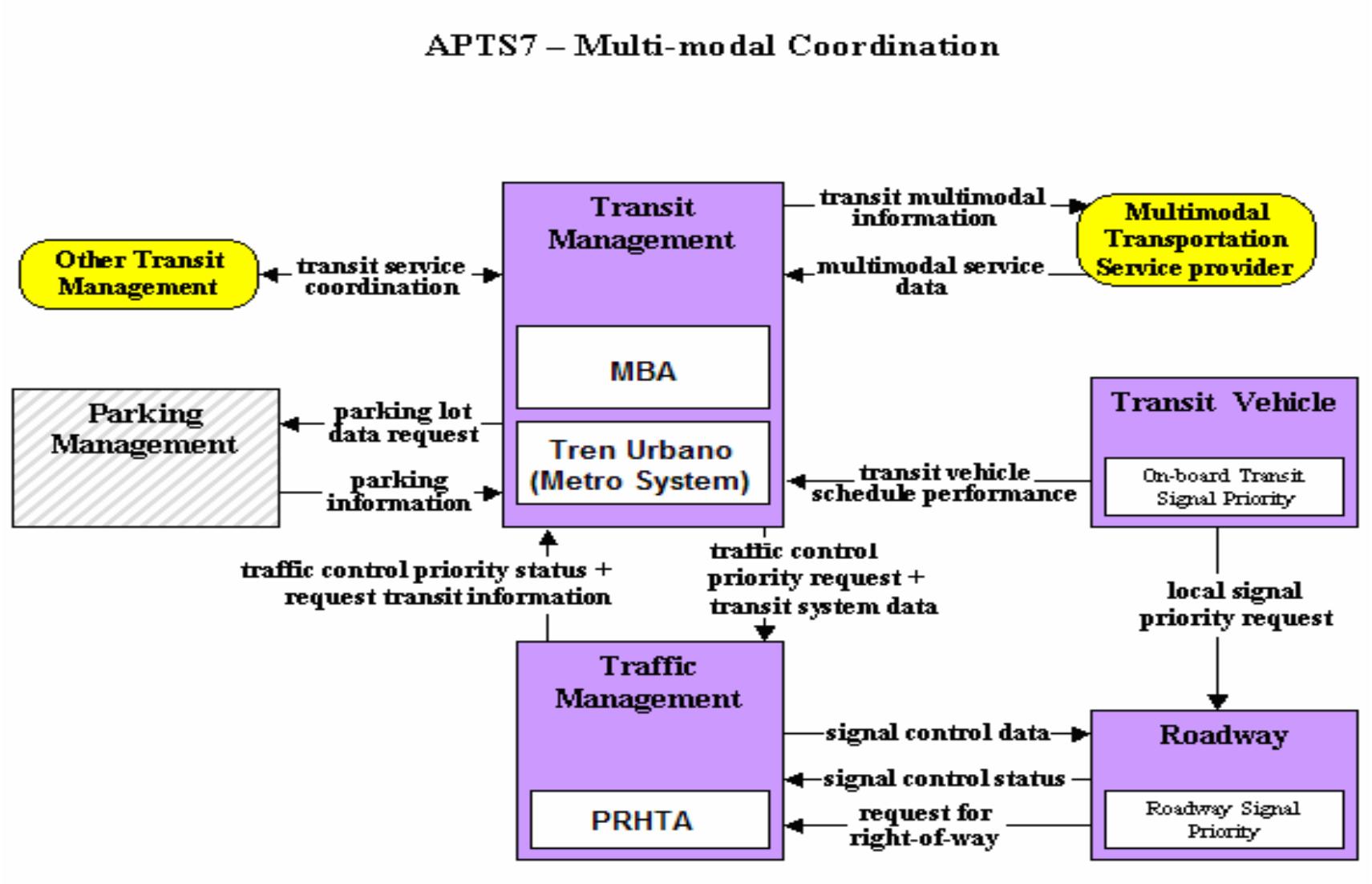

Figure 9-9: APTS 7 – Multi-modal Coordination

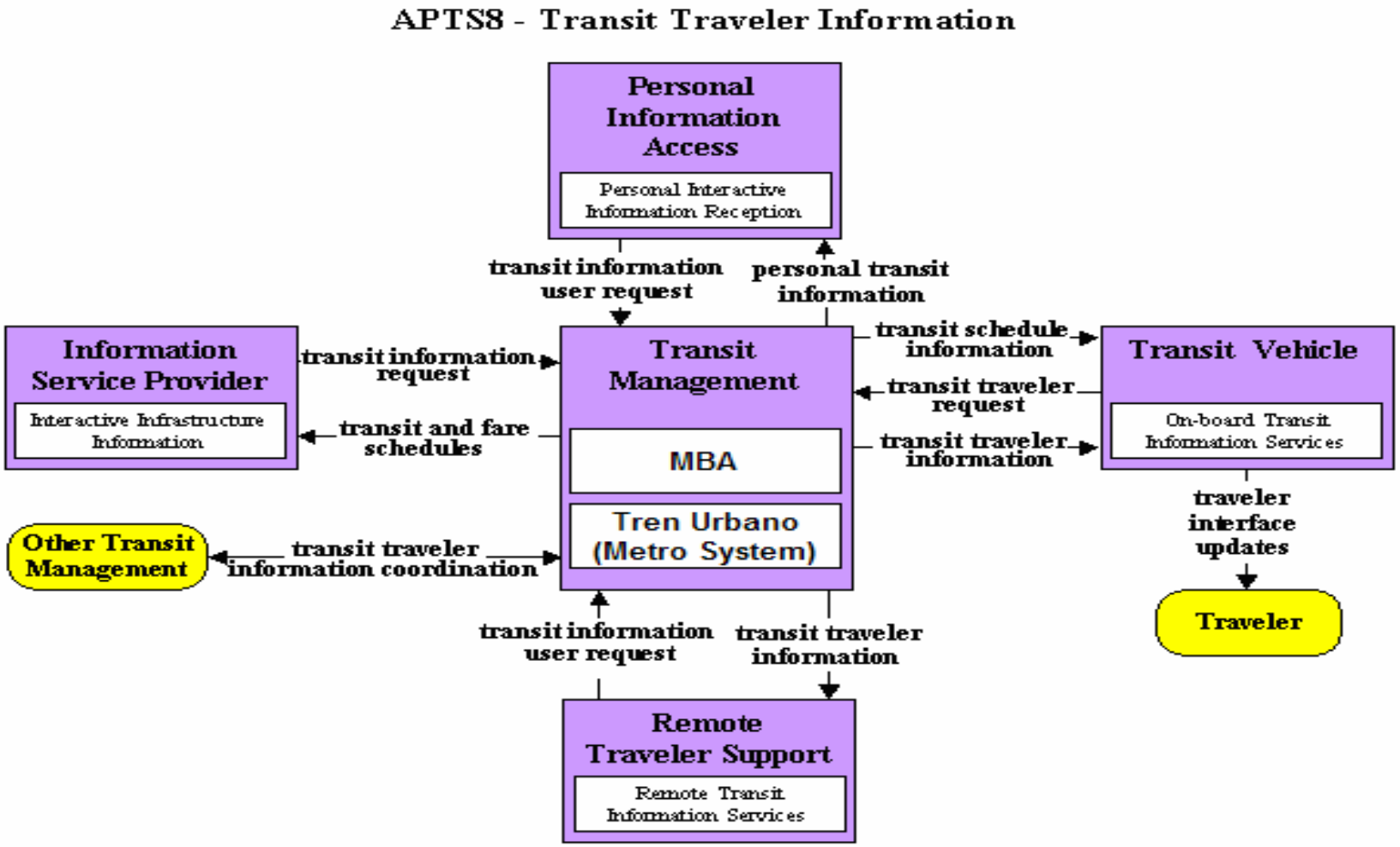

Figure 9-10: APTS 8 – Transit Traveler Information

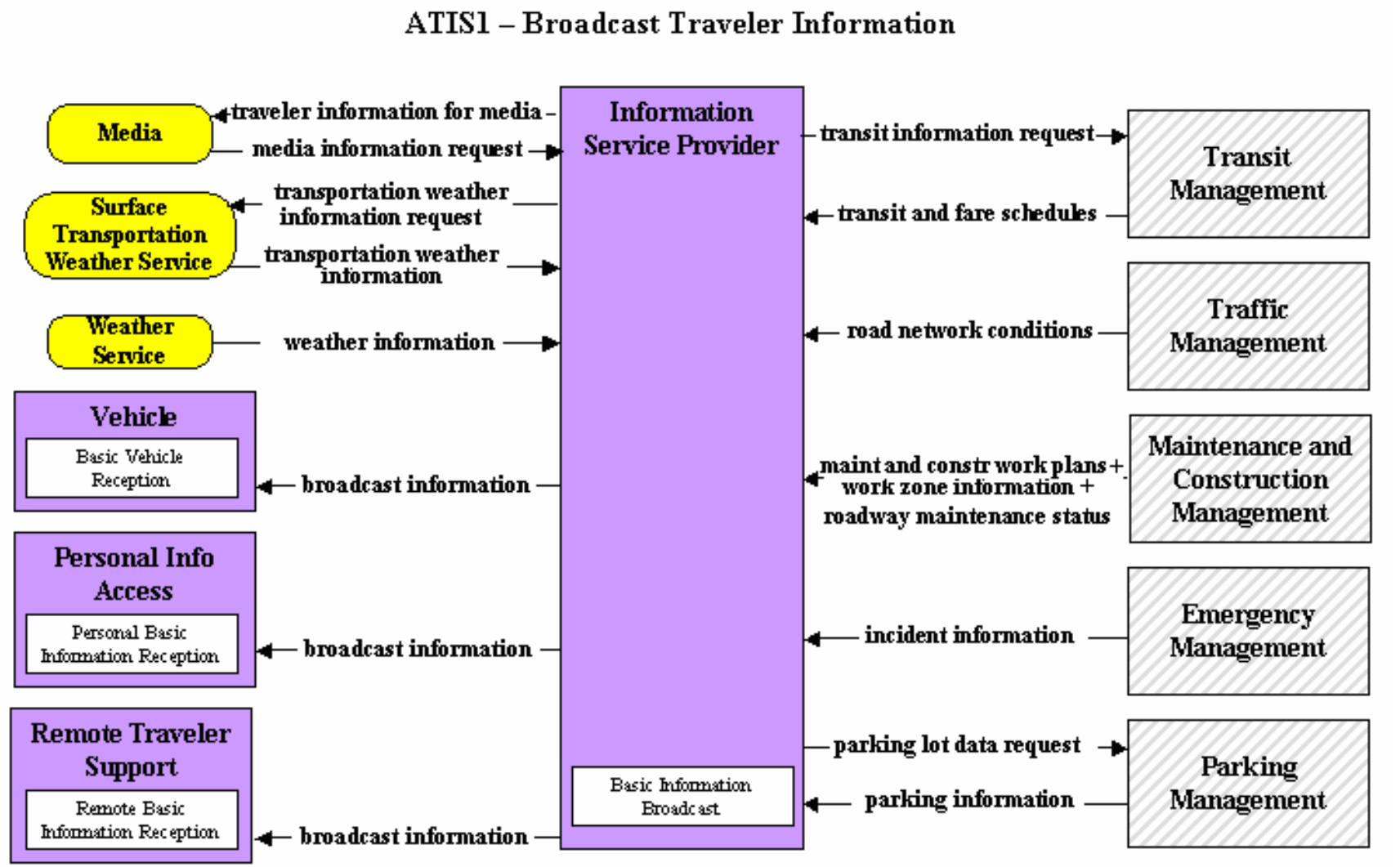

Figure 9-11: ATIS 1 – Broadcast Traveler Information

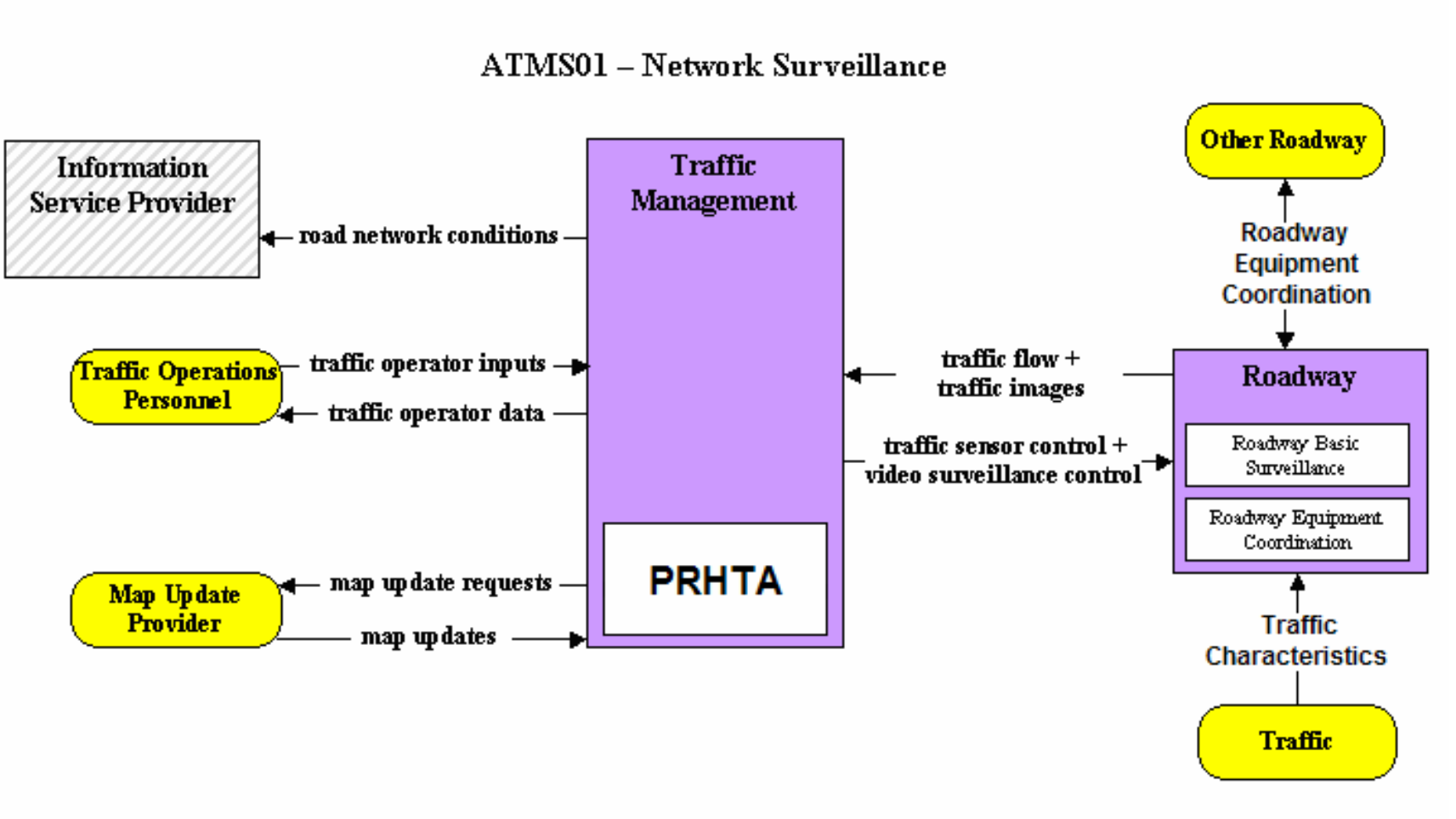

Figure 9-12: ATMS 01 – Network Surveillance

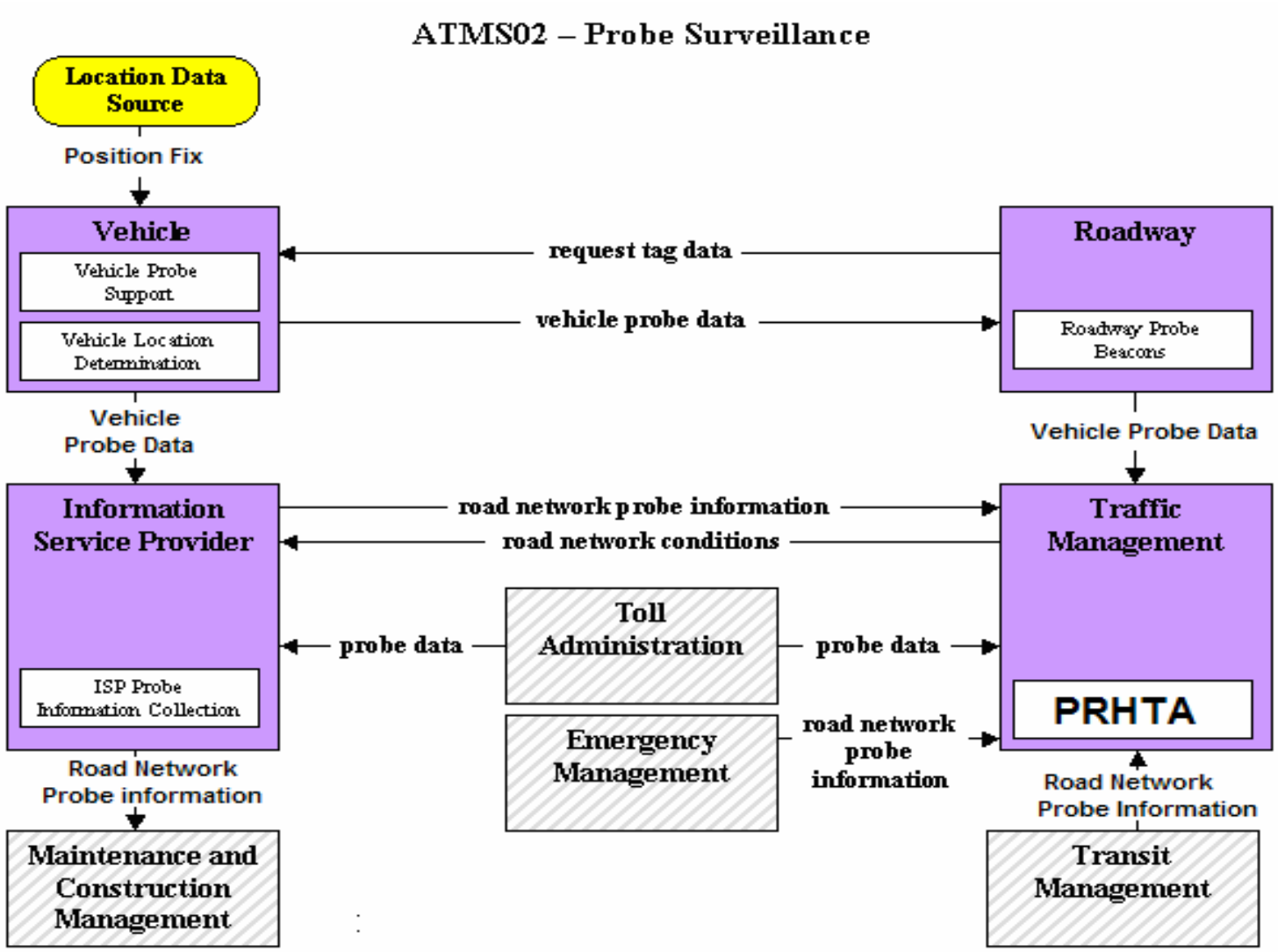

Figure 9-13: ATMS 02 – Probe Surveillance

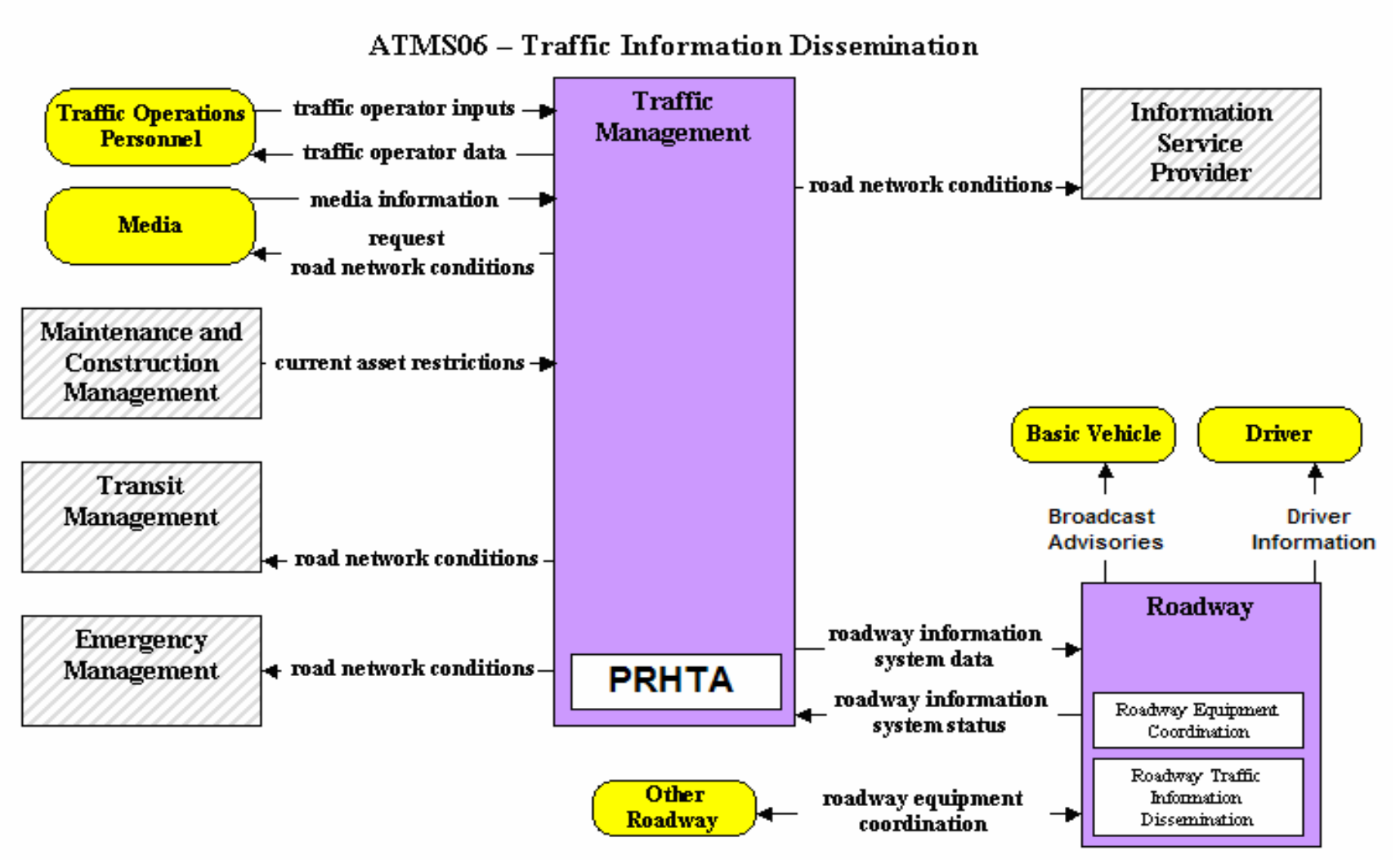

Figure 9-14: ATMS 06 – Traffic Information Dissemination

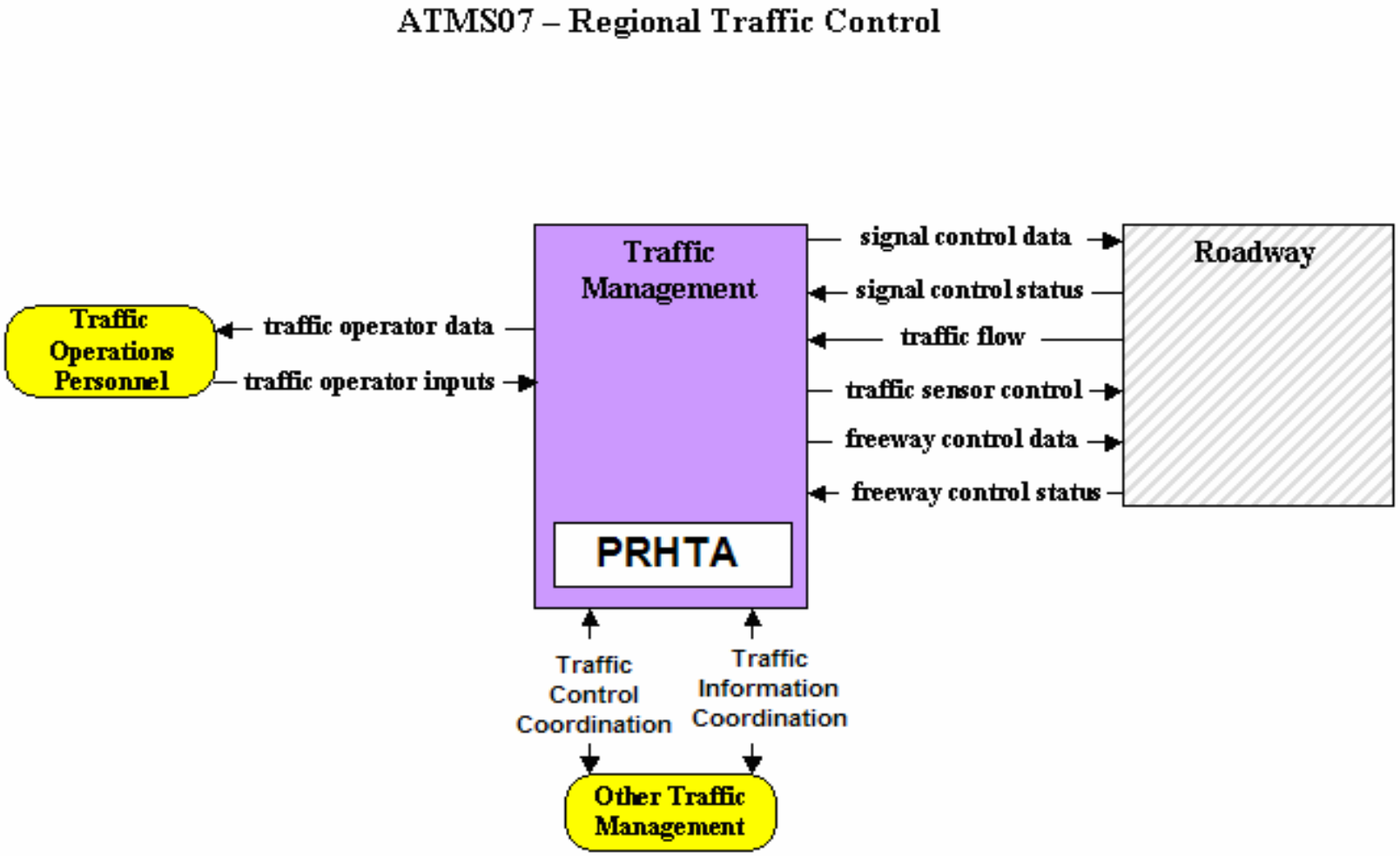

Figure 9-15: ATMS 07 – Regional Traffic Control

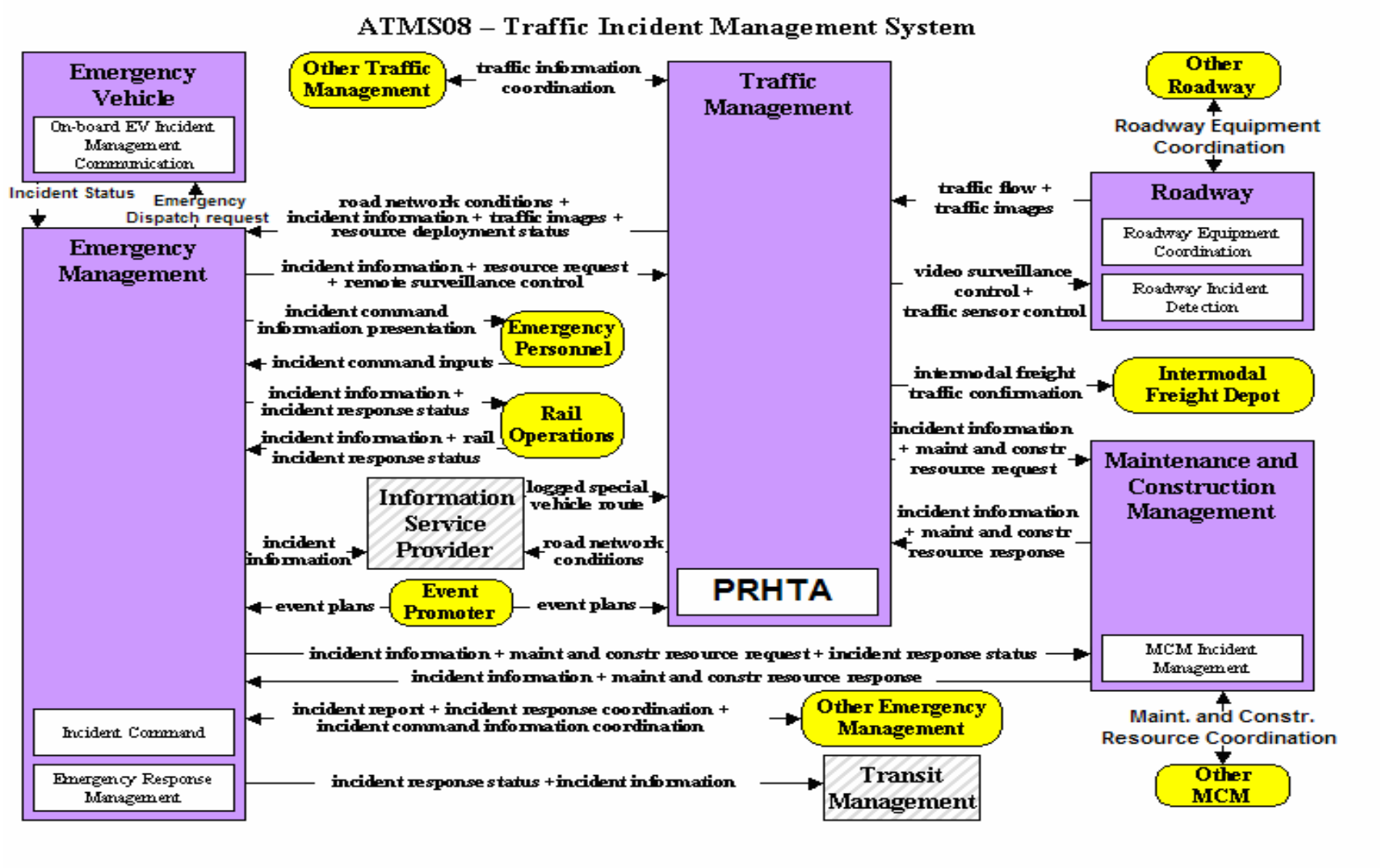

Figure 9-16: ATMS 08 – Traffic Incident Management System

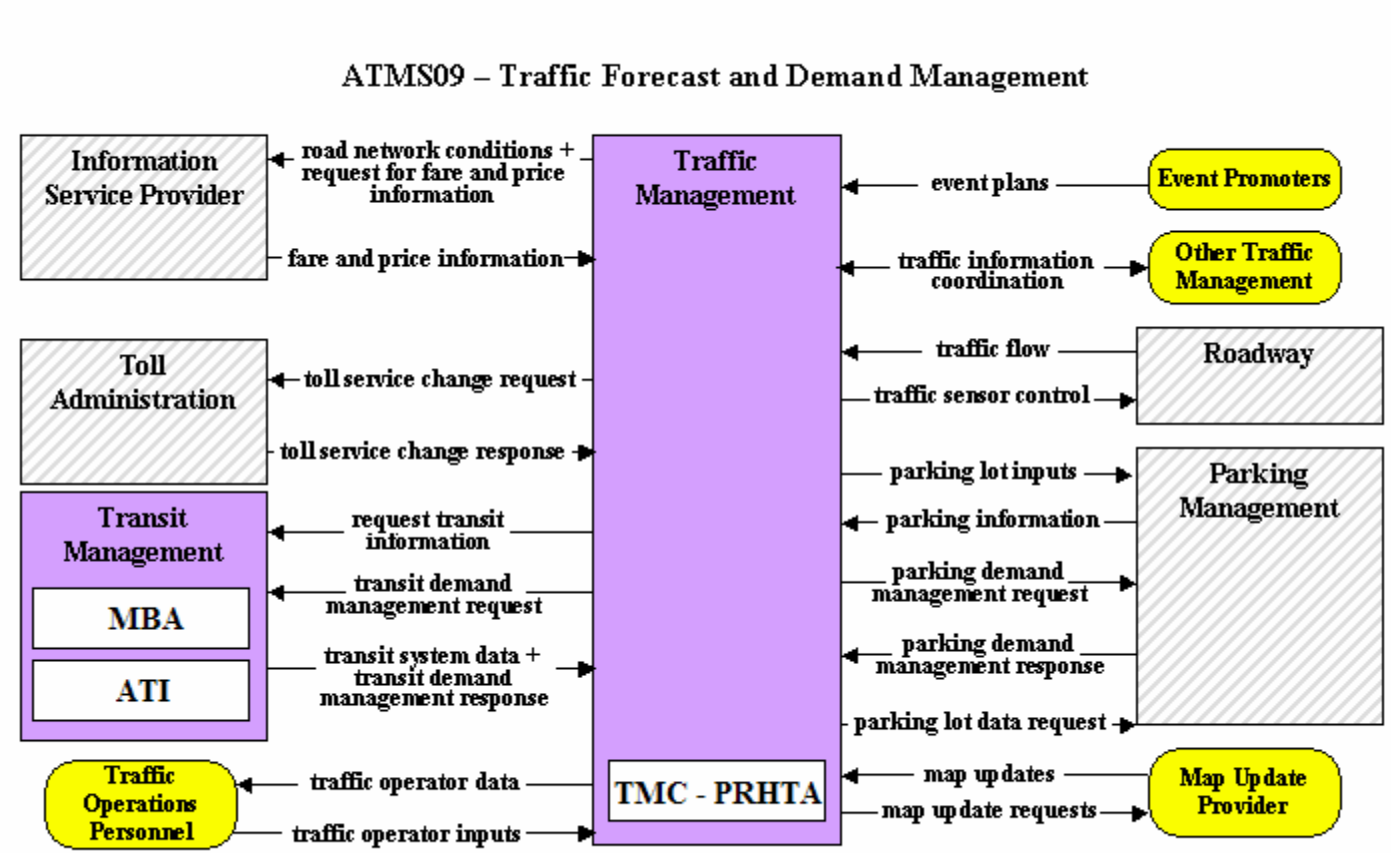

Figure 9-17: ATMS 09 – Traffic Forecast and Demand Management

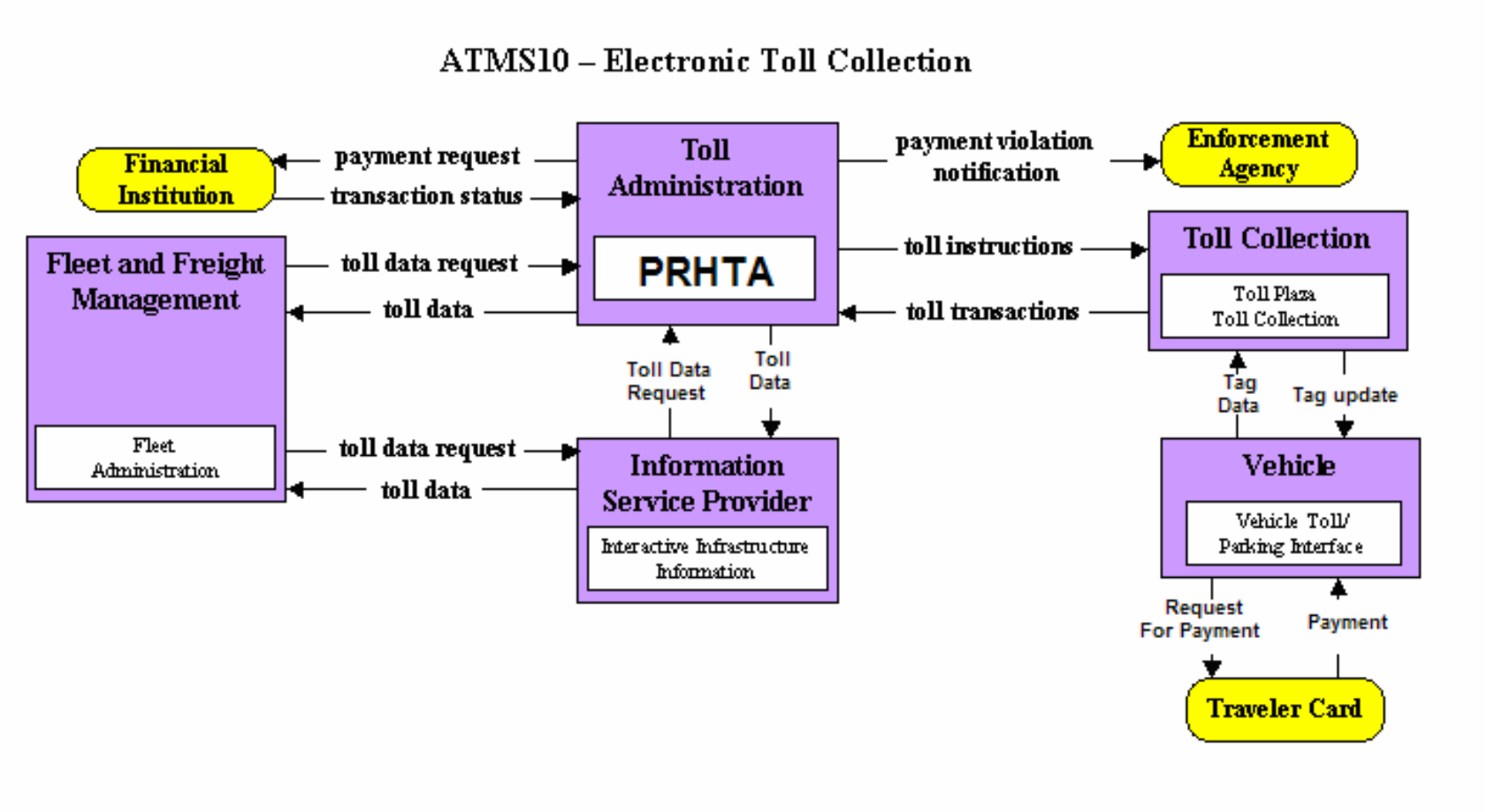

Figure 9-18: ATMS 10 – Electronic Toll Collection

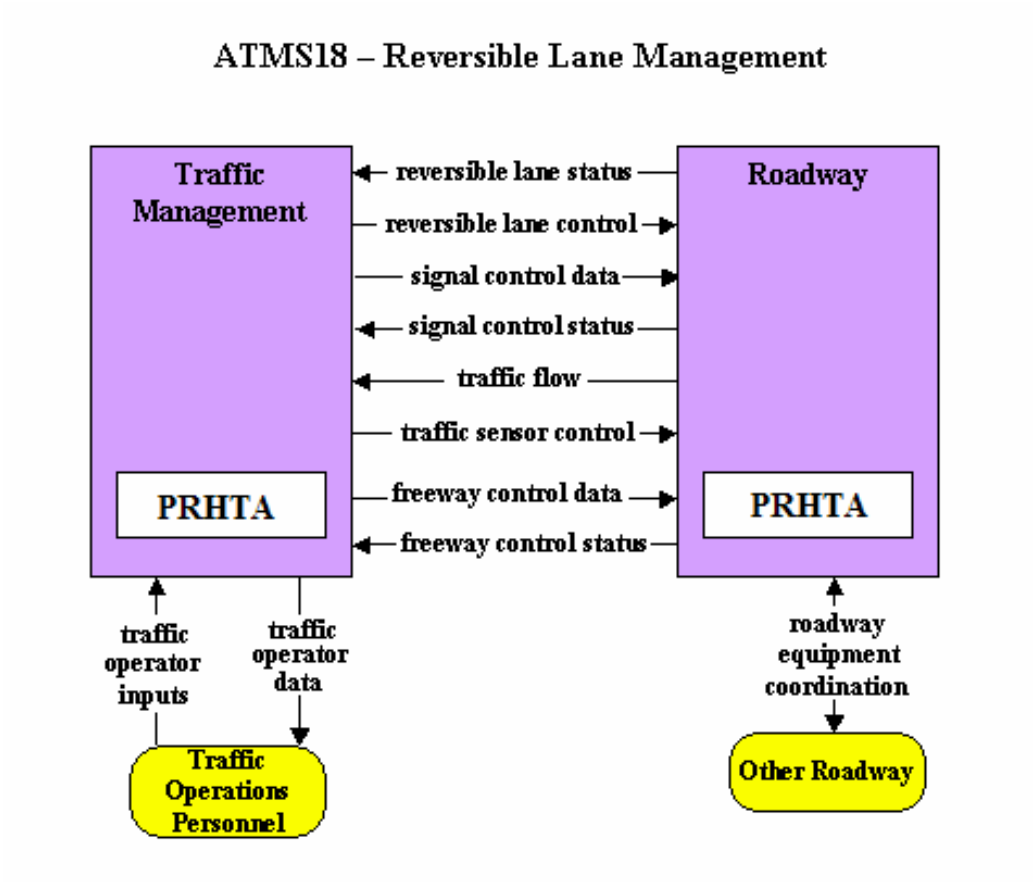

Figure 9-19: ATMS 18 – Reversible Lane Management

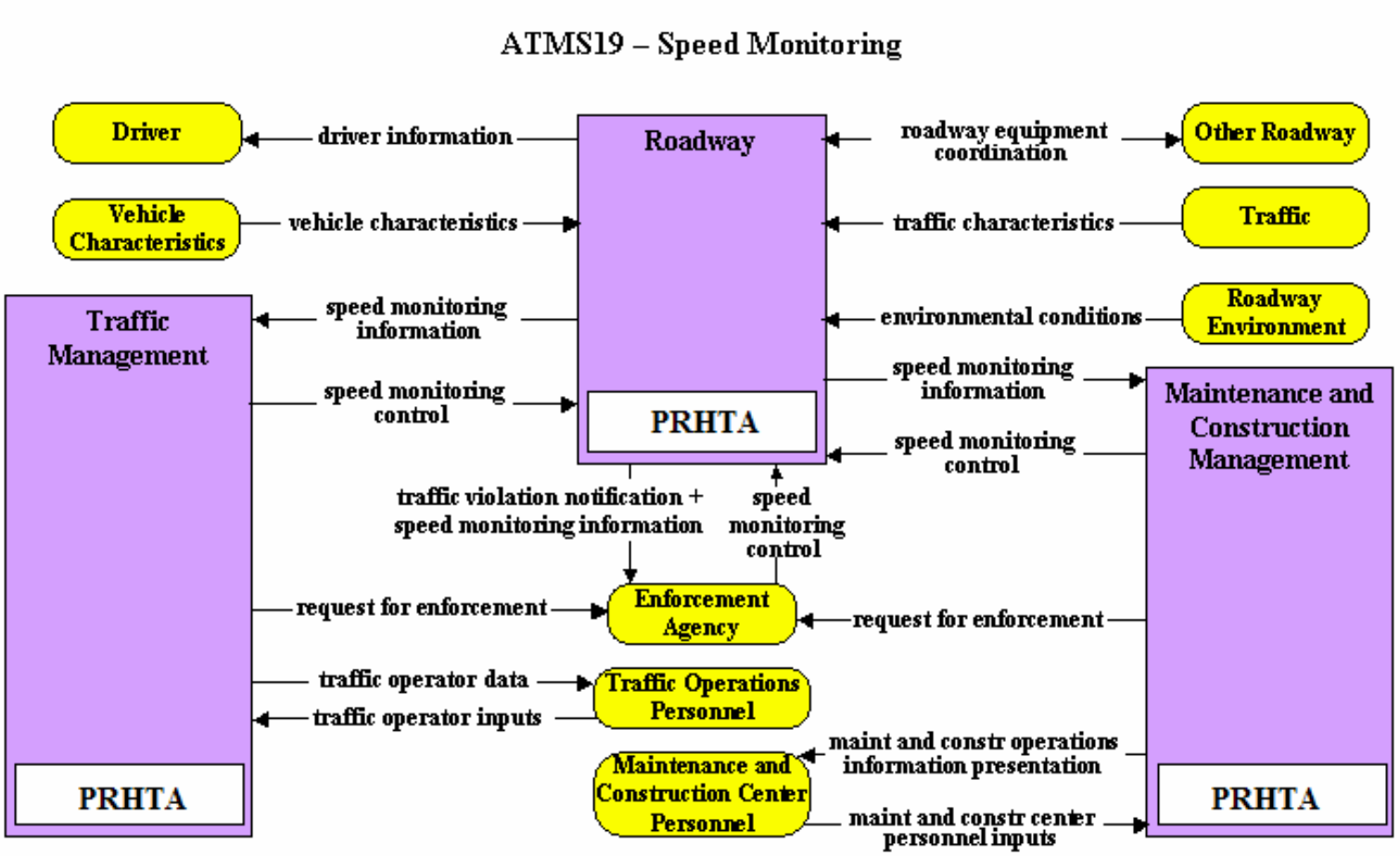

Figure 9-20: ATMS 19 – Speed Monitoring

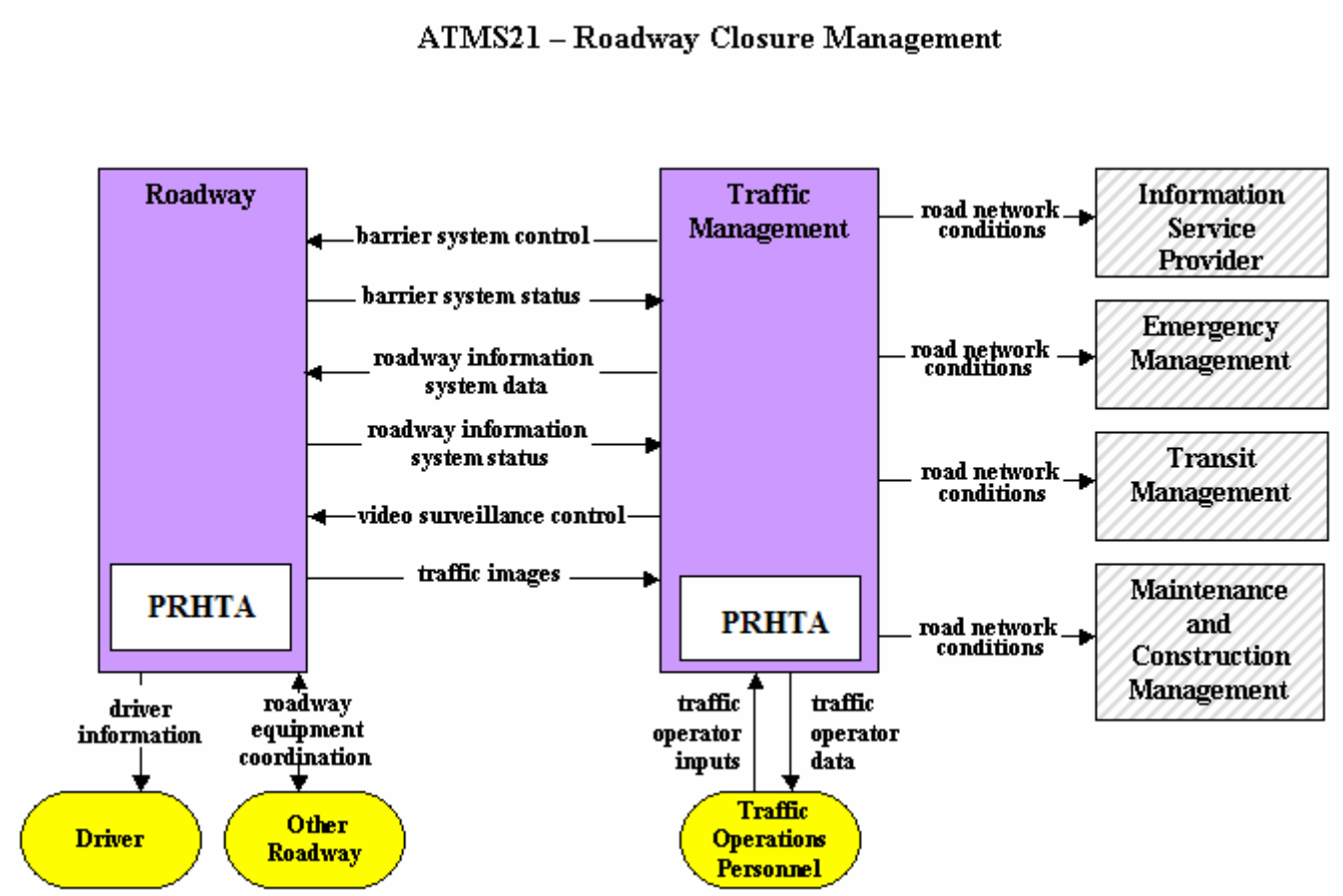

Figure 9-21: ATMS 21 – Roadway Closure Management

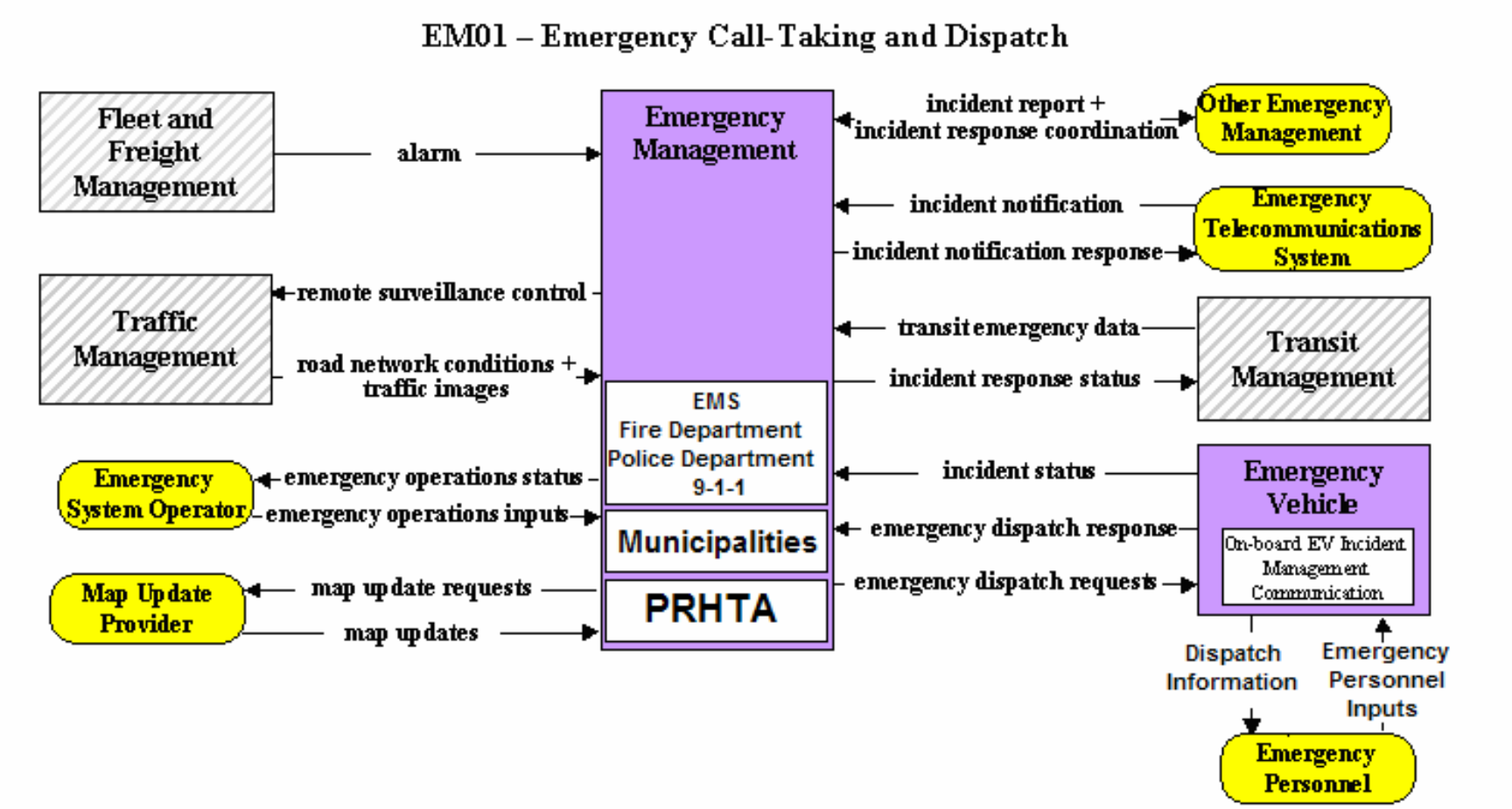

Figure 9-22: EM 01 – Emergency Call – Taking and Dispatch

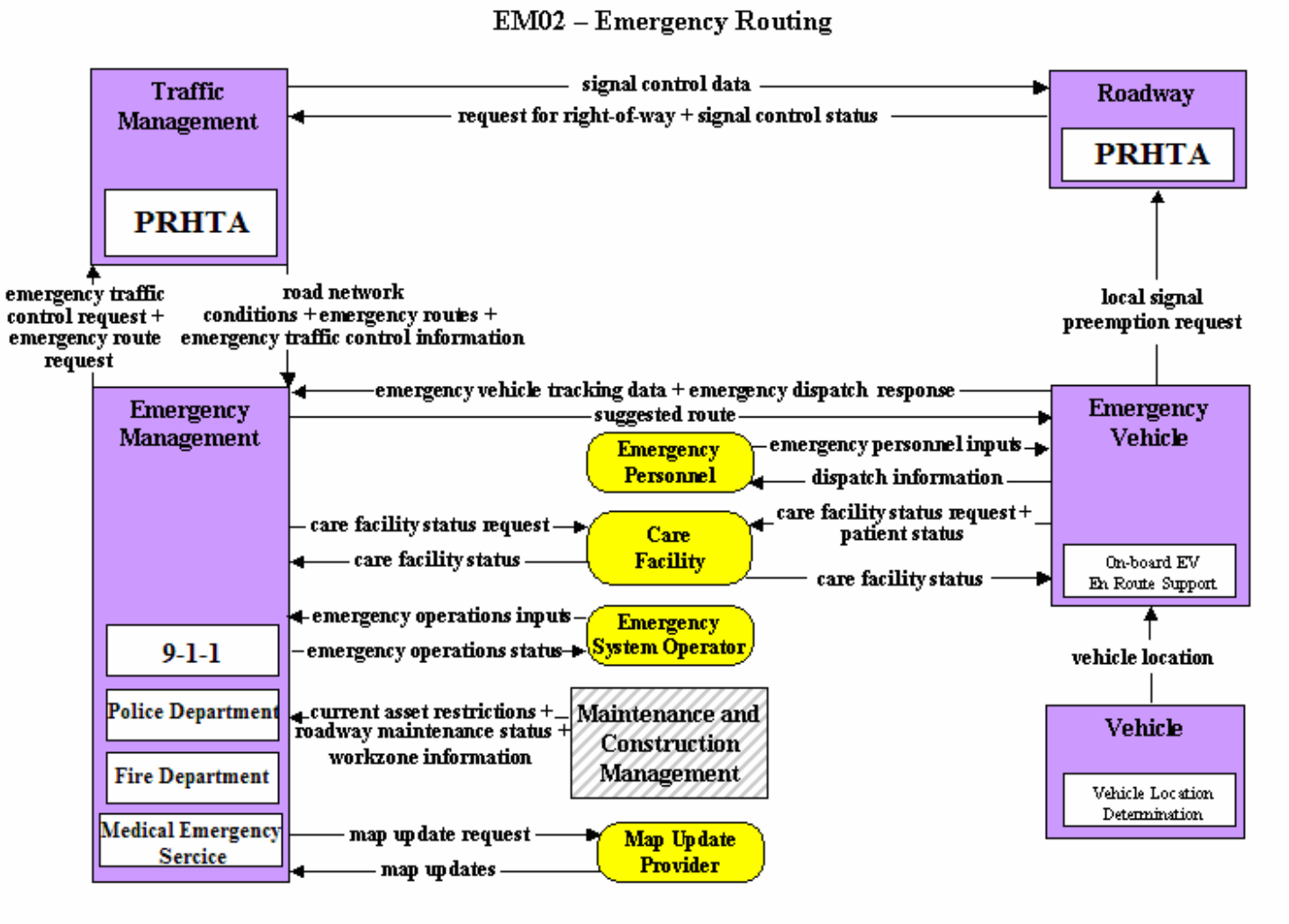

Figure 9-23: EM 02 – Emergency Routing

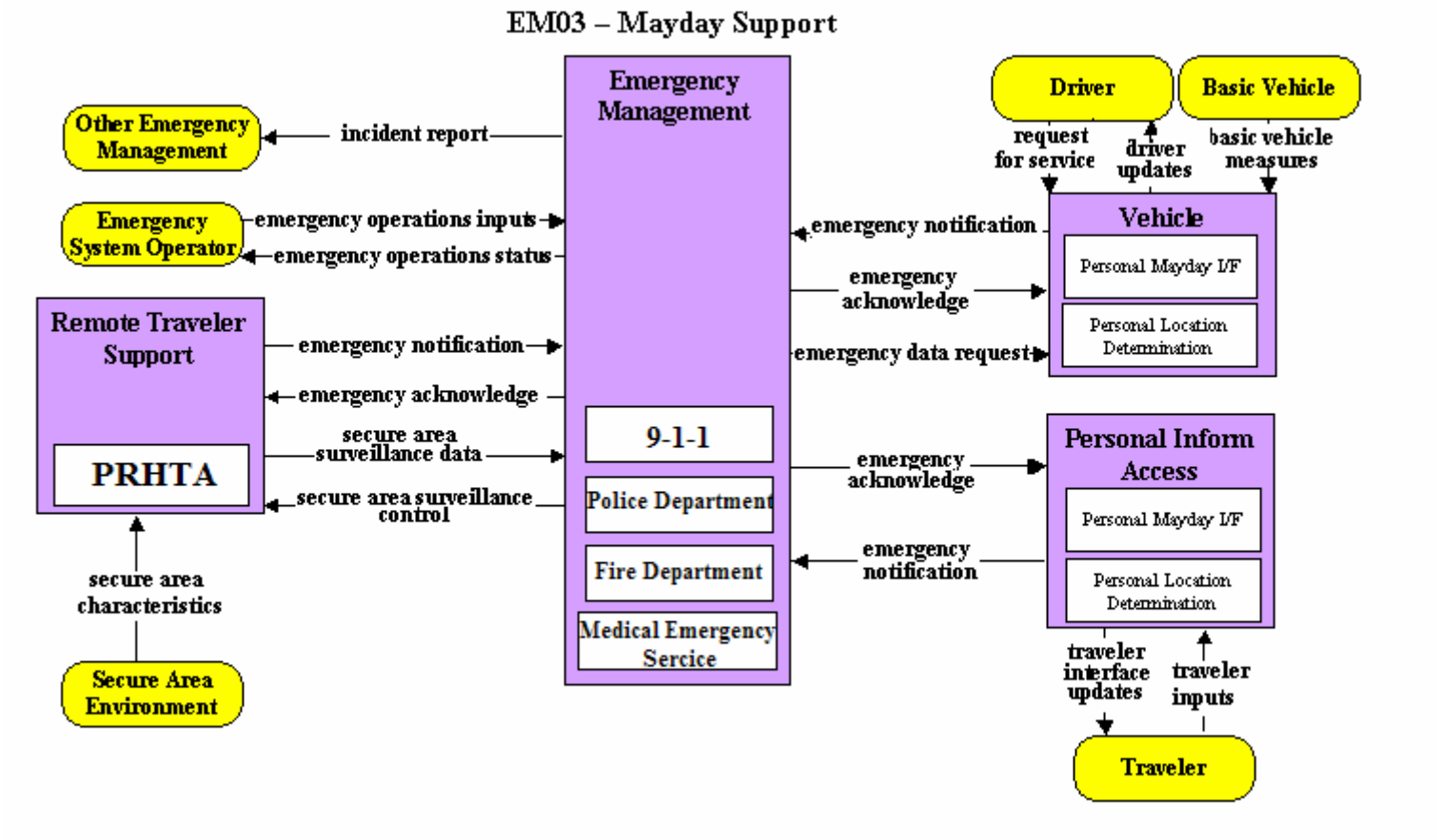

Figure 9-24: EM 03 – Mayday Support

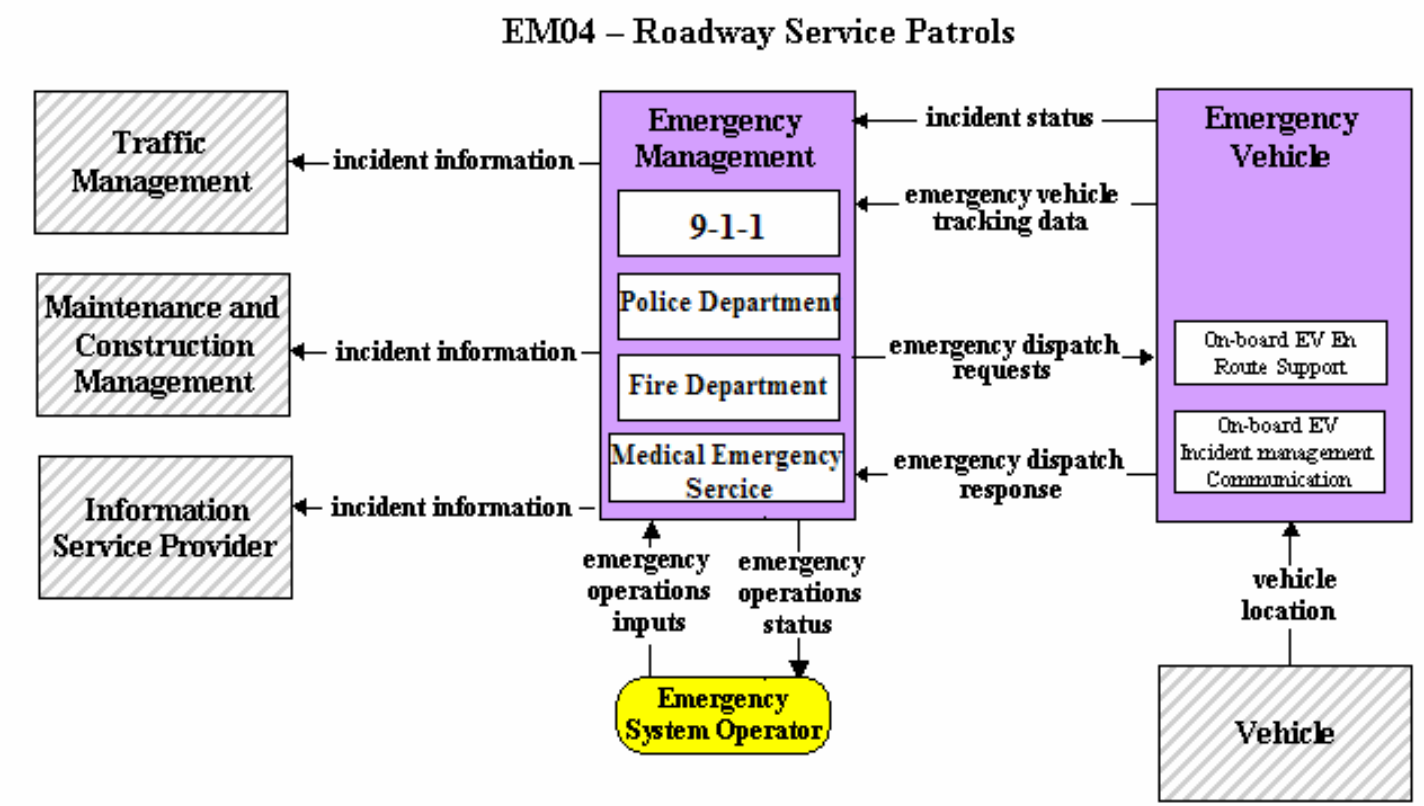

Figure 9-25: EM 04 – Roadway Service Patrols

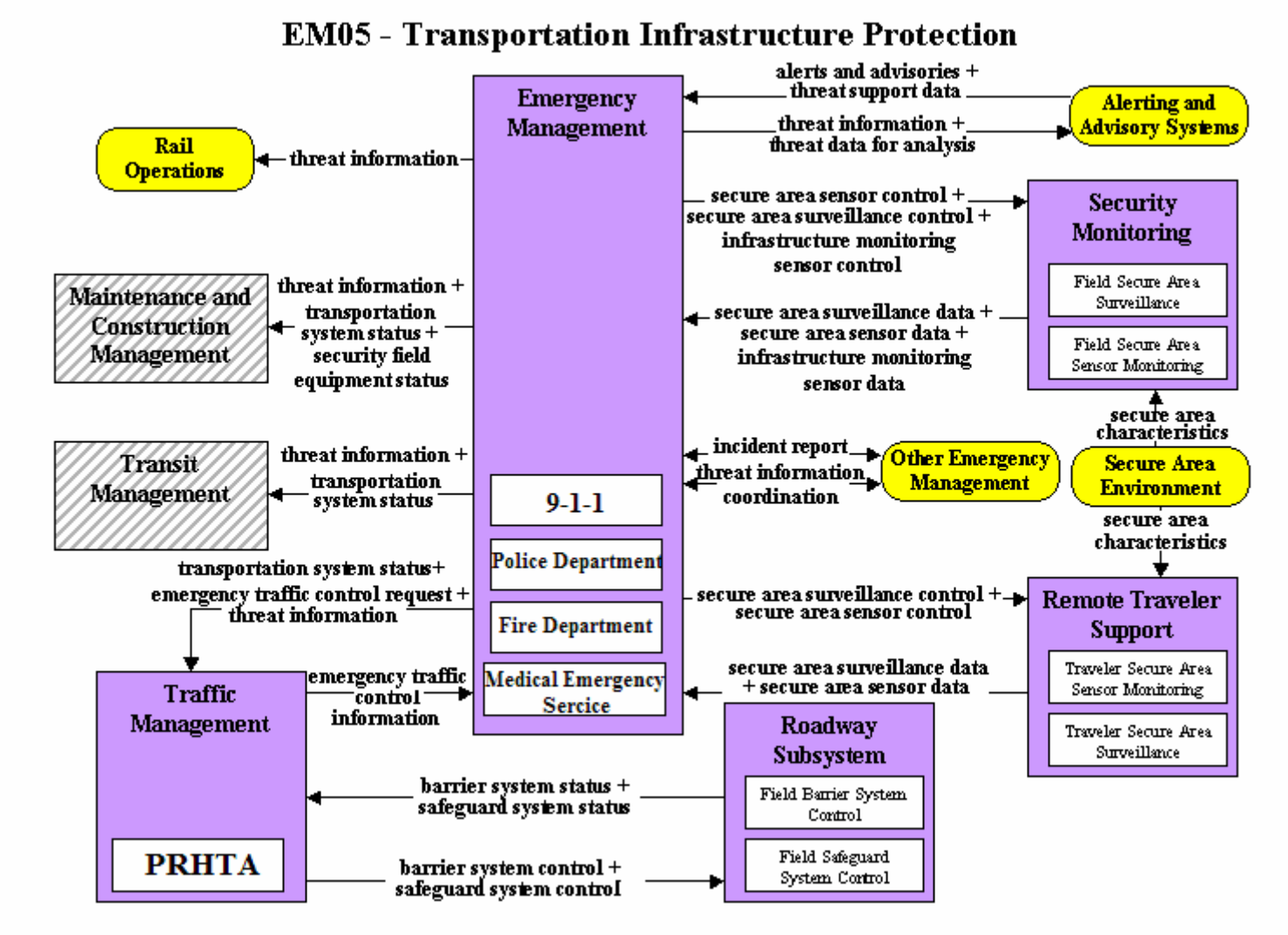

Figure 9-26: EM 05 – Transportation Infrastructure Protection

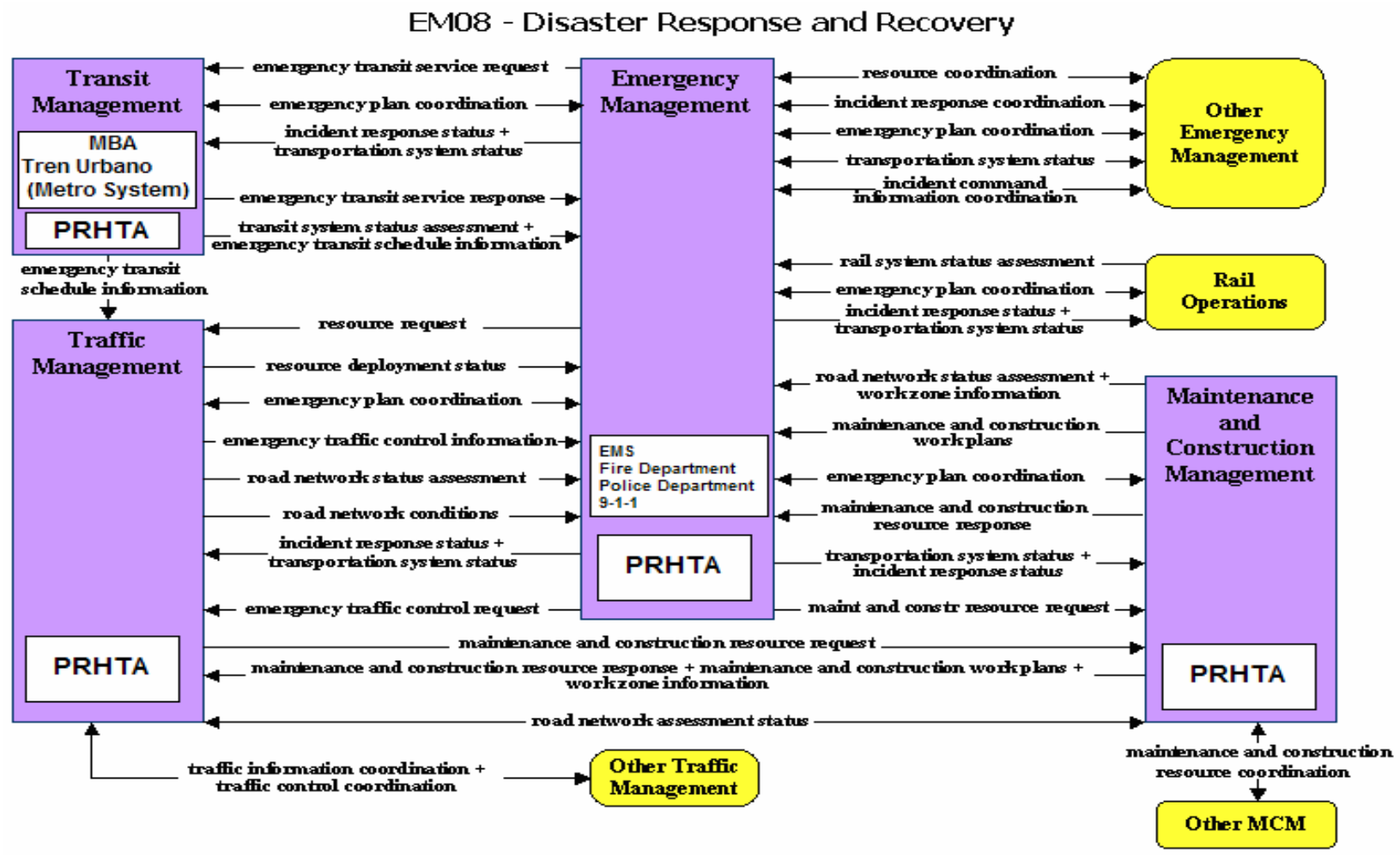

Figure 9-27: EM 08 – Disaster Response and Recovery

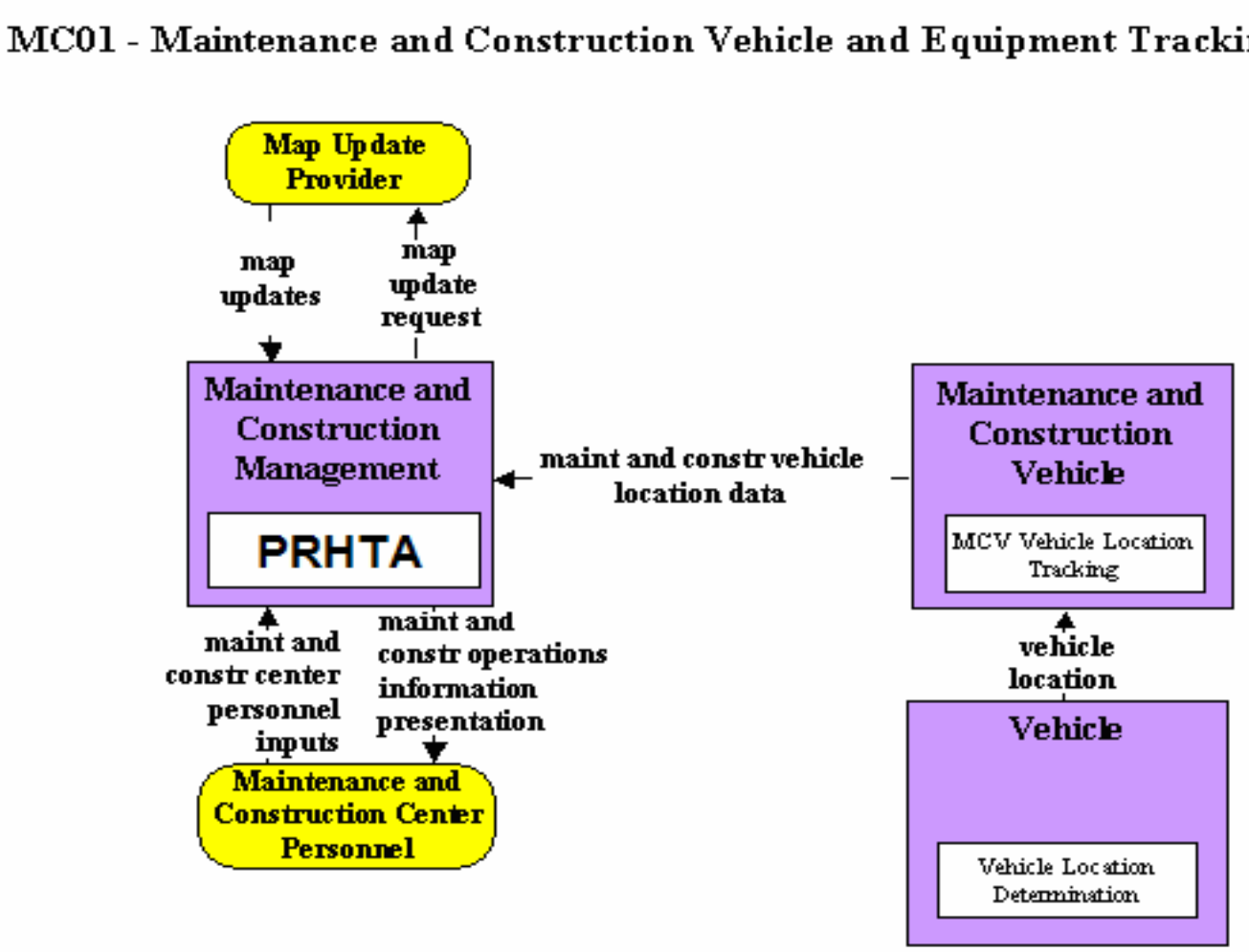

Figure 9-29: MC 01 – Maintenance and Construction vehicle and Equipment Tracking

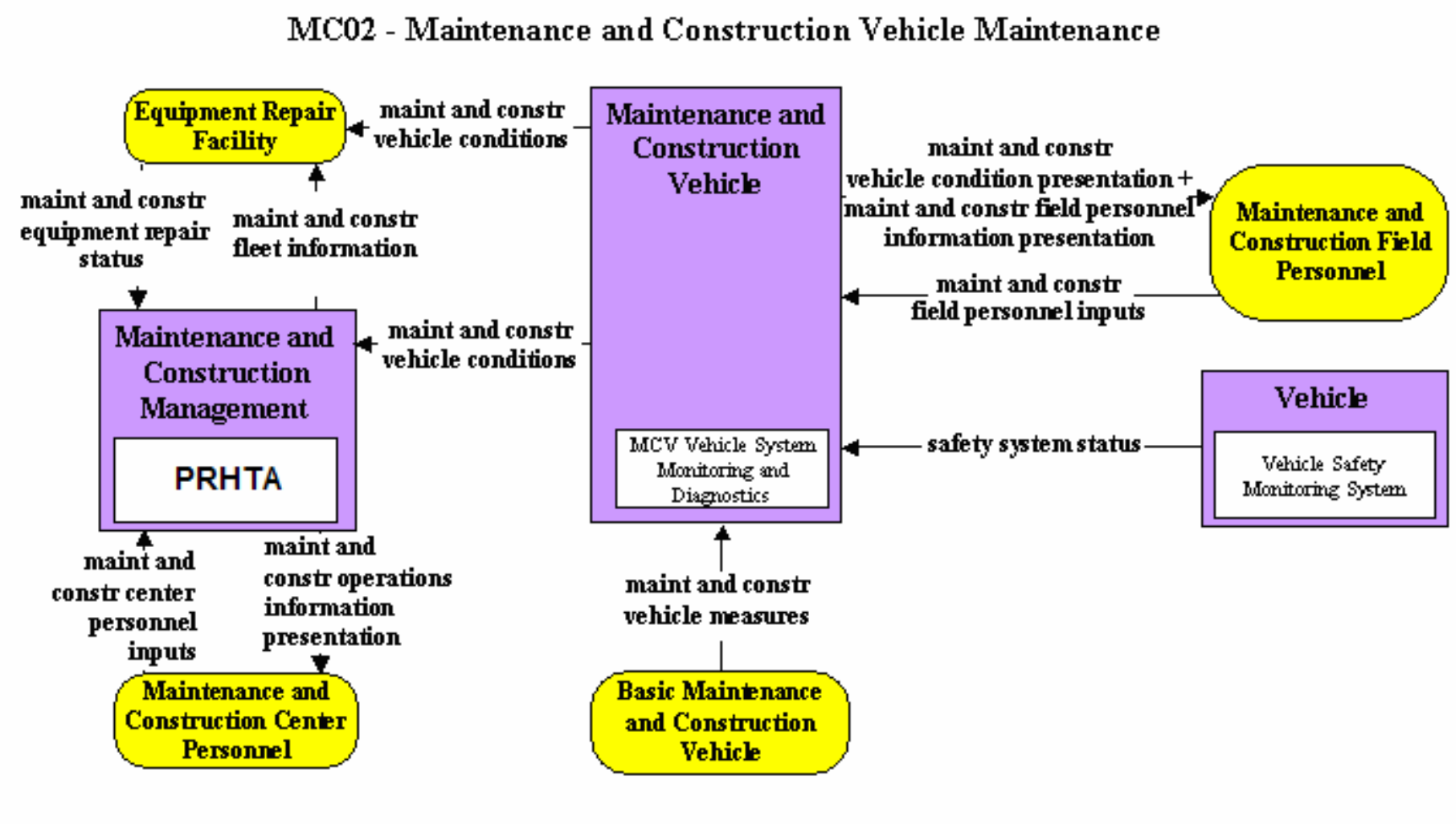

Figure 9-30: MC 02 – Maintenance and Construction Vehicle Maintenance

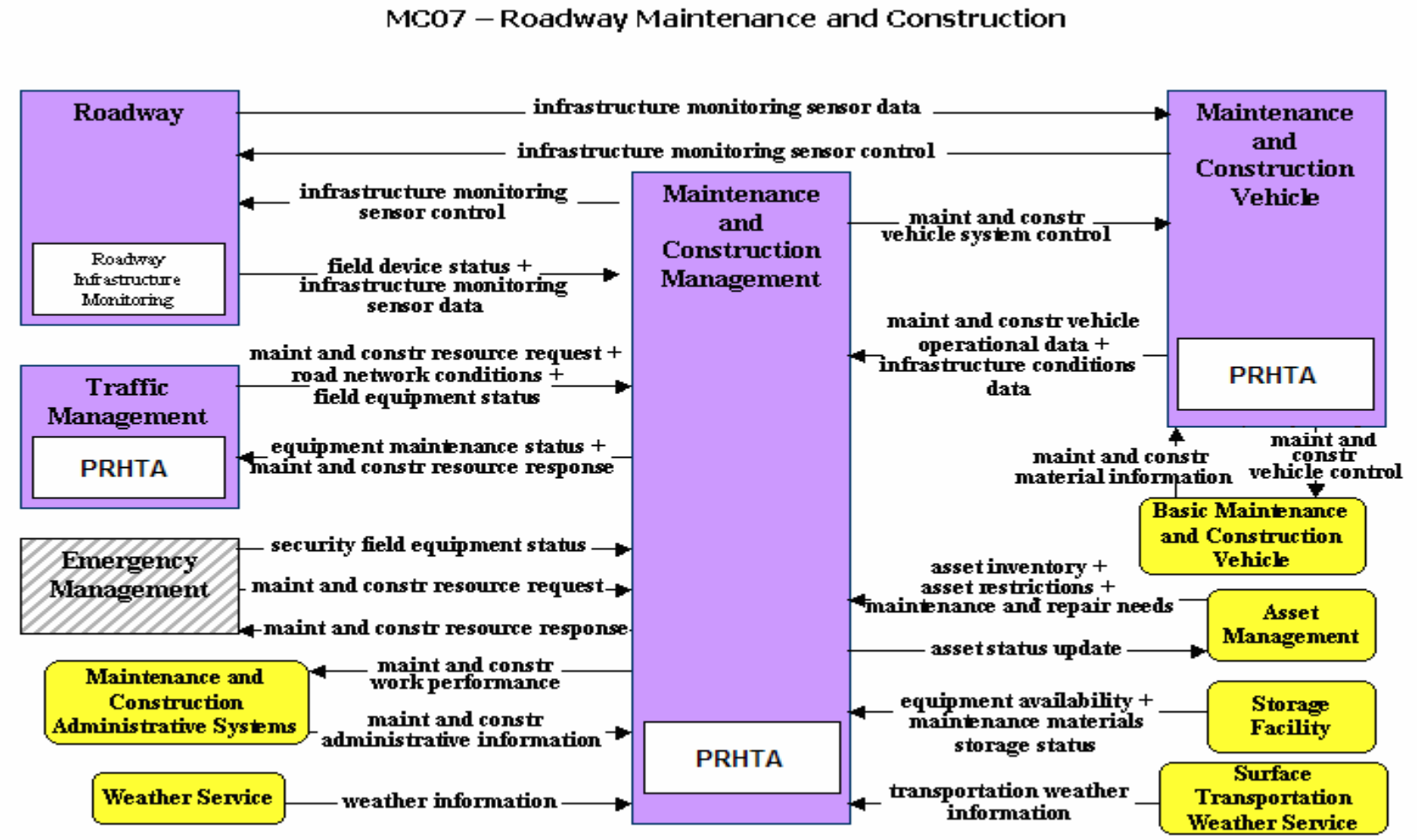

Figure 9-31: MC 07 – Roadway Maintenance and Construction

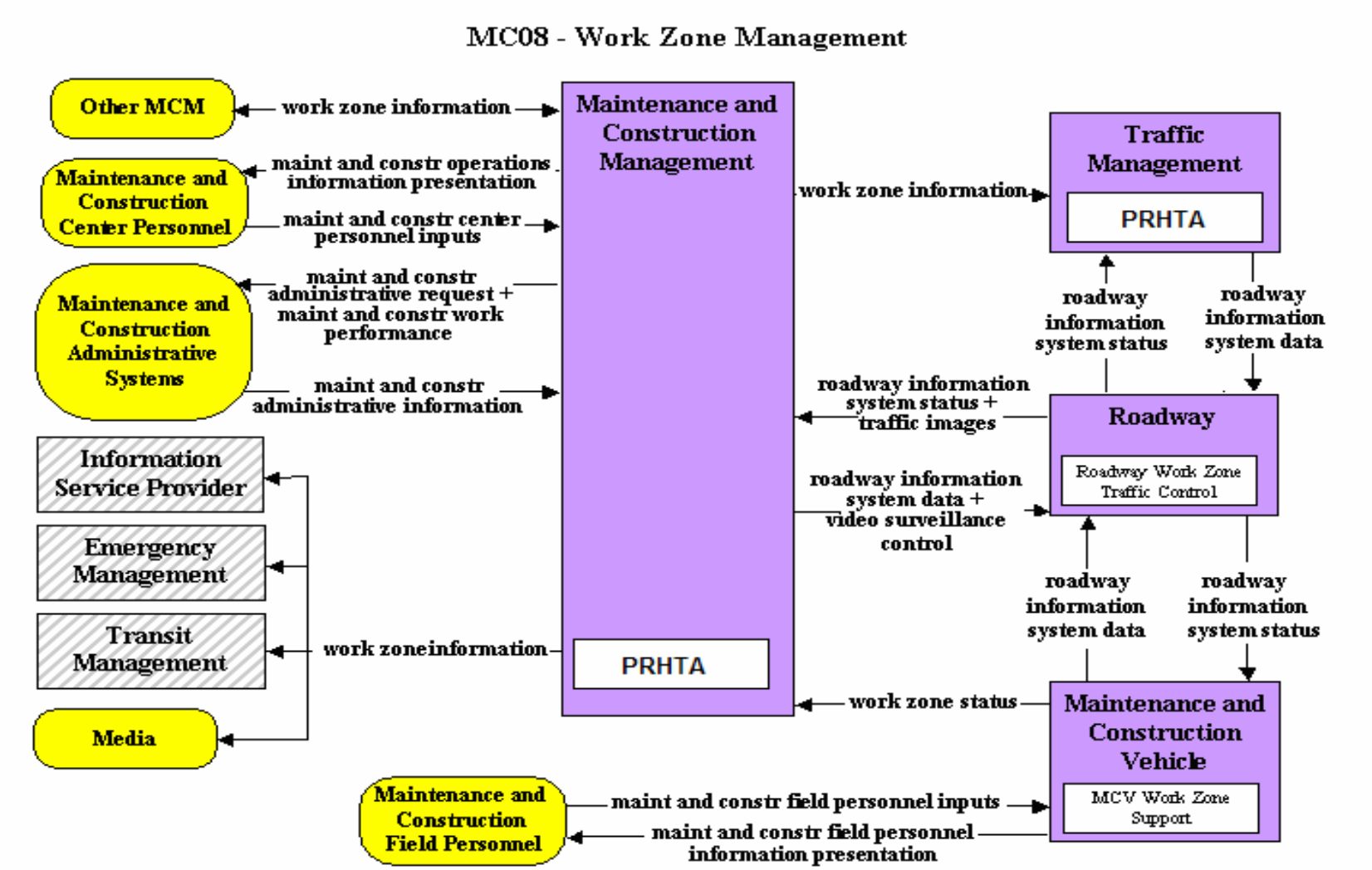

Figure 9-32: MC 08 – Work Zone Management

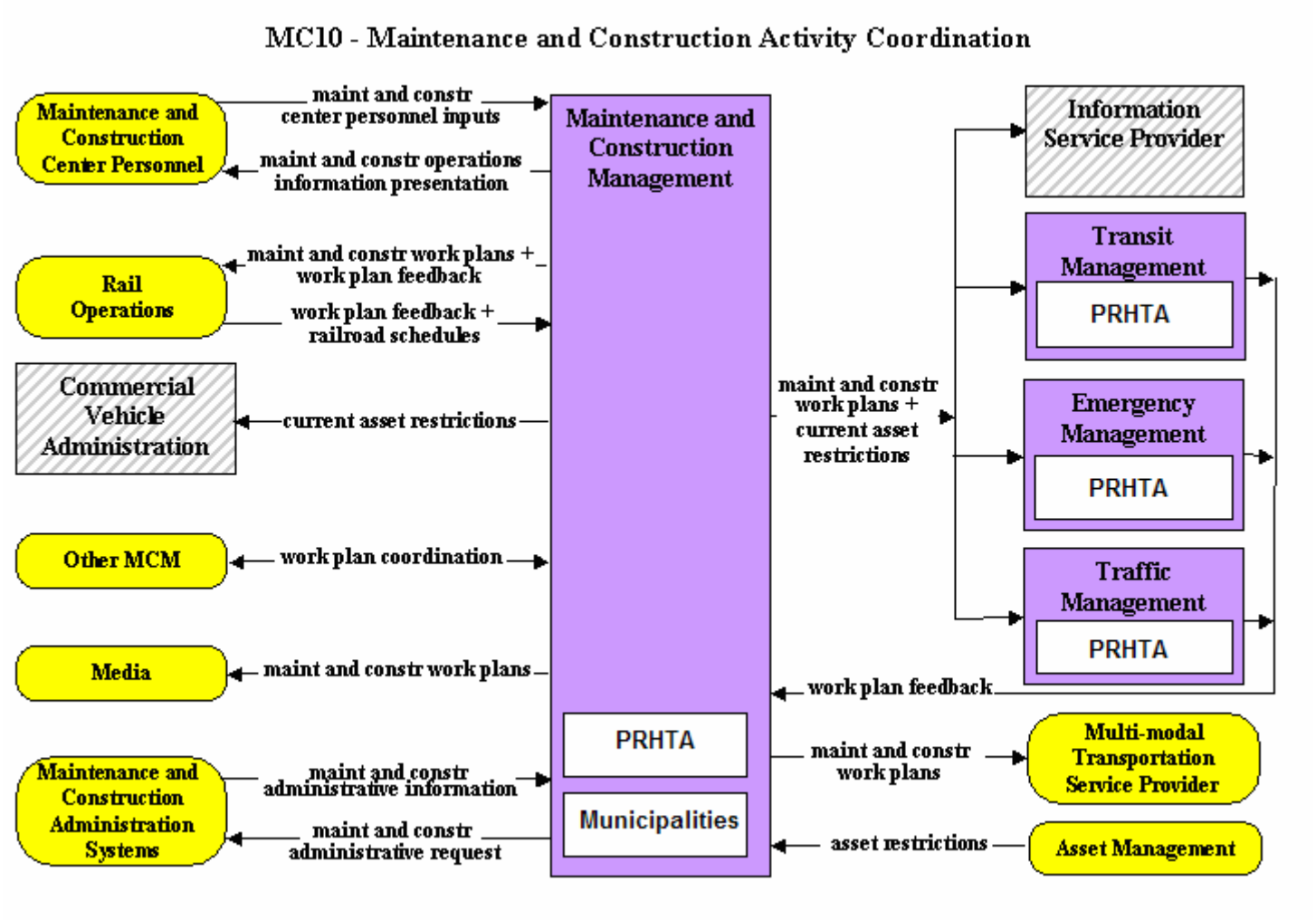

Figure 9-33: MC 10 – Maintenance and Construction Activity Coordination

10 Project Sequencing

In this step of the regional ITS architecture development, a sequence of ITS projects that will contribute to the regional transportation system is identified. These individual ITS projects will be implemented over the years. An ITS project is defined by the FHWA as "Any project that in whole or in part funds the acquisition of technologies or systems of technologies that provide or significantly contribute to the provision of one or more ITS user services as defined in the National Architecture." Furthermore, project sequencing, according to the FHWA Regional ITS Guidance Document, represents consensus building about setting priorities that show how ITS projects can build one another.

Table 10-1 presents the listing of projects by title, stakeholder, description and expected timing of implementation. All projects are listed irrespective of whether or not they will be funded through federal sources.

In order to implement the projects listed in Table 10-1 agreements between stakeholders are necessary to ensure future interoperability. Chapter 11 presents some of the agreements necessary to accomplish this goal.

Table 10.1 Project Sequencing

Project Title	Stakeholder	Description	Timing
Digital Map of Puerto Rico	911	Develop a map with all the possible geographical information and physical information.	S
PRHTA TMC	PRHTA	These systems are part of Phase I on the PR-22.	S
- Highway Advisory Radio (HAR)			S
- Dynamic Message Signs (DMS)			S
- Camera Surveillance			S
- Loop Detectors			
Control Aided Dispatch	Municipality of San Juan	Emergency Center Dispatch.	S
Mapping System		Accurate maps of the municipality of San Juan	S
Camera Surveillance of the Old San Juan		A Network surveillance of the old San Juan connected with the Control Aid Dispatch	S
Surveillance Center	Municipality of Bayamón	Outfitted with video equipment to enhance public safety in the Downtown Bayamón.	S
Surveillance Center	Municipality of Caguas	Outfitted with video equipment to enhance public safety in Downtown Caguas.	S
Surveillance Center	Municipality of Carolina	Outfitted with video equipment to enhance public safety in Downtown Carolina.	S

Surveillance Center	Municipality of Guaynabo	Outfitted with video equipment to enhance public safety in Downtown Guaynabo.	S
Surveillance Center	Municipality of Toa Baja	Outfitted with video equipment to enhance public safety in Downtown Toa Baja.	S
Automatic Bus Scheduling and Maintenance	MBA	Use of data available from the AVL system to develop automatic scheduling for busses and maintenance	M
Advanced Bus Information System	MBA	Display AVL and arrival info along the bus routes.	M
Tren Urbano Extensions to Caguas, Carolina, Minillas, Old San Juan, and Airport	Tren Urbano	According to the Master plan for Tren Urbano, various extensions of the system are planned using advanced technologies.	M/L

S = short term (0-5 years) M = medium term (6-10 years) L = long term (11-20 years)

11 Agreements

Some interagency agreements will be necessary to accomplish the implementation of the Regional ITS Architecture for the San Juan Metropolitan Area. The Puerto Rico Highway and Transportation Authority (PRHTA), key stakeholder in this development process, has identified future agreements that will necessary to implement the Regional Architecture and support project interoperability.

Priority will be placed to agreements with the Local Emergency / Security Agencies. Within this group are included the Police Department, the Fire Department, 911 and the Medical Emergency Services. An agreement between the PRHTA and the Police Department is especially important since the Police will have continuous presence in the PRHTA TMC. Agreements between the PRHTA and the other emergency management agencies mentioned above will be necessary to guarantee an efficient exchange of information between agencies to better coordinate incident management. An agreement between the Media and the PRHTA has also been identified as being necessary for a proficient distribution of information.

As the project develops more interagency agreements will be considered and executed as necessary. The next chapter presents the standards required to ensure the exchange of information between stakeholders.

12 Identification of Required Standards

The Rule/Policy requires, where appropriate, that federally funded ITS projects use ITS Standards that are adopted by the USDOT. Establishing regional and national standards for exchanging information among ITS Systems is important not only from an inter-operability point of view; it also reduces risk and cost since a region can select among multiple vendors for deployment products.

The PRHTA is aware of the importance of identifying relevant standards for the deployment of projects, especially for the future expansion of the TMC. The PRHTA as a leading agency in this effort will ensure that the selected ITS standards will be evaluated, tracked and folded into the project deployment plans to facilitate the future expansion of this architecture.

TurboArchitecture™ provides an ITS Standards Report based on all of the architecture flows selected in the region. The report lists all standards associated with each architecture flow. Refer to Appendix F for TurboArchitecture™ Standards Report.

At this point the architecture and the elements necessary to support it are already in place. In the next two chapters elements related to its use and maintenance are discussed. Chapter 13 describes how the architecture will be used both in the planning process and in the project implementation process. Chapter 14 describes the maintenance plan designed to keep the architecture current and relevant to the region's needs.

13 Using the Regional ITS Architecture

The San Juan Metropolitan Area Regional ITS Architecture will serve as a cornerstone for interagency ITS coordination within the San Juan Metropolitan Area. It is intended that stakeholders will use this document as a resource to identify planned and existing regional ITS projects, and to see how various projects are dependent upon one another. Therefore, the Regional ITS architecture will be used to support both the planning process and the project implementation process.

Regarding the planning process, the Architecture will be the main source of the regional ITS projects that will be included in the Long Range Plan and also in the Transportation Improvement Plan. The nature of the architecture is multimodal; therefore, various modes of transportation will be incorporated into these plans.

The incorporation of Intelligent Transportation Systems has posed additional challenges to the planning process. The use of the architecture allows for ITS projects to be considered in a thorough way, integrating various stakeholders and allowing for the evaluation and integration of these types of projects in the planning structure.

In addition, the Architecture will be used to better describe and define the projects that will be incorporated for deployment in the TIP. The architecture includes high level information that will be used to prioritize project implementation.

In terms of project implementation, the main use of the architecture will be to help in the process of obtaining a well defined and well thought out project from beginning to end. Once the systems engineering analysis is being performed, the project implementation is in a better position to be successful.

In particular, it is expected that the SJMA Regional ITS Architecture will be used to its potential to support project implementation in the following ways:

- Identifying stakeholders roles and responsibilities as well as interagency cooperation,
- Providing the functional requirements of elements within the project,
- Providing applicable standards to the project, and
- Providing bidders with a better understanding of the scope of the project.

For example, in the case of the Traffic Management Center for the region, PRHTA will meet with key stakeholders/ITS Project Implementers as the project is developed. PRHTA will also convene the core group of stakeholders, as necessary, for project collaboration and to ensure all regional ITS efforts conform to the regional architecture. PRHTA and project implementers will ensure that integration between elements and the use of ITS standards are consistent with the architecture. Refer to Appendix G for the Puerto Rico Intelligent Traffic Management Center Concept of Operations developed using the Federal Highway Administration guidance document titled *Developing and Using a Concept of Operations in Transportation Management System.*

14 Regional ITS Architecture Maintenance Plan

The regional ITS Architecture is not static. It changes as plans change, ITS projects are implemented, and the ITS needs and services evolve in the region. Changes in regional needs, new stakeholders, and/or changes in the scope of the services considered, make necessary the maintenance of the architecture so it can continuously reflect these. Also, changes related to project definition such as: changes due to project implementation; changes due to project addition or deletion; and/or changes in project priority, create a need for updates to the regional ITS architecture.

The purpose of maintaining the regional ITS architecture is to keep it current and relevant so it can be used by stakeholders as a technical reference when developing specific ITS projects. As conditions in a region change and effective maintenance process will also change the architecture to accommodate changing conditions. These changes may occur frequently or infrequently, depending upon the region. This should be taken into account when determining how often the regional ITS architecture should be updated.

14.1 Architecture Maintenance Process

This section presents the architecture maintenance process that has been determined by stakeholders involved in this regional ITS architecture. The *Regional ITS Architecture Maintenance White Paper* of the Federal Highway Administration was used to support the process of developing the maintenance plan for the architecture. Initially, a configuration control board (CCB) is established to have the responsibility of submitting changes. After that, the

general maintenance process is outlined from the generation of changes to the incorporation in new versions of the regional ITS architecture.

A Configuration Control Board is established to evaluate and approve changes to the architecture. The standing CCB members will be from the following key stakeholders in the region: two (2) representatives from the Puerto Rico Highway and Transportation Authority, one (1) from the Metropolitan Bus Authority, one (1) from the Local Emergency Security Agencies and one (1) from the Municipalities. Members of all the other stakeholders will be invited to participate on the CCB as deem needed for specific maintenance activities.

The Puerto Rico Highway and Transportation Authority (PRHTA) has had a leading role in the development of the SJMA Regional ITS Architecture. Due to this agency's technical understanding of the transportation systems in the region and the various parts of the architecture, and considering that PRHTA has knowledgeable staff to update the architecture, this agency will take the lead to maintain the regional ITS architecture. The PRHTA has the authority to maintain the functional scope of the architecture considering all the stakeholders involved; therefore, is ideally suited to assume the maintenance responsibility for the regional ITS architecture. Since the PRHTA has coordinating authority for integration of systems, the group responsible for evaluating and approving changes to the architecture and seeking consensus among stakeholders may be hosted in this agency, that will act as repository for all the documentation developed as part of the maintenance efforts.

The architecture will be updated according to an exception maintenance approach. This means that changes to the regional ITS architecture will be initiated as needed. In the maintenance process an architecture baseline, that is, the parts of the regional architecture that should be maintained must be defined. In this case, the first release of the SJMA Regional ITS Architecture document, including the maintenance plan constitutes the initial baseline for future changes. In addition, the TurboArchitecture™ Database also constitutes part of the architecture baseline. The source Architecture document will be held by PRHTA, while a printed version of the document will be created for general distribution. Regarding the Turbo Architecture Database, PRHTA will maintain the final version delivered along with the Architecture document. This will constitute version 1.0 of the architecture.

To update the architecture baseline an incremental change approach based upon individual change requests will be used. The various steps involved in the process of changing the baseline follow.

Identify Change

The primary aspects of change identification are:

- Who can suggest a change?
- How is the change request documented?

In this case, any stakeholder in the region dealing with ITS projects can initiate request changes. This ensures that changes suggested have a positive impact on the implementation of ITS by key stakeholders in the region. A request form will have the following information:

- Name of change
- Description of change
- Rationale for change
- Originator name or agency
- Originator contact information
- Date of origination

This information will be maintained by PRHTA in a change log with the following additional information:

- Change number
- Change disposition (accepted, rejected, deferred)
- Change type (minor vs. significant)
- Part of baseline affected
- Disposition comment
- Disposition date

Change requests containing the information described above will be submitted to the CCB hosted at the PRHTA. A change form containing the relevant information will be

developed by the CCB in order to facilitate the consideration of changes that should be incorporated in the Architecture.

Evaluate Change

Since an incremental change approach will be used, the group responsible for maintaining the architecture will evaluate each change request to determine what impact it has upon the architecture baseline. If the change warrants it, stakeholders will be contacted to confirm their agreement with the modification.

Approve Change

To approve a change request, approval of affected stakeholders will be needed. Once a change has been evaluated, all the stakeholders affected will have the opportunity to indicate if they agree with the changes proposed. With that input, the CCB will meet and recommend the changes according to their final evaluation.

Update Baseline

Changes to baseline documents and databases will be entered by corresponding personnel. It is recommended that if major changes to the baseline are approved, a new version of the regional architecture be established and distributed to the stakeholders in the region.

Notify Stakeholders

The personnel designated to maintain the architecture will have an up to date contact list of all stakeholders represented in the architecture. This contact list will be reviewed and updated periodically to identify changes in contact information. Stakeholders will be notified both with a hard copy and via email. The documents send via electronic messages will be “read-only” and protected so that changes are not made to released versions of the documents.

The architecture documents will be identified with a version number and date. This ensures that everyone who reads the documents and/or database knows which version they are reviewing. Additions or changes to the initial baseline will be noted with a changed version number and date. Audits related to verifying that representation of the architecture information, that is, documentation and database are in sync will be made.

15 Conclusion

As stated previously, the San Juan Metropolitan Area Regional ITS Architecture will serve as a cornerstone for interagency ITS coordination within the San Juan Metropolitan Area. It is intended that stakeholders will use this document as a resource to identify planned and existing regional ITS projects, and to see how various projects are dependent upon one another. Therefore, the Regional ITS architecture will be used to support both the planning process and the project implementation process.

Also the Federal Highway Administration requires that every state or region has an adopted ITS Architecture in place before seeking federal funding to deploy ITS projects. At the moment Puerto Rico is in non-compliance with this federal requirement. It is expected that the Regional ITS Architecture presented in this work will fulfill this federal requirement.

16 Recommendations

The San Juan Metropolitan Area Regional ITS Architecture presented in this work, considers only six of the thirty cities in the Metropolitan Area as defined by the 2000 Census. At this time this is enough since the projects being considered for deployment in the near future are well represented within this architecture. Still as conditions in the region change and projects are considered it is recommended that this version of the architecture is revised and expanded according to the maintenance plan describe previously.

17 References

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APPENDIX A

INITIAL INTERVIEW REPORT

Contact	Agency	ITS Elements
• Gladys Rodríguez *Technical Services Director* • Luis Vásquez *Project Manager*	911	• Existing o "Power 911 Intelligent Workstation" – provides call takers with on screen control of land lines and wireless calls. Helps categorize the emergency and contact emergency response agencies faster. o GPS to locate with coordinates the location of the calls originated from a cellular phone. o Interactive phone book and information of the emergency transfer – the call taker selects the agency that he wants to contact and the files are automatically sent to a printer and a call is automatically transferred to a dedicated line at the emergency response agency.
• Rafael A. Díaz Rodríguez *Inter-agency Coordinator for the Department of Transportation and Public Works*	Department of Transportation and Public Works	• Existing o Emergency Operations Center – call are work is coordinated with Public Works personnel to manage incidents.
• Carmen Sánchez *System Operator*	Medical Emergency Services	• Existing o GPS system used by the dispatch center to monitor the location of emergency vehicles and to provide route guidance. • Planned

		○ CAD System
• Wilfredo Ramos	Metropolitan Bus Authority	• Existing ○ GPS and AVL System in every transit vehicle. ○ Communication between vehicles, bus stops, and command center via radio. ○ "Automatic Passenger Counter" • Planned ○ Provide real time information to users through the Internet and on bus stops.
• Rubén Ramos *Auxiliary Director for the Technology Bureau*	Police Department	• Existing ○ Police vehicles with radio and video systems. • Planned ○ Expand microwave network to include the entire island.
• Heriberto Saurí *Chief of Programmatic Area*	San Juan Municipality	
• Gabriel Calderón *Director Department of Information Systems* • Luaida Oyola Mercado *Director Federal Proposals Office*	Toa Baja Municipality	• Planned ○ Video surveillance of public places with open access through the Internet. ○ "Traffic Web Cam" ○ City police patrols equipped with GPS. ○ Command Center for incident management.

APPENDIX B

INVENTORY REPORT

(Sorted by entity and by stakeholder)

Inventory Report (by entity)

2/16/2006 3:07:09PM

Archived Data Management Subsystem

Element: PRHTA TMC *Status:* Planned
Description: The PRHTA Traffic Management Center (TMC) is an integrated traffic management and data acquisition center. Its main goal is the effective maintenance of traffic operations in various scenarios.
Associated Stakeholder: PRHTA

Emergency Management

Element: Emergency Management System *Status:* Existing
Description: Emergency Management System refers to all systems related to managing emergencies such as medical emergencies, traffic incidents, etc. Included in this system are the emergency management systems of the police department, fire department, and medical emergency services.
Associated Stakeholder: Local Emergency / Security Agencies

Element: PRHTA TMC *Status:* Planned
Description: The PRHTA Traffic Management Center (TMC) is an integrated traffic management and data acquisition center. Its main goal is the effective maintenance of traffic operations in various scenarios.
Associated Stakeholder: PRHTA

Element: Surveillance Center *Status:* Planned
Description: The Surveillance Center will provide monitoring, through video equipment, of streets and urban centers. Although the main goal of this system is to enhance public safety, the data collected will serve in emergency management.
Associated Stakeholder: Municipalities

Emergency Vehicle Subsystem

Element: Vehicles *Status:* Existing
Description: This element refers to all vehicles equipped with ITS technology including emergency vehicles, transit vehicles and maintenance and construction vehicles and personal vehicles.
Associated Stakeholder: PRHTA, Local Emergency / Security Agencies, MBA, Tren Urbano

Information Service Provider

Element: Media *Status:* Planned
Description: The Media element represents the information systems that provide traffic reports, travel conditions, and other transportation-related news services to the traveling public through radio, TV, and other media.
Associated Stakeholder: Media

Element: PRHTA TMC *Status:* Planned

Description: The PRHTA Traffic Management Center (TMC) is an integrated traffic management and data acquisition center. Its main goal is the effective maintenance of traffic operations in various scenarios.

Associated Stakeholder: PRHTA

Maintenance and Construction Management

Element: Toll Roads *Status:* Existing

Description: This element refers to all transactions relate to toll highways.

Associated Stakeholder: PRHTA

Maintenance and Construction Vehicle

Element: Vehicles *Status:* Existing

Description: This element refers to all vehicles equipped with ITS technology including emergency vehicles, transit vehicles and maintenance and construction vehicles and personal vehicles.

Associated Stakeholder: PRHTA

Personal Information Access

Element: User Personal Computing Devices *Status:* Planned

Description: User Personal Computing Devices refers to equipment an individual owns and can personalize with their choices for information about transportation networks. An Internet-connected PC is an example.

Associated Stakeholder:

Remote Traveler Support

Element: Remote Traveler Support *Status:* Existing

Description: Remote traveler support provides access to traveler information at transit stations, transit stops, other fixed sites along travel routes (e.g., rest stops), and major trip generation locations.

Associated Stakeholder: MBA

Roadway Subsystem

Element: PRHTA TMC *Status:* Planned

Description: The PRHTA Traffic Management Center (TMC) is an integrated traffic management and data acquisition center. Its main goal is the effective maintenance of traffic operations in various scenarios.

Associated Stakeholder: PRHTA

Element: Roadside Equipment *Status:* Existing

Description: Roadside Equipment includes any and all equipment distributed on and along the roadway which monitors and controls traffic. This can include equipment for tolling.

Associated Stakeholder: PRHTA

Security Monitoring Subsystem

Element: Security Monitoring Field Equipment *Status:* Existing
Description: Security monitoring field equipment includes sensors and surveillance devices that monitor transportation infrastructure and public areas.
Associated Stakeholder: Tren Urbano

Toll Administration

Element: Toll Roads *Status:* Existing
Description: This element refers to all transactions relate to toll highways.
Associated Stakeholder: PRHTA

Toll Collection

Element: Toll Roads *Status:* Existing
Description: This element refers to all transactions relate to toll highways.
Associated Stakeholder: PRHTA

Traffic Management

Element: PRHTA TMC *Status:* Planned
Description: The PRHTA Traffic Management Center (TMC) is an integrated traffic management and data acquisition center. Its main goal is the effective maintenance of traffic operations in various scenarios.
Associated Stakeholder: PRHTA

Transit Management

Element: Transit Management System *Status:* Existing
Description: Transit Management System refers to all systems related to managing transit operations. For example the transit management systems of the Metropolitan Bus Authority and Tren Urbano.
Associated Stakeholder: MBA, Tren Urbano

Transit Vehicle Subsystem

Element: Vehicles *Status:* Existing
Description: This element refers to all vehicles equipped with ITS technology including emergency vehicles, transit vehicles and maintenance and construction vehicles and personal vehicles.
Associated Stakeholder: MBA, Tren Urbano

Vehicle

Element: Vehicles *Status:* Existing
Description: This element refers to all vehicles equipped with ITS technology including emergency vehicles, transit vehicles and maintenance and construction vehicles and personal vehicles.
Associated Stakeholder: PRHTA, MBA, Tren Urbano, Local Emergency / Security Agencies

Inventory Report (by stakeholder)

2/16/2006 3:07:48PM

Element: User Personal Computing Devices *Status:* Planned

Description: User Personal Computing Devices refers to equipment an individual owns and can personalize with their choices for information about transportation networks. An Internet-connected PC is an example.

Local Emergency / Security Agencies

Element: Emergency Management System *Status:* Existing

Description: Emergency Management System refers to all systems related to managing emergencies such as medical emergencies, traffic incidents, etc. Included in this system are the emergency management systems of the police department, fire department, and medical emergency services.

MBA

Element: Remote Traveler Support *Status:* Existing

Description: Remote traveler support provides access to traveler information at transit stations, transit stops, other fixed sites along travel routes (e.g., rest stops), and major trip generation locations.

MBA, Tren Urbano

Element: Transit Management System *Status:* Existing

Description: Transit Management System refers to all systems related to managing transit operations. For example the transit management systems of the Metropolitan Bus Authority and Tren Urbano.

Media

Element: Media *Status:* Planned

Description: The Media element represents the information systems that provide traffic reports, travel conditions, and other transportation-related news services to the traveling public through radio, TV, and other media.

Municipalities

Element: Surveillance Center *Status:* Planned

Description: The Surveillance Center will provide monitoring, through video equipment, of streets and urban centers. Although the main goal of this system is to enhance public safety, the data collected will serve in emergency management.

PRHTA

Element: PRHTA TMC *Status:* Planned

Description: The PRHTA Traffic Management Center (TMC) is an integrated traffic management and data acquisition center. Its main goal is the effective maintenance of traffic operations in various scenarios.

Element: Roadside Equipment *Status:* Existing

Description: Roadside Equipment includes any and all equipment distributed on and along the roadway which monitors and controls traffic. This can include equipment for tolling.

Element: Toll Roads *Status:* Existing
Description: This element refers to all transactions relate to toll highways.

PRHTA, MBA, Tren Urbano, Local Emergency, Security Agencies

Element: Vehicles *Status:* Existing
Description: These element refers to all vehicles equipped with ITS technology including emergency vehicles, transit vehicles and maintenance and construction vehicles and personal vehicles.

Tren Urbano

Element: Security Monitoring Field Equipment *Status:* Existing
Description: Security monitoring field equipment includes sensors and surveillance devices that monitor transportation infrastructure and public areas.

APPENDIX C

ROLES AND RESPONSIBILITIES BY STAKEHOLDER

Market Package	Contents	Operating Agency	Roles and Responsibilities
AD1 ITS Data Mart	Provides a archived that houses data collected and owned by a single agency.	PRHTA	• Collect data. • Manage and maintain the data archive.
AD2 ITS Data Warehouse	Includes all the data collection and management capabilities provided by AD1, and adds the functionality and interface definitions that allow collection of data from multiple agencies and data sources spanning across modal and jurisdictional boundaries.	PRHTA	• Manage and maintain the data archive.
		Research Groups	• Collect data from the data archive.
APTS 1 Transit Vehicle Tracking	Monitors current transit vehicle location using AVL.	MBA/Tren Urbano (Metro System)	• Operate the tracking system to monitor vehicle location.
APTS 4 Transit Passenger and Fare Management	Manages passenger loading and fare payments on transit vehicles using electronic means	MBA / Tren Urbano (Metro System)	• Establish transit passenger and management system. • Operate and maintain the transit passenger and fare management system.

APTS 5 Transit Security	Provides for the physical security of transit passengers and transit vehicle operators	MBA / Tren Urbano (Metro System)	• Monitor transit vehicle security. • Monitor transit related pubic area. • Receive security call from transit drivers. • Maintain the communication network with transit vehicle and emergency services.
APTS 6 Transit Maintenance	Supports automatic transit maintenance scheduling and monitoring.	MBA / Tren Urbano (Metro System)	• Coordinate transit maintenance.
APTS 7 Multimodal Coordination	Establishes two way communications between multiple transit and traffic agencies to improve service coordination.	MBA / Tren Urbano (Metro System)	• Maintain the communication network with other agencies. • Coordinates transit service with other agencies.
APTS 8 Transit Traveler Information	Provides transit users at transit stops and on-board transit vehicles with ready access to transit information.	MBA / Tren Urbano (Metro System)	• Provide transit schedule and route information through Website, telephone services, and other ISP.

ATIS 1 Broadcast Traveler Information	Collects traffic conditions, advisories, general public transportation , incident information, roadway maintenance and construction information, weather information, and broadly disseminates this information through existing infrastructures.	PRHTA	• Provide traffic and incident information to drivers. • Share traffic information with other emergency agencies. • Update information to ISPs and Media Outlets and send alerts on DMS and HAR equipment. • Report highway road closure to all agencies.
		Media	• Provide traffic and incident information to drivers.
		MBA/ Tren Urbano (Metro System)	• Provide transit information.
ATMS 1 Network Surveillance	Traffic detectors, other surveillance equipment, the supporting field equipment, and fixed-point to fixed-point communication to transmit the collected data back to the Traffic Management Subsystem.	PRHTA	• Install CCVT cameras, DMS and HAR along the highways. • Maintain field equipment. • Share surveillance data with other agencies.

ATMS 2 Probe Surveillance	An alternative surveillance approach of network. Two general paths: (1) wide-area wireless communications between the vehicle and ISP about current vehicle location and status, (2) short range communications between the vehicle and roadside for equivalent information directly to TMC.	PRHTA	• Implement roadside network probe surveillance equipment. • Operate and maintain probe surveillance equipment.
ATMS 3 Surface Street Control	Central control and monitoring equipment, communication links, and the signal control equipment that supports local surface street control and/or arterial traffic management.	PRHTA	• Monitor traffic on arterials. • Manage traffic on arterials using traffic signals including preemptions for emergency vehicles and priority for transit vehicles. • Coordinate traffic control responding to incidents which involve emergency and traffic agencies. • Share traffic information with other emergency and transportation agencies. • Maintain field equipment.

ATMS 6 Traffic Information Dissemination	Driver information using roadway equipment such as dynamic message signs or highway advisory radio.	PRHTA	• Install and maintain the traffic information dissemination equipment along freeways. • Update information to ISP and Media Outlets and send alerts on CMS and HAR equipment. • Provide traffic and incident information to the public.
ATMS 7 Regional Traffic Control	Sharing of traffic information and control among traffic management centers to support a regional control strategy. Adding the communication links and integrated control strategies that enable integrated inter-jurisdictional traffic control	PRHTA	• Develop policies and agreements among local agencies to connect and share traffic control related infrastructure and procedures.
ATMS 8 Traffic Incident Management System	Managing both unexpected incidents and planned events so that the impact to the transportation network and traveler safety is minimized.	PRHTA	• Receive public safety calls and forward them to appropriate dispatch center. • Collect incident data and confirm incident time and location. • Implement traffic control responding to incidents. • Coordinate road closure with other agencies. • Coordinate traffic control and incident response with other agencies. • Respond to incident by coordinating with field staff. • Communicate with other

		PRHTA	emergency and traffic agencies to support coordinated emergency response when necessary. • Monitor traffic on designated arterials. • Dispatch highway patrol vehicles. • Provide incident status information. • Report freeway road closure to all agencies.
		Local Emergency / Security Agencies	• Respond to incident situations or planned events according to their functions.
		Municipalities	• Provide resources when requested by emergency agency
		Media	• Receive incident information.
ATMS 9 Traffic Forecast and Demand Management	Includes advanced algorithms, processing, and mass storage capabilities that support historical evaluation, real-time assessment of the roadway network performance.	PRHTA	• Collect and process roadway performance data.

ATMS 10 Electronic Toll Collection	Collect tolls electronically and detect and process violations.	PRHTA	• Install, maintain and operate electronic collection system. • Detect and process violations.
ATMS 19 Speed Monitoring	Monitors the speeds of vehicles through a roadway system.	PRHTA	• Install, maintain and operate speed monitoring equipment.
ATMS 21 Roadway Closure Management	Closes roadways to vehicular traffic when driving conditions are unsafe, maintenance must be performed, and other scenarios where access to the roadway must be prohibited.	PRHTA	• Implement road closure when necessary. • Report highway closure to all agencies.
EM 1 Emergency Call-Taking and Dispatch	Basic public safety call-taking and dispatch services.	PRHTA	• Monitor and manage traffic on highways. • Monitor and manage traffic for freeway on-ramps, control their signals to include preemption for emergencies. • Implement traffic control responding to incidents. • Share traffic information with other emergency agencies. • Assume a leading role in handling and clearance of incidents on highways. • Monitor and manage traffic on highways. • Monitor and management traffic for freeway on-ramps, control their signals to include preemption for emergencies. • Dispatch patrol vehicles.

			• Report highway closure to all agencies.
		Municipalities	• Share traffic information with other emergency and transportation agencies. • Provide resources when requested by emergency agency.
		Local Emergency / Security Agencies	• Receive public calls and forward them to appropriate dispatch centers. • Dispatch police, fire, ambulance, and other emergency vehicles.
EM 2 Emergency Routing	Supports automated vehicle location and dynamic routing of emergency vehicles. Traffic information, road conditions, and suggested routing information are provided to enhance emergency vehicle routing.	PRHTA	• Provide routing information to emergency vehicles. • Share traffic information with other emergency agencies.
		Municipalities	• Provide routing information to emergency vehicles.
		Local Emergency / Security Agencies	• Provide routing information to emergency vehicles.

EM 3 Mayday Support	Allows the user to initiate a request for emergency assistance and enables the EMS to locate the user, gather information about the incident, and determine the appropriate response.	PRHTA	• Monitor and manage traffic on highways.
		Municipalities	• Share traffic information with other emergency and transportation agencies. • Provide resources when requested by emergency agencies.
		Local Emergency / Security Agencies	• Receive public calls and forward them to appropriate dispatch centers. • Dispatch police, fire, ambulance, and other emergency vehicles
EM 4 Roadway Service Patrols	Supports roadway service patrols vehicles that monitor roads that aids motorists, offering rapid response to minor incidents to minimize disruption to the traffic stream.	PRHTA	• Assume a leading role in handling and clearance of incidents on highways. • Monitor and manage traffic on highways. • Dispatch patrol vehicles.
		Municipalities	• Share traffic information with other emergency and transportation agencies. • Provide resources when requested by emergency agency.
		Local Emergency / Security Agencies	• Dispatch police, fire, ambulance, and other emergency vehicles.

EM 5 Transportation Infrastructure Protection	Includes the monitoring of transportation infrastructure for potential threats using sensors and surveillance equipment and barrier and safeguard systems to preclude an incident, control access during and after an incident or mitigate impact of an incident.	PRHTA	• Monitor transportation infrastructure. • Implement traffic control responding to incidents. • Share traffic information with other emergency agencies.
		Municipalities	• Share traffic information with other emergency and transportation agencies. • Provide resources when requested by emergency agency.
		Local Emergency / Security Agencies	• Share traffic information with other emergency and transportation agencies. • Dispatch police, fire, ambulance, and other emergency vehicles.
EM 8 Disaster Response and Recovery	Enhances the ability of the surface transportation system to respond to and recover from disasters.	PRHTA	• Provide road network status. • Coordinate with emergency management agencies on emergency traffic control.
		Municipalities	• Share traffic information with other emergency and transportation agencies. • Provide resources when requested by emergency agency.
		Local Emergency / Security Agencies	• Respond to disaster situations. • Collect disaster status. • Send out request of resources to all centers.

EM 10 Disaster Traveler Information	Provides disaster-related traveler information to the general public, including evacuation and reentry information and other information concerning the operation of the transportation system during a disaster.	PRHTA	• Provide road network status. • Share disaster-related information with other emergency and transportation agencies. • Provide disaster-related information to the public.
		Municipalities	• Provide disaster-related information to the public.
		Local Emergency / Security Agencies	• Dispatch police, fire, ambulance, and other emergency vehicles.
MC 1 Maintenance and Construction Vehicle and Equipment Tracking	Will track the location of maintenance and construction vehicles and other equipment to ascertain the progress of their activities.	PRHTA	• Install and maintain tracking equipment. • Monitor location of maintenance and construction vehicles. • Monitor progress of maintenance and construction activities.
MC 2 Maintenance and Construction Vehicle Maintenance	Performs vehicle maintenance scheduling and manages both routine and corrective maintenance activities on vehicles and other maintenance and construction equipment. It includes on-board sensors capable of automatically performing diagnostics for maintenance and construction vehicles.	PRHTA	• Schedule maintenance activities. • Monitor vehicle performance. • Install and maintain equipment capable of performing diagnostics.

MC 7 Roadway Maintenance and Construction	Supports numerous services for scheduled and unscheduled maintenance and construction on a roadway system or right-of-way. Maintenance services would include landscape maintenance, hazard removal, routine maintenance activities (roadway cleaning, grass cutting), and repair and maintenance of both ITS and non-ITS equipment on the roadway (e.g., signs, traffic controllers, traffic detectors, dynamic message signs, traffic signals, CCTV, etc.).	PRHTA	• Monitor maintenance and construction activities on the roadway system. • Coordinate traffic control responding to incidents which involve maintenance and construction activities. • Provide traffic information during maintenance and construction activities.
MC 8 Work Zone Management	Directs activity in work zones, controlling traffic through portable dynamic message signs (DMS) and informing other groups of activity (e.g., ISP, traffic management, other maintenance and construction centers) for better coordination management.	PRHTA	• Coordinate traffic control responding to maintenance and construction activities. • Provide traffic information during maintenance and construction activities.

	Work zone speeds and delays are provided to the motorist prior to the work zones.		
MC 10 Maintenance and Construction Activity Coordination	Supports the dissemination of maintenance and construction activity to centers that can utilize it as part of their operations, or to the Information Service Providers who can provide the information to travelers.	PRHTA	• Share traffic information with other public and emergency agencies. • Provide traffic information during maintenance and construction activities.

APPENDIX D

ROLES AND RESPOSIBILITIES BY STAKEHOLDER

Operational Concept (Roles & Responsibilities)
Sorted by Stakeholder
SJMA Regional ITS Architecture (Region)

2/21/2006 9:49:46AM

Local Emergency / Security Agencies

RR Area: **Emergency Management for SJMA Regional ITS Architecture**

RR Area MarketPackage

EM01: Emergency Call-Taking and Dispatch
EM02: Emergency Routing
EM03: Mayday and Alarms Support
EM04: Roadway Service Patrols
EM05: Transportation Infrastructure Protection
EM08: Disaster Response and Recovery
EM10: Disaster Traveler Information

RR Area: **Incident Management for SJMA Regional ITS Architecture**

RR Area MarketPackage

ATMS08: Traffic Incident Management System

MBA

RR Area: **Transit Services for SJMA Regional ITS Architecture**

RR Area MarketPackage

APTS1: Transit Vehicle Tracking
APTS4: Transit Passenger and Fare Management
APTS5: Transit Security
APTS6: Transit Maintenance
APTS7: Multi-modal Coordination
APTS8: Transit Traveler Information

RR Area: **Traveler Information for SJMA Regional ITS Architecture**

RR Area MarketPackage

ATIS1: Broadcast Traveler Information

Media

RR Area: **Incident Management for SJMA Regional ITS Architecture**

RR Area MarketPackage

ATMS08: Traffic Incident Management System

RR Area: **Traveler Information for SJMA Regional ITS Architecture**

RR Area MarketPackage

ATIS1: Broadcast Traveler Information

Municipalities

RR Area: **Emergency Management for SJMA Regional ITS Architecture**

RR Area MarketPackage

EM01: Emergency Call-Taking and Dispatch
EM02: Emergency Routing
EM03: Mayday and Alarms Support
EM04: Roadway Service Patrols
EM05: Transportation Infrastructure Protection
EM08: Disaster Response and Recovery
EM10: Disaster Traveler Information

RR Area: **Incident Management for SJMA Regional ITS Architecture**

RR Area MarketPackage

ATMS08: Traffic Incident Management System

PRHTA

RR Area: **Archived Data Systems for SJMA Regional ITS Architecture**

RR Area MarketPackage

AD1: ITS Data Mart
AD2: ITS Data Warehouse

RR Area: **Electronic Toll Collection for SJMA Regional ITS Architecture**

RR Area MarketPackage

ATMS10: Electronic Toll Collection

RR Area: **Emergency Management for SJMA Regional ITS Architecture**

RR Area MarketPackage

EM01: Emergency Call-Taking and Dispatch
EM02: Emergency Routing
EM03: Mayday and Alarms Support
EM04: Roadway Service Patrols
EM05: Transportation Infrastructure Protection
EM08: Disaster Response and Recovery
EM10: Disaster Traveler Information

RR Area: **Freeway Management for SJMA Regional ITS Architecture**

RR Area MarketPackage

ATMS01: Network Surveillance
ATMS02: Probe Surveillance
ATMS06: Traffic Information Dissemination
ATMS07: Regional Traffic Control
ATMS09: Traffic Forecast and Demand Management
ATMS19: Speed Monitoring
ATMS21: Roadway Closure Management

RR Area: **Incident Management for SJMA Regional ITS Architecture**

RR Area MarketPackage

ATMS08: Traffic Incident Management System

RR Area: **Maintenance and Construction for SJMA Regional ITS Architecture**

RR Area MarketPackage

MC01: Maintenance and Construction Vehicle and Equipment Tracking
MC02: Maintenance and Construction Vehicle Maintenance
MC07: Roadway Maintenance and Construction
MC08: Work Zone Management
MC10: Maintenance and Construction Activity Coordination

RR Area: **Surface Street Management for SJMA Regional ITS Architecture**

RR Area MarketPackage

ATMS01: Network Surveillance
ATMS03: Surface Street Control
ATMS06: Traffic Information Dissemination
ATMS07: Regional Traffic Control
ATMS21: Roadway Closure Management

RR Area: **Traveler Information for SJMA Regional ITS Architecture**

RR Area MarketPackage

ATIS1: Broadcast Traveler Information

Research Groups

RR Area: **Archived Data Systems for SJMA Regional ITS Architecture**

RR Area MarketPackage

AD1: ITS Data Mart
AD2: ITS Data Warehouse

Tren Urbano

RR Area: **Transit Services for SJMA Regional ITS Architecture**

RR Area MarketPackage

APTS1: Transit Vehicle Tracking
APTS4: Transit Passenger and Fare Management
APTS5: Transit Security
APTS6: Transit Maintenance
APTS7: Multi-modal Coordination
APTS8: Transit Traveler Information

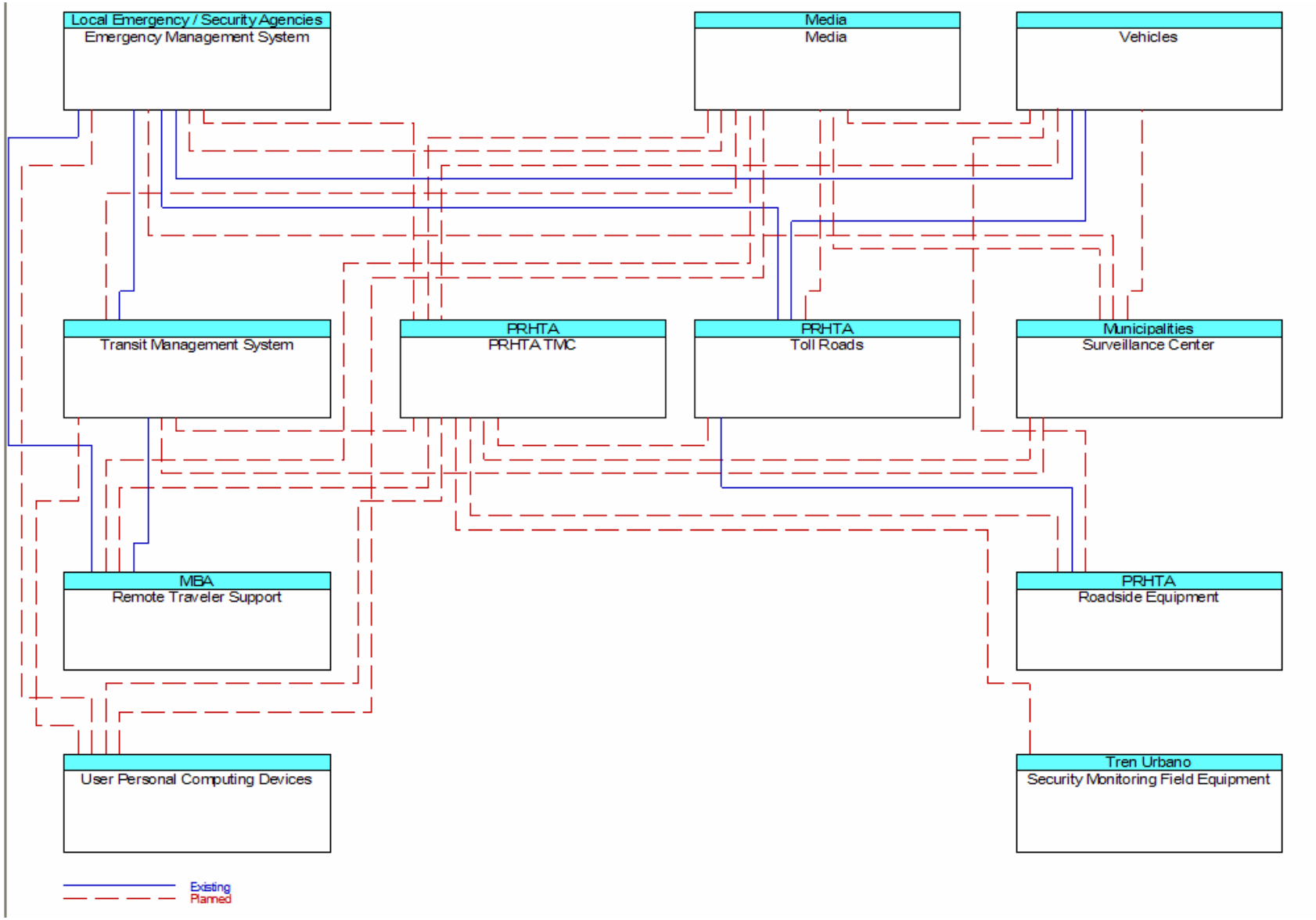
RR Area: **Traveler Information for SJMA Regional ITS Architecture**

RR Area MarketPackage

ATIS1: Broadcast Traveler Information

APPENDIX E

INTERCONNECTS DIAGRAM


Local Emergency / Security Agencies
Emergency Management System
Media
Media
Vehicles
Transit Management System
PRHTA
PRHTA TMC
PRHTA
Toll Roads
Municipalities
Surveillance Center
MBA
Remote Traveler Support
PRHTA
Roadside Equipment
User Personal Computing Devices
Tren Urbano
Security Monitoring Field Equipment
Existing
Planned

APPENDIX F

ITS STANDARDS REPORT

Relevant Standards Activities

1/16/2006 4:06:23PM

AASHTO/ITE/NEMA	**NTCIP Center-to-Center Standards Group**	**(See Footnote)**
AASHTO/ITE/NEMA	**NTCIP Center-to-Field Standards Group**	**(See Footnote)**
AASHTO/ITE/NEMA	**Global Object Definitions**	**NTCIP 1201**
AASHTO/ITE/NEMA	**Object Definitions for Actuated Traffic Signal Controller Units**	**NTCIP 1202**
AASHTO/ITE/NEMA	**Object Definitions for Dynamic Message Signs (DMS)**	**NTCIP 1203**
AASHTO/ITE/NEMA	**Object Definitions for Closed Circuit Television (CCTV) Camera Control**	**NTCIP 1205**
AASHTO/ITE/NEMA	**Object Definitions for Data Collection and Monitoring (DCM) Devices**	**NTCIP 1206**
AASHTO/ITE/NEMA	**Object Definitions for Ramp Meter Control (RMC) Units**	**NTCIP 1207**
AASHTO/ITE/NEMA	**Object Definitions for Closed Circuit Television (CCTV) Switching**	**NTCIP 1208**
AASHTO/ITE/NEMA	**Data Element Definitions for Transportation Sensor Systems (TSS)**	**NTCIP 1209**
AASHTO/ITE/NEMA	**Field Management Stations - Part 1: Object Definitions for Signal System Masters**	**NTCIP 1210**
AASHTO/ITE/NEMA	**Object Definitions for Signal Control and**	**NTCIP 1211**

	Prioritization	
AASHTO/ITE/NEMA	**TCIP Incident Management (IM) Objects**	**NTCIP 1402**
AASHTO/ITE/NEMA	**TCIP Passenger Information (PI) Objects**	**NTCIP 1403**
AASHTO/ITE/NEMA	**TCIP Scheduling/Runcutting (SCH) Objects**	**NTCIP 1404**
AASHTO/ITE/NEMA	**TCIP Spatial Representation (SP) Objects**	**NTCIP 1405**
AASHTO/ITE/NEMA	**TCIP On-Board (OB) Objects**	**NTCIP 1406**
AASHTO/ITE/NEMA	**TCIP Control Center (CC) Objects**	**NTCIP 1407**
AASHTO/ITE/NEMA	**TCIP Fare Collection (FC) Business Area Objects**	**NTCIP 1408**
ASTM	**Dedicated Short Range Communication at 915 MHz Standards Group**	**(See Footnote)**
ASTM	**Standard Specification for Metadata to Support Archived Data Management Systems**	**ASTM E2259-xx**
IEEE	**Incident Management Standards Group**	**(See Footnote)**
IEEE	**Standard for Message Sets for Vehicle/Roadside Communications**	**IEEE Std 1455-1999**
ITE	**Standard for Functional Level Traffic Management Data Dictionary (TMDD)**	**ITE TM 1.03**
ITE	**Message Sets for External TMC Communication (MS/ETMCC)**	**ITE TM 2.01**

SAE	**Advanced Traveler Information Systems (ATIS) Bandwidth Limited Standards Group**	**(See Footnote)**
SAE	**Advanced Traveler Information Systems (ATIS) General Use Standards Group**	**(See Footnote)**
SAE	**On-board Vehicle Mayday Standards Group**	**(See Footnote)**
SAE/IEEE	**Dedicated Short Range Communication at 5.9 GHz Standards Group**	**(See Footnote)**

Footnotes:

Advanced Traveler Information Systems (ATIS) Bandwidth Limited Standards Group

SDO	Standard Name	Document ID
SAE	Location Referencing Message Specification (LRMS)	SAE J2266
SAE	Message Set for Advanced Traveler Information System (ATIS)	SAE J2354
SAE	Standard for ATIS Message Sets Delivered Over Reduced Bandwidth Media	SAE J2369
SAE	Messages for Handling Strings and Look-Up Tables in ATIS Standards	SAE J2540
SAE	RDS (Radio Data System) Phrase Lists	SAE J2540-1
SAE	ITIS (International Traveler Information Systems) Phrase Lists	SAE J2540-2
SAE	National Names Phrase List	SAE J2540-3

Advanced Traveler Information Systems (ATIS) General Use Standards Group

SDO	Standard Name	Document ID
SAE	Location Referencing Message Specification (LRMS)	SAE J2266
SAE	Message Set for Advanced Traveler Information System (ATIS)	SAE J2354
SAE	Messages for Handling Strings and Look-Up Tables	SAE J2540

	in ATIS Standards	
SAE	RDS (Radio Data System) Phrase Lists	SAE J2540-1
SAE	ITIS (International Traveler Information Systems) Phrase Lists	SAE J2540-2
SAE	National Names Phrase List	SAE J2540-3

Dedicated Short Range Communication at 5.9 GHz Standards Group

SDO	Standard Name	Document ID
IEEE	Resource Manager for DSRC 5.9 GHz	IEEE 1609.1
IEEE	Application Services (Layers 6,7) for DSRC 5.9 GHz	IEEE 1609.2
IEEE	Communications Services (Layers 4,5) for DSRC 5.9 GHz (Future Standard)	IEEE 1609.3
IEEE	Medium Access Control (MAC) Extension & the MAC Extension Management Entity for DSRC 5.9 GHz	IEEE 1609.4
IEEE	Standard Specification for Telecommunications and Information Exchange Between Roadside and Vehicle Systems - 5 GHz Band Dedicated Short Range Communications (DSRC) Medium Access Control (MAC) and Physical Layer (PHY) Specifications	IEEE 802.11
IEEE	Logical Link (Layer 2) for DSRC 5.9 GHz	IEEE 802.2
ISO	Networking Services (Layer 3) for DSRC 5.9 GHz	ISO 21210

Dedicated Short Range Communication at 915 MHz Standards Group

SDO	Standard Name	Document ID
ASTM	Standard Specification for Dedicated Short Range Communication (DSRC) Physical Layer using Microwave in the 902-928 MHz Band	ASTM E2158-01
ASTM	Standard Provisional Specification for Dedicated Short Range Communication (DSRC) Data Link Layer	ASTM PS 105-99

Incident Management Standards Group

SDO	Standard Name	Document ID
IEEE	Standard for Traffic Incident Management Message Sets for Use by EMCs	IEEE 1512.1-2003
IEEE	Standard for Public Safety IMMS for use by EMCs	IEEE 1512.2-2004
IEEE	Standard for Hazardous Material IMMS	IEEE 1512.3-2002

IEEE	Standard for Common Incident Management Message Sets (IMMS) for use by EMCs	IEEE 1512-2000
IEEE	Standard for Common Traffic Incident Management Message Sets for Use in Entities External to Centers	IEEE P1512.4

NTCIP Center-to-Center Standards Group

SDO	Standard Name	Document ID
AASHTO/ITE/NEMA	Octet Encoding Rules (OER) Base Protocol	NTCIP 1102
AASHTO/ITE/NEMA	Center-to-Center Naming Convention Specification	NTCIP 1104
AASHTO/ITE/NEMA	CORBA Security Service Specification	NTCIP 1105
AASHTO/ITE/NEMA	CORBA Near-Real Time Data Service Specification	NTCIP 1106
AASHTO/ITE/NEMA	Ethernet Subnetwork Profile	NTCIP 2104
AASHTO/ITE/NEMA	Internet (TCP/IP and UDP/IP) Transport Profile	NTCIP 2202
AASHTO/ITE/NEMA	File Transfer Protocol (FTP) Application Profile	NTCIP 2303
AASHTO/ITE/NEMA	Application Profile for DATEX-ASN (AP-DATEX)	NTCIP 2304
AASHTO/ITE/NEMA	Application Profile for CORBA (AP-CORBA)	NTCIP 2305
AASHTO/ITE/NEMA	Application Profile for XML Message Encoding and Transport in ITS C2C Communications	NTCIP 2306
AASHTO/ITE/NEMA	Information Profile for DATEX	NTCIP 2501
AASHTO/ITE/NEMA	Information Profile for CORBA	NTCIP 2502

NTCIP Center-to-Field Standards Group

SDO	Standard Name	Document ID
AASHTO/ITE/NEMA	Simple Transportation Management Framework (STMF)	NTCIP 1101
AASHTO/ITE/NEMA	Octet Encoding Rules (OER) Base Protocol	NTCIP 1102
AASHTO/ITE/NEMA	Transportation Management Protocols (TMP)	NTCIP 1103
AASHTO/ITE/NEMA	Point to Multi-Point Protocol Using RS-232 Subnetwork Profile	NTCIP 2101
AASHTO/ITE/NEMA	Point to Multi-Point Protocol Using FSK Modem Subnetwork Profile	NTCIP 2102
AASHTO/ITE/NEMA	Point-to-Point Protocol Over RS-232 Subnetwork Profile	NTCIP 2103
AASHTO/ITE/NEMA	Ethernet Subnetwork Profile	NTCIP 2104
AASHTO/ITE/NEMA	Transportation Transport Profile	NTCIP 2201
AASHTO/ITE/NEMA	Internet (TCP/IP and UDP/IP) Transport Profile	NTCIP 2202
AASHTO/ITE/NEMA	Simple Transportation Management Framework (STMF) Application Profile	NTCIP 2301
AASHTO/ITE/NEMA	Trivial File Transfer Protocol (TFTP) Application Profile	NTCIP 2302

AASHTO/ITE/NEMA	File Transfer Protocol (FTP) Application Profile	NTCIP 2303

On-board Vehicle Mayday Standards Group

SDO	Standard Name	Document ID
SAE	Location Referencing Message Specification (LRMS)	SAE J2266
SAE	On-Board Land Vehicle Mayday Reporting Interface	SAE J2313
SAE	Message Set for Advanced Traveler Information System (ATIS)	SAE J2354
SAE	Messages for Handling Strings and Look-Up Tables in ATIS Standards	SAE J2540
SAE	RDS (Radio Data System) Phrase Lists	SAE J2540-1
SAE	ITIS (International Traveler Information Systems) Phrase Lists	SAE J2540-2
SAE	National Names Phrase List	SAE J2540-3

APPENDIX G

PUERTO RICO INTELLIGENT TRAFFIC MANAGEMENT CENTER (PRITMAC) CONCEPT OF OPERATIONS

Puerto Rico Intelligent Traffic Management Center Concept of Operations

San Juan Metropolitan Area TMC

Table of Contents

1 Introduction

1.1 Document Organization

This document sets forth the Concept of Operations for the San Juan Metropolitan Area Puerto Rico Intelligent Traffic Management Center (PRITMAC). The document will provide the reader the following information:

- User-oriented operational description of the PRITMAC
- Operational needs to define the use and intent of the PRITMAC
- System overview
- Operational and supporting environments of the system
- Operational scenarios to better understand the functionality of the system

1.2 Scope

The Puerto Rico Intelligent Traffic Management Center (PRITMAC) will be one of several ITS projects to be implemented in the San Juan Metropolitan Area in accordance with the San Juan Metropolitan Area Regional ITS Architecture. The PRITMAC will cover the surrounding areas of the municipalities of Bayamón, Caguas, Carolina, Guaynabo, San Juan, and Toa Baja. The map on Figure 1 shows the municipalities in the PRITMAC coverage area as well as the main highways and arterials in the area.

The PRITMAC is an integrated traffic management and data acquisition center. Its main goal is the effective maintenance of traffic operations in various scenarios. These scenarios address recurrent and non-recurrent congestion including: ongoing roadway reconstruction, new infrastructure construction, and special events that may require extra efforts of coordination. The objectives of the system are to monitor traffic, user security, unforeseen incidents, and system failures, in a rapid and effective manner.

The PRITMAC is being implemented by the Puerto Rico Highway and Transportation Authority (PRHTA). Besides PRHTA, other stakeholders associated with this project are the Local Emergency / Security Agencies in the area including the Police Department, the Fire Department, Medical Emergency Services and 911. The Police Department is especially important since it will have physical presence in the PRITMAC.

Figure 2 : PRITMAC Coverage Area

2 Referenced Documents

Documents that have been utilized in the development of the PRITMAC Concept of Operations are:

- San Juan Metropolitan Area Regional ITS Architecture Version 1.0
- Developing and Using a Concept of Operations in Transportation Management Systems – U.S. Department of Transportation, Federal Highway Administration, 2004

3 User-Oriented Operational Description

To fully understand the operational needs of the PRITMAC system, we must first understand who the users are. The classes of users of the system have been defined to include motorists, external agencies and TMC operators. Each user class's interaction is further defined in Table 3.1 as follows:

Table 3-1. User's Interaction with the PRITMAC system.

User Class	Interaction
Motorists	• Motorists will receive both regulatory and advisory information from Dynamic Message Signs (DMS) and Highway Advisory Radio (HAR). • Vehicles passing through sensor fields generate data for Traffic Management processing. • With the use of cellular phones, the motorists provide additional input for the identification and verification of highway incidents.
External Agencies • Puerto Rico Highway and Transportation Authority • Local Emergency / Security Agencies	• These agencies will rely on the PRITMAC for traffic information as well as access to VMS and HAR for communication with the motorists.
TMC Operators	• Monitor traffic flow on the expressway and lateral connections via the vehicle detection system. • Verify incidents through video surveillance systems. • Enact response plans consistent with regional/local policies and procedures.

	• Document traffic/incident status and occurrences as necessary.
PRITMAC Administrator	• Set responsibilities for the TMC operators and define the range of their monitoring and control of the TMC resources.
PRITMAC Support Personnel	• Coordinate the maintenance of field equipment and inventories of spares.

4 Operational Needs

The operational vision for the Puerto Rico Intelligent Traffic Management Center is to assist in achieving regionally established transportation goals using ITS services. These goals include the following:

- Enhance mobility of people and goods by reducing recurrent traffic congestion
- Enhance mobility of people and goods by reducing traffic congestion caused by incidents

To achieve these goals, the following functionalities will be included in the system:

- Dynamic Message Signs
- CCTV video cameras
- Vehicle detection (e.g. loops)
- Highway Advisory Radio
- Incident scenario response
- Maintenance dispatching / tracking system

To implement the system, the following aspects and requirements should be considered:

Method of Implementation

- Architects and engineers working on the TMC must be very familiar with all the aspects involved in its operation and the devices and systems hosted in the site.

- It is important to verify the experience of the software developers and their knowledge of the conditions at the site where the TMC is located.

- Independent consultants with previous ITS implementation experience may be hired to obtain second technical opinions on particularly complex areas such as fiber optic network implementation and geographic information systems.

- The software developer must turn in completely operational software with all the features according to the specifications.

- All system components including hardware devices and software development should be ready to handle future expansions of the system to all the municipalities in the SJMA and later on to other locations in Puerto Rico.

- Operations and Maintenance should be involved in the development of the project from day one.

- In contracting for operations and maintenance, the Agency will clearly specify which services would be provided by their own employees and which by other consultants or service providers.

System testing and operations readiness testing

- The contractor shall assist the PRHTA in inspecting, testing, and approving all roadway devices that are installed.

- The contractor will develop a maintenance routine for the PRHTA to employ.

Maintenance

- The contractor shall provide, at no additional cost, one-year of on-site service of all systems developed and installed. This service shall include the repair, to the equivalent operational state at the time of final delivery, of any Contractor installed hardware or software.

- The contractor will provide a two-year guarantee.

- PRHTA will provide routine maintenance.

- The Contractor shall provide an operational and training manual.

Configuration management

- The purpose of this subsystem is to support the maintenance of the TMC. This includes both field and central equipment. Tables shall be created in the DBMS storing, at a minimum, for each piece of equipment:

    - Identification
    - Manufacturer & Model Number
    - Manufacturer contact information
    - Last date of preventive maintenance
    - Location (latitude/longitude)
    - Suggested maintenance cycle

- Software version
- Parameters (as employed in the software)
- Documentation of software patch

- In addition, each piece of equipment shall have a table storing its complete maintenance history. Each record will store a maintenance action.

Logistics

- Spare replacement parts shall be available.

5 System Overview

As stated previously the PRITMAC is for the most part an integrated traffic management and data acquisition center. This section identifies and describes both internal and external interfaces of the system. Figure 5-1 presents a high level diagram to illustrate information flows among partners. Refer to the San Juan Metropolitan Area Regional ITS Architecture for the customized market packages for more detailed information on flows among partners. (Look for the following market packages: AD01, AD02, EM04, and ATMS 01, 02, 06, 07 and 08)

Puerto Rico Intelligent Traffic Management Center
Concept of Operations

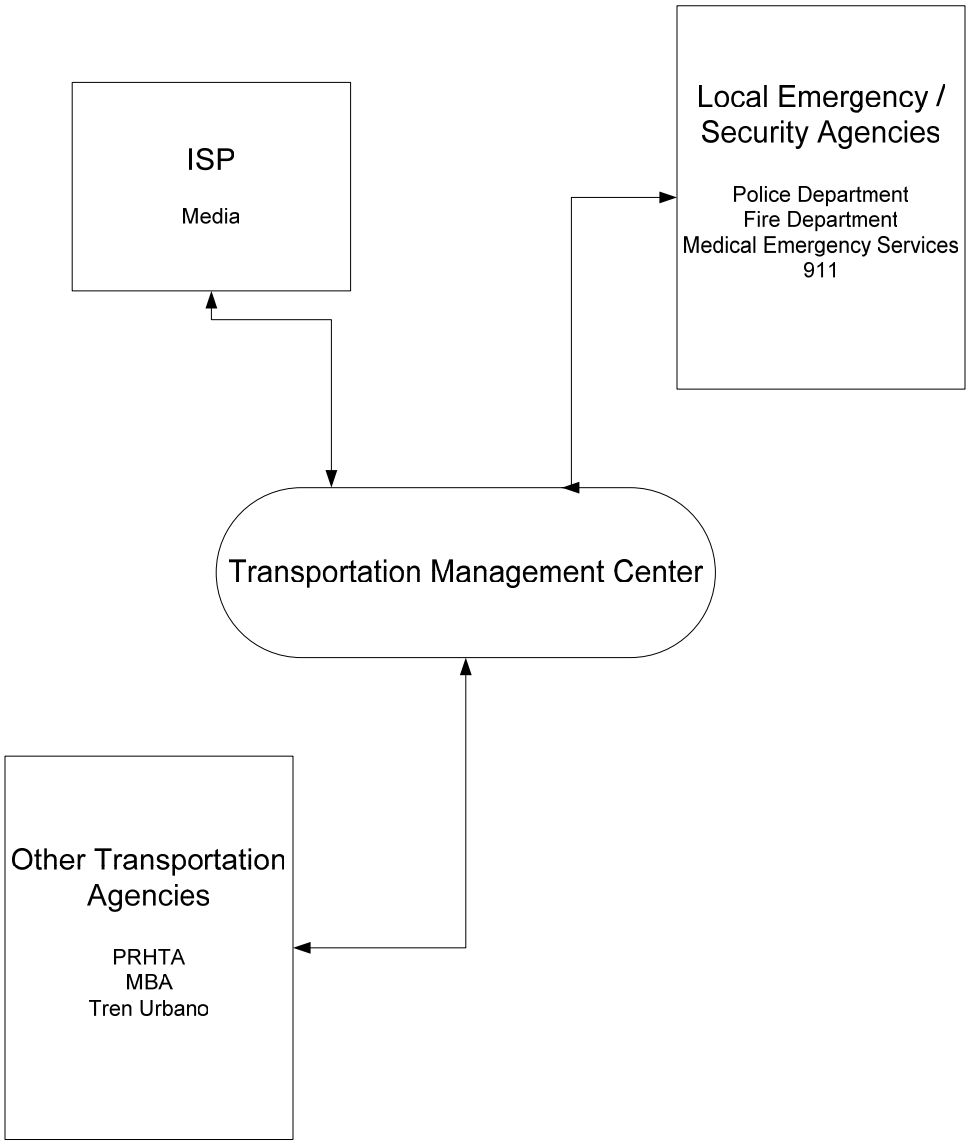


Figure 5-1 PRITMAC Concept of Operations

As stated previously one of the main objectives of the PRITMAC is to reduced congestion by managing incidents. In this capacity, the Incident Management System will include

identification, verification and response to incident situations. The TMC software shall log all significant events. This data shall be archived automatically. The elements involved in each stage are presented below:

Identification

- Cameras → Identification of an incident can be done when an operator detects an event visually on the workstation screen.

    - The PRHTA will install and maintain CCVT cameras, DMS and HAR along the highways. This data will be shared with other agencies.
    - Refer to the page 20 of the TMC ITS Architecture for more information on corresponding market packages.

- Phone calls (Integration with 911 and the Police Department)

    - Receive public calls and forward them to appropriate dispatch centers.
    - Dispatch police, fire, ambulance, and other emergency vehicles.
    - Refer to page 24 of the TMC ITS Architecture for more information on corresponding market packages.
    - The system is activated when a possible incident is detected or after an operator manually declares an incident on a link. After reaching the incident management subsystem, the incident or congestion location is displayed on the operator's workstation

Verification

- Cameras

- Police at the scene of the incident

    - Coordination between field officers at the scene of the incident will be a source of information to confirm or deny possible situations detected.

- Service Patrol

    - As with police officers, during peak hours when the service patrol is patrolling the highways communication with the TMC will be crucial to assist in incident verification.

- Maintenance vehicles

    - The operator shall enter information describing the incident (such as severity, estimated duration, number of lanes blocked, HAZMAT conditions, injuries, etc.). This description is potential traveler information helping disseminate

incident-related delays; this information is to be displayed on Dynamic Message Signs (DMS) and/or Highway Advisory Radio (HAR).

Response

- Typical predefined scenarios
    - Refer to the last section of this document for information on possible Operational Scenarios.
- If necessary change traffic signal control on parallel arterials
    - Manage traffic on arterials using traffic signals including preemption for emergency vehicles and priority for transit vehicles.
- Coordinate traffic control responding to incidents which involve emergency and traffic agencies.
- Share traffic information with other emergency and transportation agencies.
- Service Patrol
    - The Service Patrol units will patrol the highways during hours of maximum congestion and be stationed on-call the rest of the time. In case of accidents detected by the TMC, the Service Patrol will be dispatched by the TMC Manager.
    - The main task of the Service Patrol is to remove a vehicle from the roadway as quickly as possible to reduce the negative impact of incidents on congestion.
    - The Service Patrol driver will have sufficient knowledge of mechanics, transportation and safety to provide assistance in minor events. Measures will be taken to avoid PRHTA liability.

6 Operational and Supporting Environments

The following section describes the environment in which the PRITMAC system will operate.

Control Center Design

- The TMC will be located at Doménech / Muñoz Rivera. This location should provide easy, convenient access to the freeway network for both passenger vehicles and for larger maintenance and construction vehicles. Refer to Figure 6.1 for the Floor Plan.
- The TMC will take up approximately 6,500 square feet. The center should have adequate room including the possibility of expansion if space needs increase. This space will host

the TMC, Administrative staff and the traffic operations personnel to assist with the TMC and freeway operations.

- The space allotted to each agency in the TMC shall be specified. A conference room or other office space where each agency could comfortably address sensitive internal issues privately should be provided.

- Provide dedicated space to media adjoining the control room.

- Security in the TMC will be provided by security personnel located at the entrance of the building. Swipe cards will be used as an access control system for all the employees. Visitors will need to register before entering the premises.

- TMC Configuration shall be appropriate to handle all the functions of the TMC including traffic management and emergency management.

- The level of noise in the TMC will be controlled by the TMC manager who will establish a professional environment for all the personnel. Radios and scanners will be used according to the protocol established by the manager.

- Provide adequate sizing of backup power units, communication connections and accommodations for personnel working around the clock (even though the initial working hours may be less than 24 hours/day).

- Provide adequate space for storage and testing of new equipment, repaired units, stock.

- Provide adequate space for data management and storage including office space for this function.

System Design

- Manage images presented in the workstations such that the entire roadway network covered by the TMC is attended with enough detail in an efficient manner. Two computer monitors for each computer workstation should be provided.

- Control “shaking” images and latency in camera actuation.

- Establish adequate distance between detector stations to use them for incident detection purposes.

- Dynamic Message Signs (DMS) should be easy to verify (verify message status) using the camera systems.

- Provide useful coverage of the road network on both freeways and arterials and adequate magnification.

- Maintain regular contact with field devices through an adequate network wide communication capacity.

- Define the coverage area such that a complete integration of management of freeways and surface streets can be achieved.

Devices in the System

- The TMC shall contain video walls, LCD monitors, and individual video amplifiers with rack mountable units.

- The system will include the following features:

    - Camera coverage in the freeways and high demand intersections.
    - Interconnectivity with the camera system of tolls and Minillas tunnel.
    - Dynamic Message Signs (DMS).
    - Incident detection algorithms shall be developed either using probe vehicles, loop detectors or cameras.
    - Communication will occur over fiber optic and microwave wireless networks.
    - A video-based traffic signal control system on critical intersections along the arterials parallel to the freeways. This system will control all CCTV cameras that are directly linked to the TMC.
    - HAR coverage in the freeways and main arterial streets along the freeways corridors.
    - Integration with traffic control system along parallel main arterials

Workload and performance

- Centers will be operational Monday through Friday from 5:00 AM to 7:00 PM and on special events.

- The system will be operated in two shifts, incorporating the a.m. and p.m. peak hours (four full time employees from 6-9 AM and from 4-7 PM; employees will be on-call on-site the rest of the time).

- At least one operator will be present at all times.

- Operators of the TMC will be employed by the PRHTA.

Coordination

- Coordination with emergency services and service patrol will be through calls from 911 operators and the TMC.

- Communication will be through telephone, radio, internet, and video out.

Conflict resolution

- Because of the proximity of key personnel no special arrangements are necessary for conflict resolution. The TMC manager will be available on-site.

Nonstandard operations

- If a special event or natural catastrophe should arrive, operations will be active during the duration of the event.

- A standard form will be developed to document and program special events.

- Security Coordinator from AEME will establish inter-agency coordination.

Fault detection and correction

- Software component and configuration testing shall be conducted to:

    - Verify requirements are satisfied.
    - Verify user interface is implemented correctly.
    - Verify error-free linkage of units and external software interfaces.
    - Verify storage and throughput capacity requirements.
    - Verify real time performance requirements are met.
    - Verify security measures.
    - Verify diagnostic and logging features.
    - Verify ability to recover from errors, improper input and hardware failures.
    - Ensure hardware performs correctly.

7 Operational Scenarios

Normal Operations (No Incident) with recurrent congestion

- During peak period operation, the service patrol will be patrolling the highways. Surveillance units will be active and four employees will be on site.

- During off-peak period the service patrol will be stationed on-call at strategic points through all the TMC coverage area.

Non-recurrent Congestion (Incident Management)

- In case of small congestion on the highways the service patrol will be activated.
- HAR can be used if necessary.
- If there is an incident that blocks the highway, in addition to the resources mentioned above, DMS will provide users with alternate routes.
- If an incident causes a safety threat, coordination with corresponding agencies will be crucial.

Special Event

- Coordination with event producers and local agencies like police, MBA, "Tren Urbano" will be required.
- All personnel all the time during the duration of the event, extra-hours if needed.
- Devices providing information about traffic conditions and routes will be activated before, during and after the event.

Hurricane

- If fiber optic communication is impaired, coordination via telephone with Local Emergency / Security Agencies will be established.
- After the hurricane, an assessment of damages to the TMC infrastructure and coordination with local DOT will be required.