Regional Architecture

Tech Memo #6

including:

1. **Operational Requirements**
2. **Subsystem and Equipment/Market Package Requirements**
3. **Communication Requirements**

Knoxville ITS Communication Master Plan

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1 Background

The Knoxville Urban Area serves as a major crossroads on the national highway network, both in terms of private and commercial travel. The area lies within a broad valley in east Tennessee near the Great Smoky Mountains. Knoxville is at the center of the eastern United States, situated within a one-day driving time of 75% of America's population. Historically, the region's quality of life has received national acclaim due to its location and pleasant and diverse climate, as well as many other amenities. These include important institutional resources such as the University of Tennessee (UT) and the nearby Oak Ridge National Laboratory (ORNL). Knoxville also serves as the headquarters for the Tennessee Valley Authority (TVA), the largest Federal agency oriented to domestic economic and environmental resource development. These attributes have led the area to become both a major economic hub and a tourist destination. For some time, the Tennessee Department of Transportation (TDOT) and jurisdictions in the Knoxville area have been implementing Intelligent Transportation System (ITS) technologies to improve traffic management for the area. ITS is the application of advanced information processing, communications, vehicle sensing and traffic control technologies to the surface transportation systems. The objectives of ITS are to promote more efficient use of the existing highway and transportation network, to increase safety and mobility, and to decrease the environmental impacts of congestion.

In September 1998, the ITS Strategic Assessment for the Knoxville Urban Area was completed. That Strategic Assessment Plan incorporated input from various stakeholders including local emergency services, state local city and county DOT's, regional planning entities, transit and airport authorities, and the Federal Highway Administration (FHWA).

The next step after the Strategic Assessment has been to develop the regional architecture and the concept of operations to help further define the roles of the agencies and the planned ITS deployment in the region. This provides a foundation for the integration of ITS applications within the transportation infrastructure in the region. Kimley-Horn and Associates, Inc. has been retained by TDOT to assist in developing the regional architecture plan for the Knoxville area. The architecture addresses the required user services, logical and physical architectures, and

communication requirements. This will provide a vision of regional ITS and traffic management for the Knoxville area.

The National Architecture version 3.0 divides an ITS architecture into several defined components as depicted in Figure 1. The intent of this technical memorandum is to define the User Service Bundles/User Services, Logical Architecture, Physical Architecture, implementation strategies, and required standards and Inter-agency Communication Interfaces. This will enable the Knoxville area stakeholders to develop an implementation plan to follow for deploying the desired user services.

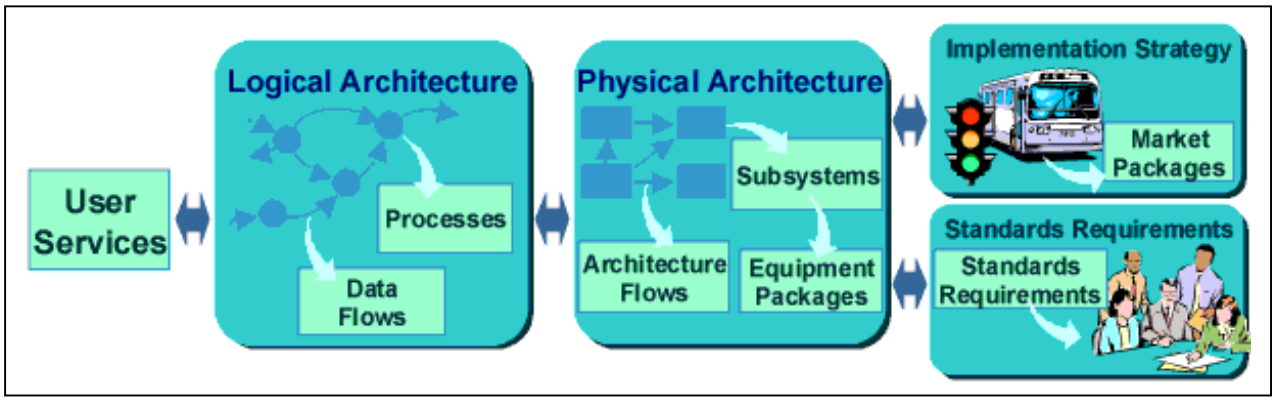


Figure 1 – Components of National Architecture

User service bundles and User Services define the ITS user requirements that will assist in resolving the transportation problems for the Knoxville area. To date, thirty-one User Services have been jointly developed by US DOT and ITS America with substantial stakeholder input. A set of requirements covering each of these User Services are the basis for the National ITS Architecture definition. The *Logical Architecture* defines the Processes (the activities or functions) required to support the ITS User Services. It defines the processes that perform ITS functions and the information or data flows that are shared between these processes. The *Physical Architecture* forms a high-level structure around the processes and data flows in the Logical Architecture. The Physical Architecture defines the Subsystems and Terminators that make up an intelligent transportation system. It defines the Architecture Flows that connect the various Subsystems and Terminators into an integrated system. The subsystems generally

provide a rich set of capabilities, more than would be implemented at any one place or time. *Equipment Packages* break up the subsystems into deployment-sized pieces. *Market Packages* represent slices of the Physical Architecture that address specific services like surface street control. A market package collects together several different subsystems, equipment packages, terminators, and architecture flows that provide the desired service. Standards Requirements provide a view of the essential data requirements for on-going ITS standards activities. The inter-agency communications interfaces provides the media required to share the data between the different subsystems and agencies.

2 Regional ITS Roles

The following list presents proposed operational roles for the principal agencies for the Knoxville Region. This was developed by allocating functions identified in the ITS Strategic Assessment and interviews with stakeholders. The subheading under each of the principal agencies is either an existing entity within the organization or one that would be required in the future.

2.1 Tennessee Department of Transportation

2.1.1 Freeway Management

- Monitor real-time traffic flow
- Identify equipment failure and enact backup plan
- Track and implement preventive maintenance schedules for field equipment
- Employ control strategies that seek to maximize safe traffic movement
- Devise, enact and monitor the results of changes in tactical operations
- Share information on traffic flow conditions with other agencies
- Provide information to travelers on current status of roadway network

- Maintain communications with other TDOT operating agencies
- Identify incident locations and monitor the impact of incidents
- Evaluate the severity of incidents
- Provide data on the status of incident management operations
- Participate in devising a regional incident management plan
- Maintain the capability to coordinate with other agencies for responding to incidents and emergencies
- Operate variable message signs and highway advisory radio
- Support the Department of Environmental Quality in roadside emission testing
- Share traffic data with those agencies that promote ride sharing and parking management
- Evaluate system effectiveness
- Implement systems in coordination with planned construction/maintenance activities
- Provide motorists with safe driving conditions on highways and bridges during icy weather
- Support the University Research
- Coordinate with other TDOT regions (Nashville, Memphis, Chattanooga)

2.1.2 Contract Administration

- Issue Request for Proposal for ITS projects
- Award contracts for ITS projects
- Prepare, coordinate and manage the development of contract documents for ITS programs

- Monitor the ITS budget for the region
- Forecast the budget for ITS projects
- Administer contracts for ITS projects and activities

2.1.3 Technical Construction

- Supervise construction of ITS projects
- Coordinate construction, maintenance and permit works
- Support testing and evaluation of new systems and concepts for improved operations and management
- Implement work zone safety measures

2.1.4 Traffic Engineering

- Analyze traffic operations problem
- Provide safe and effective solutions to traffic operations problems
- Provide traffic engineering advice for construction projects
- Support testing and evaluation of new systems and concepts for improved operations and management
- Implement crash countermeasures at high accident locations

2.1.5 Traffic Field Operations

- Install traffic signs, traffic signals and pavement markings
- Support ITS projects

2.1.6 Maintenance

- Perform snow removal operations on arterials
- Receive maintenance request from the Regional Transportation Coordination Center
- Automate the process for inventory and reporting of resources
- Provide data on emergency and non-emergency repair needs

2.1.7 Interstate Maintenance

- Support snow removal on Interstate highways
- Receive maintenance request from the Regional Transportation Coordination Center
- Automate the process for inventory and reporting of resources
- Provide motorists with the safest driving conditions on highways and bridges during icy weather

2.1.8 Regional Transportation Coordination Center

- Receive and respond to customer calls
- Monitor roadways during inclement weather
- Maintain contact with media during emergencies
- Disseminate construction, maintenance and permit work schedules
- Coordinate emergency response using all appropriate agencies
- Support incident management on freeways and surface streets
- Receive motorist emergency notification call information from other agencies

2.1.9 Planning

- Integrate ITS Programs in the planning process
- Analyze the impact of ITS programs and strategies on the regional transportation system
- Integrate ITS Program in the multimodal strategies adopted for the regional long range plan and short range improvement program

2.1.10 Construction

- Identify traffic needs
- Coordinate road construction, maintenance, and permit works with the Transportation Centers
- Implement work zone safety measures
- Provide information to travelers on current status of roadway network through traveler information providers
- Coordinate with Transportation System operators to maintain/improve ITS functions during construction

2.2 *City and County Agencies*

2.2.1 Surface Street Management

- Monitor real-time traffic flow
- Monitor and operate district wide signal control system
- Identify field equipment failure and enact established backup plans to maintain safe operations

- Adjust the signal system operations during emergencies
- Maintain communications with an operations facility that communicates and coordinates multi-agency resources
- Share information on current status of network conditions with other agencies
- Receive incident information
- Manage the flow of traffic at the incident scene by possibly changing timing plans
- Participate in devising a regional incident management plan
- Share traffic data with those agencies that promote ride sharing and parking management
- Provide signal priority to transit vehicles
- Provide signal priority to emergency vehicles responding to incidents
- Provide communications with all the traffic signals from a central control facility
- Evaluate system effectiveness
- Support incident management by developing and manipulating signal timing plans
- Coordinate with other jurisdictions' signal system
- Improve bicyclist safety on roadways
- Implement pedestrian safety measures at pedestrian crossings

2.2.2 Sub-area Transportation Coordination Center (provided by the lead agency of a sub-area)

- Receive and respond to customer calls
- Monitor roadways during inclement weather

- Maintain contact with media during emergencies
- Coordinate traffic information provided to media
- Disseminate construction, maintenance and permit work schedules
- Coordinate emergency response using appropriate agencies
- Support incident management on freeways and surface streets
- Receive motorist emergency notification call information from other sub-area agencies
- Provide regional coordination with other sub-areas and regional ITS coordination program

2.3 Transit Agencies

2.3.1 Transit Vehicle Management

- Provide Tracking and Dispatch of Transit Vehicles
- Provide Transit Information Services to Public
- Coordinate Fixed Route Operations
- Coordinate Paratransit Operation
- Provide Transit Center Fare and Load Management
- Provide Transit Multi-modal Coordination

2.3.2 Maintenance

- Coordinate Center Garage Operation
- Automate the process for inventory and reporting of resources

- Provide data on emergency and non-emergency repair needs

2.4 Joint Operations between TDOT and local jurisdictions

2.4.1 Regional Transportation Management

- Coordinate with other regions and sub-area centers
- Provide data sharing between sub-areas, Freeway and Transit operations
- Develop and maintain regional framework and architecture
- Provide regional data archiving and retrieval
- Coordinate ITS projects to ensure an integrated regional system
- Coordinate with statewide ITS programs and activities
- Promote Knoxville regional ITS program to the general public, ITS professionals, and elected and appointed local officials

3 Deployment Approach

3.1 Sub-area Deployment

The local agencies all have or are planning deployment of local transportation management systems, primarily centered on traffic signal management and traveler information services. The general consensus of the stakeholders is to build up to a fully integrated regional system in smaller logical groupings of geographically associated agencies. This concept provides each sub-area group of agencies with the ability to share information and better manage sub-area transportation needs without having to be fully integrated with a regional system. Each sub-area as defined in the regional physical architecture would work together to share and coordinate their operations between the jurisdictions. A lead agency will be responsible for the role of providing the Sub-area Transportation Coordination Management System. This Coordination Management System would provide a central repository of sub-area pertinent information. This information would be used for sub-area agency coordination. It will also be available for dissemination to interested parties such as media, public, and information service providers. Because each agency and sub-area would follow the overall regional architecture, each sub-area would also be able to

integrate with the regional coordination center, when feasible and necessary. This would provide the regional center with the sub-area information and the sub-area would in return receive regional information.

This approach has numerous benefits including:

- Ability to build and deploy in smaller manageable increments
- Ability to claim early success and build consensus in the region
- Learn and improve process incrementally
- Reduce technical obsolescence by deploying in stages

Jurisdictions that do not participate in the initial deployments can always integrate in the future as funding and needs dictate. By following the regional architecture, becoming a member of the network can be accomplished at any time.

3.2 Freeway Management System Deployment

TDOT is moving forward with deployment of the initial freeway traffic management system. Pilot projects and subsequent expansion projects are envisioned. Freeway traffic management generally embodies the field elements that provide surveillance, detection and information dissemination to fulfill the functional requirements as defined above. This will include the linkage between the field elements and the operations center where control and management functions are performed. Provided within the system will be the link to the Regional Transportation Management System (defined later) to share pertinent traffic data and coordination.

3.3 Transit Management System Deployment

The transit authorities in the region are continuing to expand and improve their operations. Examples include providing vehicle tracking, and automated transit information. As the authorities continue to expand and improve their systems, links to the regional or sub-area networks will be needed. This will enable the transit authority to consolidate the transit information within the regional structure and provide data to the transit authority to better operate the transit system.

3.4 Regional Transportation Management System Deployment

It is envisioned that a Regional Transportation Management System (RTMS) will emerge from the deployment process. The RTMS would be a functional "agency" sponsored by State and local agencies. Its primary purpose would be coordination of transportation management on a regional level. It is envisioned that the RTMS would provide interagency coordination with each of the sub-areas and the Freeway Management System as they come "on-line". Pertinent information would be communicated to and received from each of the sub-areas in the region.

4 User Service Bundles and User Services for the Knoxville Area

To be consistent with the National ITS Architecture, the functional requirements defined by the Knoxville area stakeholders need to be framed into the National Architecture User Services. User Services further document and standardize what ITS should do from the user's perspective. A broad range of users are considered, including the traveling public as well as many different types of system operators and agencies. Thirty-one User Services form the basis for the National ITS Architecture development effort. United States Department of Transportation (USDOT) and ITS America, with significant stakeholder input, jointly defined these user services. The concept of user services allows system or project definition to begin by establishing the high level services that will be provided to address identified problems and needs. New or updated user services may be added to the National ITS Architecture over time.

A logical grouping of user services provides a convenient way to discuss the range of requirements in a broad stakeholder area. In the National ITS Architecture User Service Requirements, the User Services are grouped into seven bundles. For the Knoxville area the applicable bundles include:

- Travel and Traffic Management,
- Public Transportation Management,
- Electronic Payment,
- Emergency Management, and
- Information Management.

At this time, the area does not envision implementing Commercial Vehicle Operations and Advanced Vehicle Safety Systems. By utilizing the National ITS Architecture, these two

bundles are not precluded from being implemented at any time in the future. Each can be implemented as deemed appropriate in the future. It is also important to note that Commercial Vehicle Operations are being separately addressed at a statewide level by TDOT.

The following describes the User Services being used for the Knoxville area. A top-level description of each User Service is provided. Additional User Service descriptions and Process Specifications that further detail each one are not included and can be referenced in the National ITS Architecture Document. The bundles and User Services that are not being utilized presently are left for reference and noted as such.

4.1 Travel and Traffic Management User Service Bundle

4.1.1 Pre-trip Travel Information - ITS shall provide a Pre-Trip Travel Information (PTTI) capability to assist travelers in making mode choices, route decisions, and estimating travel times prior to trip departure. It consists of four major functions: Available Services Information, Current Situation Information, Trip Planning Service, and User Access. Information is integrated from various transportation modes and presented to the user for decision making.

4.1.2 En-route Driver Information - ITS shall include an En-Route Driver Information (DI) function. Driver Information provides vehicle drivers with information, while en-route, which will allow alternative routes to be chosen for their destination. Driver Information consists of two major functions: Driver Advisory, and In-vehicle Signing. The potential diversion of traffic may also provide benefits in highway safety, reduced air pollution, and decreased congestion.

4.1.3 Route Guidance – not used

4.1.4 Ride Matching And Reservation – ITS shall include a Ride Matching and Reservation (RMR) function. Ride Matching and Reservation will provide traveling users with information on rideshare providers. Three major functions are provided which are: Rider Request, Transportation Provider Services, and Information Processing. This will also include a billing service to the providers

4.1.5 Traveler Services Information - ITS shall include a Traveler Services Information (TSI) function. Traveler Services Information provides travelers with service and facility data for the purpose of assisting prior to embarking on a trip or after the traveler is underway. The functions which are included in this capability are Information Receipt and Information Access. This will provide the traveler with a "yellow pages" type of capability.

4.1.6 Traffic Control - ITS shall provide a Traffic Control capability. Traffic Control provides the capability to efficiently manage the movement of traffic on streets and highways.

Four functions are provided which are: Traffic Flow Optimization, Traffic Surveillance, Control Function, and Provide Information. This will also include control of network signal systems with eventual integration of freeway control.

4.1.7 Incident Management - ITS shall include an Incident Management (IM) function. Incident Management will identify incidents, formulate response actions, and support initiation and ongoing coordination of those response actions. Six major functions are provided which are:

- Scheduled Planned Incidents,
- Identify Incidents,
- Formulate response Actions,
- Support Coordinated Implementation of Response Actions,
- Support Initialization of Response to Actions, and
- Predict Hazardous Conditions.

4.1.8 Travel Demand Management – Travel Demand Management will generate and communicate management and control strategies that will support and facilitate the implementation of TDM programs, policies and regulations. It consists of two major functions that are (1) Increase Efficiency of Transportation System and (2) Provide Wide Variety of Mobility Options.

4.1.9 Emissions Testing And Mitigation– ITS shall include an Emission Testing and Mitigation (ETAM) Function. The ETAM function will provide state and local governments with the capability to enhance their air quality control strategies. The ETAM will provide both wide area and roadside emissions monitoring. Information gleaned from ETAM will be used by Traffic Demand Management (TDM) in the Traffic Management Center (TMC) to mitigate pollution, and may be provided to enforcement agencies to compel offenders to comply with standards.

4.1.10 Highway-rail Intersection – ITS shall include a Highway-Rail Intersection (HRI) function to control highway and rail traffic in at-grade HRIs. Two sub-services are supported:

- Standard Speed Rail Subservice, which is applicable to light-rail transit, commuter rail and heavy rail trains with operational speeds up to 79 miles per hour MPH, and
- High Speed Rail Subservice, which is applicable to all passenger and freight trains with operational speeds from 80 to 125 MPH.

4.2 Public Transportation Management User Service Bundle

4.2.1 Public Transportation Management - ITS shall include a Public Transportation Management (PTM) function. PTM shall include an Operation of Vehicles and Facilities (OVF) function that provides computer assisted control of the operation of vehicles and their associated facilities.

4.2.2 En-route Transit Information - ITS shall include an En-Route Transit Information (TI) function. En-Route Transit Information provides travelers with real-time transit and high-occupancy vehicle information allowing travel alternatives to be chosen once the traveler is en-route. It consists of three major functions: Information Distribution, Information

Receipt, and Information Processing. These capabilities integrate information from different transit modes and present it to travelers for decision making.

4.2.3 Personalized Public Transit - ITS shall include a Personalized Public Transit (PPT) function. ITS shall include a Personalized Public Transit (PPT) function. The PPT shall include a Rider Request that shall provide the capability for an individual rider to request a trip by specifying the trip origin and destination, time and date. It shall provide the capability for an individual to specify a rider's special equipment or handling requirements. The Rider Request shall provide the capability to notify a requester of the fact that a trip assignment has been made including the time at which the vehicle is expected at the point of departure.

4.2.4 Public Travel Security – not used

4.3 Electronic Payment User Service Bundle

4.3.1 Electronic Payment Services - ITS shall include an Electronic Payment capability. Electronic Payment Services allows travelers to pay for transportation services by electronic means. Four functions are provided: Electronic Toll Collection, Electronic Fare Collection, Electronic Parking Payment, and Electronic Payment Services Integration.

*4.4 Commercial Vehicle Operations User Service Bundle (*not used)

4.4.1 Commercial Vehicle Electronic Clearance – not used

4.4.2 Automated Roadside Safety Inspection – not used

4.4.3 On-board Safety Monitoring – not used

4.4.4 Commercial Vehicle Administrative Processes – not used

4.4.5 Hazardous Material Incident Response – not used

4.4.6 Commercial Fleet Management – not used

4.5 Emergency Management User Service Bundle

4.5.1 Emergency Notification and Personal Security - ITS shall include an Emergency Notification And Personal Security (ENPS) function that provides for faster notification of travelers involved in an incident.

4.5.2 Emergency Vehicle Management - ITS shall include an Emergency Vehicle Management (EVM) Service. The Emergency Vehicle Management Service shall be provided by an Emergency Vehicle Fleet Management System. The Emergency Vehicle Fleet Management System shall maintain the availability status of relevant emergency vehicles, determine the emergency response vehicles best suited to respond to an incident, and dispatch the appropriate emergency response vehicle (s) to the incident. The Emergency Vehicle Management Service shall be provided by a Route Guidance System. The Route Guidance system shall maintain real-time information on traffic conditions, emergency response vehicle locations, and emergency response vehicle destinations. It shall advise emergency response vehicles of appropriate routes. Emergency Vehicle Management Service shall be provided by a Signal Priority System. The Signal Priority System shall maintain real-time information on signal timing, emergency vehicle locations and emergency vehicle routing.

4.6 Advanced Vehicle Safety Systems User Service Bundle (not used)

4.6.1 Longitudinal Collision Avoidance – not used

4.6.2 Lateral Collision Avoidance – not used

4.6.3 Intersection Collision Avoidance – not used

4.6.4 Vision Enhancement for Crash Avoidance – not used

4.6.5 Safety Readiness – not used

4.6.6 Pre-crash Restraint Deployment – not used

4.6.7 Automated Vehicle Operation– not used

4.7 Information Management User Service Bundle

4.7.1 Archived Data Function - ITS shall provide an Archived Data Function to control the archiving and distribution of ITS data. The Archived Data User Service provides the Historical Data Archive Repositories and controls the archiving functionality for all ITS data with five major functions:

- Operational Data Control function to manage operations data integrity,
- Data Import and Verification function to acquire historical data from the Operational Data Control function,
- Automatic Data Historical Archive function for permanently archiving the data,
- Data Warehouse Distribution function, which integrates the planning, safety, operations, and research communities into ITS and processes data products for these communities, and
- ITS Community Interface which provides the ITS common interface to all ITS users for data products specification and retrieval. ADUS helps achieve the ITS information goal of unambiguous interchange and reuse of data and information throughout all functional areas.

5 Logical Architecture

The Logical Architecture defines the Processes (the activities or functions) that are required to satisfy the User Services. Many different Processes must work together and share information to provide a User Service. Utilizing Data Flow Diagrams (DFD) and Process Specifications (Pspec), the logical architecture defines the functions that are required to perform ITS user services and the information or data flows that need to be exchanged between these functions. Data Flows identify the information that is shared by the Processes.

Data flow diagrams (DFD) provide a graphical view of how the processes and data flows fit together. In a data flow diagram, circles represent functions that are broken down into lower levels of detail on subsequent diagrams. Rectangles represent the external entities. The lines drawn between the function circles and between the functions and the external entity rectangles represent data flows. They are further subdivided on subsequent diagrams and are described in a data dictionary. The data dictionary has not been included in this document, but can be referenced in the National ITS Architecture Documentation. The lowest level of decomposition is a Pspec. An example of a Pspec would be *Process Traffic Sensor Data*. This process is responsible for collecting surveillance data obtained from the roadside, vehicles, pedestrians

(travelers using other modes of transport), railroad grade and multimodal crossings. Process Traffic Sensor Data passes the data on to another process, *Collect and Process Sensor Fault Data*, where it is combined with other such detected data. Both process specifications are within the *Manage Traffic* function.

Appendix A contains the data flow diagrams and Process Specifications required for the Knoxville area User Services. Each Process Specification in the Appendix is cross-referenced to the user requirements that it satisfies.

The following is a list of the selected system Data Flow Diagrams (DFD) with their respective Pspecs. The number following each data flow or Pspec title is its level in the overall logical architecture.

DFD Manage ITS 0

DFD Manage Traffic 1

DFD Provide Traffic Surveillance 1.1

DFD Process Sensor Data 1.1.1

- Pspec Process Traffic Sensor Data 1.1.1.1
- Pspec Collect and Process Sensor Fault Data 1.1.1.2
- Pspec Process Environmental Sensor Data 1.1.1.3
- Pspec Manage Data Collection and Monitoring 1.1.1.4

DFD Process and Store Traffic Data 1.1.2

- Pspec Process Traffic Data for Storage 1.1.2.1
- Pspec Process Traffic Data 1.1.2.2
- Pspec Update Data Source Static Data 1.1.2.3
- Pspec Monitor HOV lane use 1.1.2.4 (not included in Knoxville)
- Pspec Process Tag/AVL Data for Link Time Data 1.1.2.5 (not included in Knoxville)
- Pspec Process Collected Vehicle Smart Probe Data 1.1.2.6 (not included in Knoxville)

Pspec Monitor Reversible Lanes 1.1.2.7 (not included in Knoxville)

Pspec Generate Predictive Traffic Model 1.1.3

DFD Display and Output Traffic Data 1.1.4

Pspec Retrieve Traffic Data 1.1.4.1

Pspec Provide Traffic Operations Personnel Traffic Data Interface 1.1.4.2

Pspec Provide Direct Media Traffic Data Interface 1.1.4.3

Pspec Update Traffic Display Map Data 1.1.4.4

Pspec Provide Media System Traffic Data Interface 1.1.4.5

Pspec Provide Traffic Data Retrieval Interface 1.1.4.6

Pspec Manage Traffic Archive Data 1.1.4.7

Pspec Exchange data with Other Traffic Centers 1.1.5

DFD Provide Device Control 1.2

Pspec Select Strategy 1.2.1

DFD Determine Road and Freeway State 1.2.2

Pspec Determine Indicator State for Freeway Management 1.2.2.1

Pspec Determine Indicator State for Road Management 1.2.2.2

Pspec Determine Ramp State 1.2.3

DFD Output Control Data 1.2.4

Pspec Output Control Data for Roads 1.2.4.1

Pspec Output Control Data for Freeways 1.2.4.2

DFD Manage Parking Lot State 1.2.5

Pspec Determine Parking Lot State 1.2.5.1

Pspec Coordinate Other Parking Data 1.2.5.2

Pspec Provide Parking Lot Operator Interface 1.2.5.3

Pspec Determine P+R needs for Transit Management 1.2.5.4

Pspec Manage Parking Archive Data 1.2.5.5

Pspec Calculate Parking Lot Occupancy 1.2.5.6

DFD Maintain Static Data for TMC 1.2.6

Pspec Maintain Traffic and Sensor Static Data 1.2.6.1

Pspec Provide Static Data Store Output Interface 1.2.6.2

DFD Provide Roadside Control Facilities 1.2.7

Pspec Process Indicator Output Data for Roads 1.2.7.1

Pspec Monitor Roadside Equipment Operation for Faults 1.2.7.2

Pspec Manage Indicator Preemptions 1.2.7.3

Pspec Process In-vehicle Signage Data 1.2.7.4

Pspec Process Indicator Output Data for Freeways 1.2.7.5

Pspec Provide Intersection Collision Avoidance Data 1.2.7.6 (not included in Knoxville)

Pspec Process Vehicle Smart Probe Data for Output 1.2.7.7 (not included in Knoxville)

DFD Collect and Process Indicator Fault Data 1.2.8

Pspec Collect Indicator Fault Data 1.2.8.1

Pspec Maintain Indicator Fault Data Store 1.2.8.2

Pspec Provide Indicator Fault Interface for C and M 1.2.8.3

Pspec Provide Traffic Operations Personnel Indicator Fault Interface 1.2.8.4

DFD Manage Incidents 1.3

DFD Traffic Data Analysis for Incidents 1.3.1

Pspec Analyze Traffic Data for Incidents 1.3.1.1

Pspec Maintain Static Data for Incident Management 1.3.1.2

Pspec Process Traffic Images 1.3.1.3

DFD Review and Manage Incident Data 1.3.2

Pspec Store Possible Incident Data 1.3.2.1

Pspec Review and Classify Possible Incidents 1.3.2.2

Pspec Review and Classify Planned Events 1.3.2.3

Pspec Provide Planned Events Store Interface 1.3.2.4

Pspec Provide Current Incidents Store Interface 1.3.2.5

Pspec Respond to Current Incidents 1.3.3

DFD Provide Operator Interfaces for Incidents 1.3.4

Pspec Retrieve Incident Data 1.3.4.1

Pspec Provide Traffic Operations Personnel Incident Data Interface 1.3.4.2

Pspec Provide Media Incident Data Interface 1.3.4.3

Pspec Update Incident Display Map Data 1.3.4.4

Pspec Manage Resources for Incidents 1.3.4.5

Pspec Manage Possible Predetermined Responses Store 1.3.5

Pspec Manage Predetermined Incident Response Data 1.3.6

Pspec Analyze Incident Response Log 1.3.7

DFD Manage Travel Demand 1.4

Pspec Provide Traffic Operations Personnel Demand Interface 1.4.1

Pspec Collect Demand Forecast Data 1.4.2

Pspec Update Demand Display Map Data 1.4.3

Pspec Implement Demand Management Policy 1.4.4

Pspec Calculate Forecast Demand 1.4.5

DFD Manage Emissions 1.5

Pspec Provide Traffic Operations Personnel Pollution Data Interface 1.5.1

Pspec Process Pollution Data 1.5.2

Pspec Update Pollution Display Map Data 1.5.3

Pspec Manage Pollution State Data Store 1.5.4

Pspec Process Vehicle Pollution Data 1.5.5

Pspec Detect Roadside Pollution Levels 1.5.6

Pspec Manage Pollution Data Log 1.5.7

Pspec Manage Pollution Reference Data Store 1.5.8

Pspec Manage Pollution Archive Data 1.5.9

DFD Manage Highway Rail Intersections 1.6

DFD Manage HRI Vehicle Traffic 1.6.1

Pspec Detect Roadway Events 1.6.1.1

DFD Activate HRI Device Controls 1.6.1.2

Pspec Control HRI Traffic Signals 1.6.1.2.1

Pspec Control HRI Warnings and Barriers 1.6.1.2.2

Pspec Provide SSR Device Controls 1.6.1.2.3

Pspec Provide HSR Device Controls 1.6.1.2.4

Pspec Manage Device Control 1.6.1.2.5

Pspec Maintain Device State 1.6.1.2.6

Pspec Perform Equipment Self-Test 1.6.1.3

DFD Provide Advisories and Alerts 1.6.1.4

Pspec Generate Alerts and Advisories 1.6.1.4.1

Pspec Provide Closure Parameters 1.6.1.4.2

Pspec Report Alerts and Advisories 1.6.1.4.3

Pspec Report HRI Status on Approach 1.6.1.4.4

Pspec Detect HRI Hazards 1.6.1.5

DFD Provide Advance Warnings 1.6.1.6

Pspec Close HRI on Detection 1.6.1.6.1

Pspec Detect Imminent Vehicle/Train Collision 1.6.1.6.2

DFD Execute Local Control Strategy 1.6.1.7

Pspec Control Vehicle Traffic at Passive HRI 1.6.1.7.1

Pspec Control Vehicle Traffic at Active HRI 1.6.1.7.2

Pspec Close HRI on Command 1.6.1.7.3

DFD Interact with Rail Operations 1.6.2

Pspec Exchange Data with Rail Operations 1.6.2.1

Pspec Manage Alerts and Advisories 1.6.2.2

Pspec Manage Rail Traffic Control Data 1.6.2.3

DFD Manage HRI Rail Traffic 1.6.3

Pspec Interact with Wayside Systems 1.6.3.1

Pspec Advise and Protect Train Crews 1.6.3.2

Pspec Provide ATS Alerts 1.6.3.3

DFD Interact with Vehicle Traffic Management 1.6.4

Pspec Manage HRI Closures 1.6.4.1

Pspec Exchange Data with Traffic Management 1.6.4.2

DFD Monitor HRI Status 1.6.5

Pspec Provide Interactive Interface 1.6.5.1

Pspec Determine HRI Status 1.6.5.2

Pspec Maintain HRI Closure Data 1.6.5.3

DFD Manage Commercial Vehicles (not included in Knoxville) 2

DFD Provide Vehicle Monitoring and Control (not included in Knoxville) 3

DFD Manage Transit 4

DFD Operate Vehicles and Facilities 4.1

Pspec Process Transit Vehicle Sensor Trip Data 4.1.1

DFD Determine Transit Vehicle Deviation and Corrections 4.1.2

Pspec Determine Transit Vehicle Deviation and ETA 4.1.2.1

Pspec Determine Transit Vehicle Corrective Instructions 4.1.2.2

Pspec Provide Transit Vehicle Driver Interface 4.1.2.3

Pspec Provide Transit Vehicle Correction Data Output Interface 4.1.2.4

Pspec Request Transit Vehicle Preemptions 4.1.2.5

Pspec Provide Transit Vehicle Location Data 4.1.3

Pspec Manage Transit Vehicle Deviations 4.1.4

Pspec Provide Transit Vehicle Status Information 4.1.5

Pspec Manage Transit Vehicle Operations Data 4.1.6

Pspec Provide Transit Vehicle Deviation Data Output Interface 4.1.7

Pspec Provide Transit Operations Data Distribution Interface 4.1.8

Pspec Process Transit Vehicle Sensor Maintenance Data 4.1.9

DFD Plan and Schedule Transit Services 4.2

DFD Provide Demand Responsive Transit Service 4.2.1

Pspec Process Demand Responsive Transit Trip Request 4.2.1.1

Pspec Compute Demand Responsive Transit Vehicle Availability 4.2.1.2

Pspec Generate Demand Responsive Transit Schedule and Routes 4.2.1.3

Pspec Confirm Demand Responsive Transit Schedule and Route 4.2.1.4

Pspec Process Demand Responsive Transit Vehicle Availability Data 4.2.1.5

Pspec Provide Demand Responsive Transit Driver Interface 4.2.1.6

Pspec Provide Transit Plans Store Interface 4.2.2

DFD Generate Transit Routes and Schedules 4.2.3

Pspec Generate Transit Routes 4.2.3.1

Pspec Generate Schedules 4.2.3.2

Pspec Produce Transit Service Data for External Use 4.2.3.3

Pspec Provide Transit Fleet Manager Interface for Services Generation 4.2.3.4

Pspec Manage Transit Operational Data Store 4.2.3.5

Pspec Produce Transit Service Data for Manage Transit Use 4.2.3.6

Pspec Provide Interface for Other TRM Data 4.2.3.7

Pspec Provide Interface for Transit Service Raw Data 4.2.3.8

Pspec Update Transit Map Data 4.2.3.9

Pspec Manage Transit Archive Data 4.2.4

DFD Schedule Transit Vehicle Maintenance 4.3

Pspec Monitor Transit Vehicle Condition 4.3.1

Pspec Generate Transit Vehicle Maintenance Schedules 4.3.2

Pspec Generate Technician Work Assignments 4.3.3

Pspec Monitor And Verify Maintenance Activity 4.3.4

Pspec Report Transit Vehicle Information 4.3.5

Pspec Update Transit Vehicle Information 4.3.6

Pspec Manage Transit Vehicle Operations Data Store 4.3.7

DFD Support Security and Coordination 4.4

DFD Provide Transit Security and Emergency Management 4.4.1

Pspec Manage Transit Security 4.4.1.1

Pspec Manage Transit Emergencies 4.4.1.2

Pspec Provide Transit System Operator Security Interface 4.4.1.3

Pspec Provide Transit External Interface for Emergencies 4.4.1.4

Pspec Provide Transit Driver Interface for Emergencies 4.4.1.5

Pspec Collect Transit Vehicle Emergency Information 4.4.1.6

Pspec Monitor Secure Area 4.4.1.7

Pspec Report Traveler Emergencies 4.4.1.8

Pspec Coordinate Multiple Agency Responses to Incidents 4.4.2

Pspec Generate Responses for Incidents 4.4.3

DFD Generate Transit Driver Schedules 4.5

Pspec Assess Transit Driver Performance 4.5.1

Pspec Assess Transit Driver Availability 4.5.2

Pspec Access Transit Driver Cost Effectiveness 4.5.3

Pspec Assess Transit Driver Eligibility 4.5.4

Pspec Generate Transit Driver Route Assignments 4.5.5

Pspec Update Transit Driver Information 4.5.6

Pspec Report Transit Driver Information 4.5.7

Pspec Provide Transit Driver Information Store Interface 4.5.8

DFD Collect Transit Fares in the Vehicle 4.6

Pspec Detect Transit User on Vehicle 4.6.1

Pspec Determine Transit User Needs on Vehicle 4.6.2

Pspec Determine Transit Fare on Vehicle 4.6.3

Pspec Manage Transit Fare Billing on Vehicle 4.6.4

Pspec Provide Transit User Fare Payment Interface on Vehicle 4.6.5

Pspec Update Transit Vehicle Fare Data 4.6.6

Pspec Provide Transit Vehicle Passenger Data 4.6.7

Pspec Manage Transit Vehicle Advanced Payments 4.6.8

DFD Provide Transit User Roadside Facilities 4.7

DFD Provide Transit User Roadside Information 4.7.1

Pspec Provide Transit User Roadside Data Interface 4.7.1.1

Pspec Provide Transit User Roadside Vehicle Data Interface 4.7.1.2

DFD Collect Transit Fares at the Roadside 4.7.2

Pspec Detect Transit User at Roadside 4.7.2.1

Pspec Determine Transit User Needs at Roadside 4.7.2.2

Pspec Determine Transit Fare at Roadside 4.7.2.3

Pspec Manage Transit Fare Billing at Roadside 4.7.2.4

Pspec Provide Transit User Roadside Fare Interface 4.7.2.5

Pspec Update Roadside Transit Fare Data 4.7.2.6

Pspec Provide Transit Roadside Passenger Data 4.7.2.7

DFD Manage Emergency Services 5

DFD Provide Emergency Service Allocation 5.1

Pspec Identify Emergencies from Inputs 5.1.1

Pspec Determine Coordinated Response Plan 5.1.2

Pspec Communicate Emergency Status 5.1.3

Pspec Manage Emergency Response 5.1.4

Pspec Manage Emergency Service Allocation Store 5.1.5

Pspec Process Mayday Messages 5.1.6

Pspec Provide Operator Interface for Emergency Data 5.2

DFD Manage Emergency Vehicles 5.3

Pspec Select Response Mode 5.3.1

Pspec Dispatch Vehicle 5.3.2

Pspec Track Vehicle 5.3.3

Pspec Assess Response Status 5.3.4

Pspec Provide Emergency Personnel Interface 5.3.5

Pspec Maintain Vehicle Status 5.3.6

Pspec Provide Emergency Vehicle Route 5.3.7

DFD Provide Law Enforcement Allocation 5.4

Pspec Process TM Detected Violations 5.4.1

Pspec Process Violations for Tolls 5.4.2

Pspec Process Parking Lot Violations 5.4.3

Pspec Process Fare Payment Violations 5.4.4

Pspec Process Vehicle Fare Collection Violations 5.4.5

Pspec Process CV Violations 5.4.6

Pspec Process Roadside Fare Collection Violations 5.4.7

Pspec Update Emergency Display Map Data 5.5

Pspec Manage Emergency Services Data 5.6

DFD Provide Driver and Traveler Services 6

DFD Provide Trip Planning Services 6.1

Pspec Provide Trip Planning Information to Traveler 6.1.1

Pspec Confirm Traveler's Trip Plan 6.1.2

Pspec Manage Multimodal Service Provider Interface 6.1.3

Pspec Provide ISP Operator Interface for Trip Planning Parameters 6.1.4

Pspec Collect Service Requests and Confirmation for Archive 6.1.5

Pspec Manage Traveler Info Archive Data 6.1.6

DFD Provide Information Services 6.2

DFD Provide Advisory and Broadcast Data 6.2.1

Pspec Collect Traffic Data for Advisory Messages 6.2.1.1

Pspec Provide Traffic and Transit Advisory Messages 6.2.1.2

Pspec Collect Transit Data for Advisory Messages 6.2.1.3

Pspec Provide Traffic and Transit Broadcast Messages 6.2.1.4

Pspec Provide ISP Operator Broadcast Parameters Interface 6.2.1.5

Pspec Provide Transit Advisory Data On Vehicle 6.2.1.6

Pspec Prepare and Output In-vehicle Displays 6.2.2

Pspec Provide Transit User Advisory Interface 6.2.3

Pspec Collect Yellow Pages Data 6.2.4

Pspec Provide Driver Interface 6.2.5

Pspec Provide Yellow Pages Data and Reservations 6.2.6

DFD Provide Traveler Services at Kiosks 6.3

Pspec Get Traveler Request 6.3.1

Pspec Inform Traveler 6.3.2

Pspec Provide Traveler Kiosk Interface 6.3.3

Pspec Update Traveler Display Map Data at Kiosk 6.3.4

DFD Manage Ridesharing 6.4

Pspec Screen Rider Requests 6.4.1

Pspec Match Rider and Provider 6.4.2

Pspec Report Ride Match Results to Requestor 6.4.3

Pspec Confirm Traveler Rideshare Request 6.4.4

DFD Manage Yellow Pages Services 6.5

Pspec Collect and Update Traveler Information 6.5.1

Pspec Provide Traveler Yellow Pages Information and Reservations 6.5.2

Pspec Register Yellow Pages Service Providers 6.5.3

DFD Provide Guidance and Trip Planning Services 6.6

Pspec Provide Multimodal Route Selection 6.6.1

DFD Provide Driver Personal Services 6.7

DFD Provide Traveler Personal Services 6.8

DFD Provide On-line Traveler Guidance 6.8.1

DFD Provide Traveler Guidance 6.8.1.1

Pspec Determine Personal Portable Device Guidance Method 6.8.1.1.1

Pspec Provide Personal Portable Device Dynamic Guidance 6.8.1.1.2

Pspec Provide Personal Portable Device Autonomous Guidance 6.8.1.1.3

Pspec Provide Personal Portable Device Guidance Interface 6.8.1.2

Pspec Process Personal Portable Device Location Data 6.8.1.3

Pspec Update Traveler Navigable Map Database 6.8.1.4

Pspec Provide Traveler Emergency Message Interface 6.8.1.5

DFD Provide Traveler Personal Security 6.8.2

Pspec Build Traveler Personal Security Message 6.8.2.1

Pspec Provide Traveler Emergency Communications Function 6.8.2.2

DFD Provide Traveler Services at Personal Devices 6.8.3

Pspec Get Traveler Personal Request 6.8.3.1

Pspec Provide Traveler with Personal Travel Information 6.8.3.2

Pspec Provide Traveler Personal Interface 6.8.3.3

Pspec Update Traveler Personal Display Map Data 6.8.3.4

DFD Provide Electronic Payment Services 7

DFD Provide Electronic Toll Payment (not included in Knoxville) 7.1

DFD Provide Electronic Parking Payment (not included in Knoxville) 7.2

DFD Provide Electronic Fare Collection 7.3

DFD Process Electronic Transit Fare Payment 7.3.1

Pspec Register for Advanced Transit Fare Payment 7.3.1.1

Pspec Determine Advanced Transit Fares 7.3.1.2

Pspec Manage Transit Fare Financial Processing 7.3.1.3

Pspec Check for Advanced Transit Fare Payment 7.3.1.4

Pspec Bill Transit User for Transit Fare 7.3.1.5

Pspec Collect Bad Transit Fare Payment Data 7.3.1.6

Pspec Update Transit Fare Data 7.3.1.7

Pspec Distribute Advanced Tolls and Parking Lot Charges 7.3.2

Pspec Get Transit User Image for Violation 7.3.3

Pspec Provide Remote Terminal Payment Instrument Interface 7.3.4

Pspec Provide Transit Vehicle Payment Instrument Interface 7.3.5

DFD Carry-out Centralized Payments Processing 7.4

DFD Collect Advanced Payments 7.4.1

Pspec Process Yellow Pages Services Provider Payments 7.4.1.2

Pspec Process Driver Map Update Payments 7.4.1.3

Pspec Process Traveler Map Update Payments 7.4.1.4

Pspec Process Transit User Other Services Payments 7.4.1.5

Pspec Process Traveler Trip and Other Services Payments 7.4.1.6

Pspec Collect Payment Transaction Records 7.4.1.7

Pspec Process Traveler Rideshare Payments 7.4.1.8

Pspec Collect Price Data for ITS Use 7.4.2

Pspec Route Traveler Advanced Payments 7.4.3

DFD Manage Archived Data 8

Pspec Get Archive Data 8.1

Pspec Manage Archive 8.2

Pspec Manage Archive Data Administrator Interface 8.3

Pspec Coordinate Archives 8.4

Pspec Process Archived Data User System Requests 8.5

Pspec Analyze Archive 8.6

Pspec Process On Demand Archive Requests 8.7

Pspec Prepare Government Reporting Inputs 8.8

Pspec Manage Roadside Data Collection 8.9

6 Physical Architecture

The *Physical Architecture* partitions the functions defined by the Logical Architecture into *system*s, and at a lower level, *subsystem*s, based on the functional similarity of the process specifications and the location where the functions are being performed. A diagram of the physical architecture for Knoxville is attached to this memorandum. The physical architecture defines four systems: *Traveler, Center, Roadside, and Vehicle,* and nineteen subsystems. The specific choice of nineteen subsystems represents a lower level of partitioning of functions that is intended to capture the anticipated subsystem boundaries for the present needs, and 20 years into the future. Subsystems are composed of *equipment packages* each with specific functional attributes. Equipment packages are defined to support analyses and deployment, and they represent the smallest units within a subsystem that might be purchased. In deployments, the character of a subsystem deployment is determined by the specific equipment packages chosen. For example, one municipal deployment of a *Traffic Management Subsystem* may select *Collect Traffic Surveillance* and *Basic Signal Control* equipment packages, while a state Traffic Management Center may select *Collect Traffic Surveillance* and *Freeway Control* packages. In addition, subsystems may be deployed individually or in combinations that will vary by geography and time based upon local deployment choices. A Traffic Management Center may include a *Traffic Management Subsystem*, *Information Provider Subsystem*, and *Emergency Management Subsystem*, all within one building, while another Traffic Management Center may concentrate only on the management of traffic with the *Traffic Management Subsystem*. The equipment packages for the chosen subsystems are listed in Section 6.1 below.

The Knoxville Physical Architecture diagram presents the relevant portions of the National ITS Architecture for the individual subsystems. The diagrams include only the architecture subsystems, equipment packages, system terminators, and architecture flows that are most important to the operation of the subsystem in order to simplify the presentation. For deployment of equipment packages of the subsystems, the National ITS Architecture has developed market packages. The market packages provide an accessible, deployment oriented perspective to the national architecture. They are tailored to fit - separately or in combination - real world transportation problems and needs. Market packages collect together one or more

Equipment Packages that must work together to deliver a given transportation service and the Architecture Flows that connect them and other important external systems. In other words, they identify the pieces of the Physical Architecture that are required to implement a particular transportation service. The market package graphics for Knoxville are included in the Appendix. For a complete list of all market components, reference the architecture tables or the Microsoft Access database provided on the National ITS Architecture documentation.

In developing the Knoxville regional architecture, each jurisdiction was shown with subsystems and equipment packages that either are existing or could possibly be implemented in the future. This was based on inputs from the Stakeholders of the region.

The Knoxville region is a large geographical area with diverse transportation interests from one side of the region to the other. The Knoxville Physical Architecture is a formulation that provides flexibility for sub-area implementations that meet local demands while maintaining the integrity of a regional information system. This modular approach provides groupings of relevant user agencies shown in the Physical Architecture. These groupings are defined based upon agencies and users with similar transportation information needs and interests. Sevier County may put more emphasis on tourism-related services, while the Oak Ridge region may be more concerned about evacuation notification during a nuclear reactor incident. The Knoxville Physical Architecture provides a platform for sub-regional customization and implementations that can be pursued independent of integration with other sub-regions.

6.1 Subsystems and Equipment Packages

A discussion of the function of each subsystem and the associated equipment packages are provided on the following pages. Subsystems and equipment packages that were not included in Knoxville are noted. They are left within the document for reader convenience.

6.1.1 Center Subsystems

Center Subsystems deal with those functions normally assigned to public/private administrative, management, or planning agencies. The nine Center Subsystems are described below:

Commercial Vehicle Administration (not included in Knoxville) **-** Sells credentials and administers taxes, keeps records of safety and credential check data, and participates in information exchange with other commercial vehicle administration subsystems and CVO Information Requesters.

Fleet and Freight Management (not included in Knoxville) - Monitors and coordinates vehicle fleets including coordination with intermodal freight depots or shippers.

Toll Administration (not included in Knoxville) - Provides general payment administration capabilities to support electronic assessment of tolls and other transportation usage fees.

Transit Management - Collects operational data from transit vehicles and performs strategic and tactical planning for drivers and vehicles. Transit Management has the following Equipment Packages for Knoxville.

- Transit Center Tracking and Dispatch
- Transit Center Information Services
- Transit Center Fixed-Route Operations
- Transit Garage Operations
- Transit Center Paratransit Operations
- Transit Center Fare and Load Management
- Transit Center Multi-Modal Coordination
- Transit Center Security
- Transit Data Collection
- Transit Garage Maintenance

Emergency Management - Coordinates response to incidents, including those involving hazardous materials (HAZMAT). Emergency Management has the following Equipment Packages for Knoxville.

- Emergency Call-Taking
- Emergency Data Collection
- Emergency Dispatch
- Emergency Response Management
- Mayday Support (not used in Knoxville)

Emissions Management - Collects and processes pollution data and provides demand management input to Traffic Management. Emissions Management has the following Equipment Packages for Knoxville.

- Emissions Data Collection
- Emissions Data Management

Archived Data Management - Collects, archives, manages, and distributes data generated from ITS sources for use in transportation administration, policy evaluation, safety, planning, performance monitoring, program assessment, operations, and research applications. Archived Data Management has the following Equipment Packages for Knoxville.

- Government Reporting Systems Support
- ITS Data Repository
- On-Line Analysis and Mining
- Traffic and Roadside Data Archival

- Virtual Data Warehouse Services (not used in Knoxville)

Traffic Management - Processes traffic data and provides basic traffic and incident management services through the Roadside and other subsystems. The Traffic Management Subsystem may share traffic data with Information Service Providers. Different equipment packages provide a focus on surface streets or highways (freeways and interstates) or both. This subsystem also coordinates transit signal priority and emergency vehicle signal preemption. Traffic Management has the following Equipment Packages for Knoxville.

- Collect Traffic Surveillance
- Highway-Rail Intersections (HRI) Traffic Management
- Rail Operations Coordination
- TMC for Automated Highway Systems (AHS) (not used in Knoxville)
- TMC Freeway Management
- TMC High Occupancy Vehicle (HOV) Lane Management (not used in Knoxville)
- TMC Incident Detection
- TMC Incident Dispatch Coordination/Communication
- TMC Input to In-Vehicle Signing (not used in Knoxville)
- TMC Multi-Modal Coordination
- TMC Probe Information Collection (not used in Knoxville)
- TMC Regional Traffic Control
- TMC Road Weather Monitoring

- TMC Signal Control
- TMC Toll/Parking Coordination
- TMC Traffic Information Dissemination
- TMC Traffic Network Performance Evaluation
- Traffic Data Collection
- Traffic Maintenance

Information Service Provider (ISP)- This subsystem may be deployed alone (to generally serve drivers and/or travelers) or be combined with Transit Management (to specifically benefit transit travelers), Traffic Management (to specifically benefit drivers and their passengers), Emergency Management (for emergency vehicle routing), Parking Management (for brokering parking reservations), and/or Commercial Vehicle Administration (for commercial vehicle routing) deployments. ISP's can collect and process transportation data from the aforementioned centers, and broadcast general information products (e.g., link times), or deliver personalized information products (e.g., personalized or optimized routing) in response to individual information requests. Because the ISP may know where certain vehicles are, it may use them as "probes" to help determine highway conditions, levels of congestion, and aid in the determination of travel or link times. This probe data may be shared with the Traffic Management Subsystem. The ISP is a key element of pre-trip travel information, infrastructure based route guidance, brokering demand-responsive transit and ridematching, and other traveler information services. Information Service Providers has the following Equipment Packages for Knoxville.

- Basic Information Broadcast
- Infrastructure Provided Dynamic Ridesharing (not used in Knoxville)
- Infrastructure Provided Route Selection (not used in Knoxville)

- Infrastructure Provided Yellow Pages & Reservation
- Interactive Infrastructure Information (not used in Knoxville)
- Information Service Provider (ISP) Advanced Integrated Control Support (not used in Knoxville)
- ISP Data Collection
- ISP Probe Information Collection (not used in Knoxville)

6.1.2 Roadside Subsystems

These subsystems include functions that require convenient access to a roadside location for the deployment of sensors, signals, programmable signs, or other interfaces with travelers and vehicles of all types. The four Roadside Subsystems are described below:

Roadway - Provides traffic management surveillance, signals, and signage for traveler information. This subsystem also includes the devices at roadway intersections and multi-modal intersections to control traffic.

- Advanced Rail Crossing
- Automated Road Signing (not used in Knoxville)
- Roadside Data Collection
- Roadside Signal Priority
- Roadway Basic Surveillance
- Roadway Emissions Monitoring
- Roadway Environmental Monitoring

- Roadway Freeway Control
- TMC HOV Lane Management (not used in Knoxville)
- Roadway HOV Control (not used in Knoxville)
- Roadway In-Vehicle Signing (not used in Knoxville)
- Roadway Incident Detection
- Roadway Intersection Collision Warning (not used in Knoxville)
- Roadway Probe Beacons (not used in Knoxville)
- Roadway Reversible Lanes (not used in Knoxville)
- Roadway Signal Controls
- Roadway Systems for AHS (not used in Knoxville)
- Roadway Traffic Information Dissemination
- Standard Rail Crossing

Toll Collection (not included in Knoxville) - Interacts with vehicle toll tags to collect tolls and identify violators.

Parking Management - Collects parking fees and manages parking lot occupancy/availability.

- Parking Coordination
- Parking Data Collection
- Parking Electronic Payment (not used in Knoxville)
- Parking Management

- Parking Surveillance

Commercial Vehicle Check (not included in Knoxville) - Collects credential and safety data from vehicle tags, determines conformance to requirements, posts results to the driver (and in some safety exception cases, the carrier), and records the results for the Commercial Vehicle Administration Subsystem.

6.1.3 Vehicle Subsystems

These subsystems are installed in a vehicle. The four Vehicle Subsystems are described below:

Vehicle (not included in Knoxville) - Functions that may be common across all vehicle types are located here (e.g. navigation, tolls, etc.) so that specific vehicle deployments may include aggregations of this subsystem with one of the other three specialized vehicle subsystem types. The Vehicle Subsystem includes the user services of the Advanced Vehicle Control and Safety Systems user services bundle.

Transit Vehicle - Provides operational data to the Transit Management Center, receives transit network status, provides enroute traveler information to travelers, and provides passenger and driver security functions.

- On-board Fixed Route Schedule Management
- On-board Maintenance
- On-board Paratransit Operations
- On-board Transit Fare and Load Management
- On-board Transit Information Services
- On-board Transit Security
- On-board Transit Signal Priority

- On-board Transit Trip Monitoring

Commercial Vehicle(not included in Knoxville) - Stores safety data, identification numbers (driver, vehicle, and carrier), last check event data, and supports in-vehicle signage for driver pass/pull-in messages.

Emergency Vehicle (EV) - Provides vehicle and incident status to the Emergency Management Subsystem.

- On-board EV En Route Support
- On-board EV Incident Management Communication

6.1.4 Traveler Subsystems

These subsystems represent platforms for ITS functions of interest to travelers or carriers (e.g., commercial vehicle operators) in support of multimodal traveling. They may be fixed (e.g., kiosks or home/office computers) or portable (e.g., a palm-top computer), and may be accessed by the public (e.g., through kiosks) or by individuals (e.g., through cellular phones or personal computers). The two Traveler Subsystems are described below:

Remote Traveler Support - Provides traveler information at public kiosks. This subsystem includes traveler security functions.

- Remote Basic Information Reception
- Remote Interactive Information Reception
- Remote Mayday Interface (not used in Knoxville)
- Remote Transit Fare Management (not used in Knoxville)
- Remote Transit Information Services
- Secure Area Monitoring (not used in Knoxville)

Personal Information Access **-** Provides traveler information and supports emergency requests for travelers using personal computers/telecommunication equipment at the home, office, or while on travel.

- Personal Autonomous Route Guidance (not used in Knoxville)
- Personal Basic Information Reception
- Personal Interactive Information Reception
- Personal Location Determination (not used in Knoxville)
- Personal Mayday Interface (not used in Knoxville)
- Personal Provider-Based Route Guidance (not used in Knoxville)

7 Inter-agency Communication Interfaces

Inter-agency interfaces can be accomplished over the public switched telephone network (i.e. Bell South) or via a private communication system that is owned and operated by public agencies. A private communications system would provide network redundancy and priority during emergency situations. For many interfaces, it may be necessary to establish the interface on the publicly switched network initially, and migrate to the private network as it becomes available.

Bandwidth requirements for an interface will vary depending on requirements of the agency. Interfaces may include the ability to transmit video (one way or both ways), data, and/or voice. Desired quality, intended use, and number of videos transmitted at the same time are important factors to consider when sizing an interface. **Table 7.1** summarizes ultimate agency interface requirements and associated bandwidth needs.

Inter-agency capability to control each other's cameras, while technically feasible over the proposed communications, requires more security and software to manage user priorities. If camera controls are needed or desired, Internet-based screen captures provide an effective alternative.

Video conference circuits are shown for interconnecting the Knoxville TMC with the TDOT Nashville Headquarters. These circuits provide access to video/camera feeds as well as the ability to videoconference with operation center staff. Likewise, this video conference circuit can be used to access TDOT's other regional TMCs in a similar fashion.

Table 7.1 – Bandwidth Needs for Agency Interfaces

Agency Interface Description	**Bandwidth Requirement**
Knoxville Area Transit (KAT) dispatch center ▪ Two video images (1.536Mbps each) ▪ One data channel (56kbps) ▪ One voice channel (64kbps)	3.192 Mbps (Two T1s and two telephone circuits (DS0s))
Tennessee Emergency Management Agency (TEMA) ▪ One data channel (56kbps) ▪ One voice channel (64kbps)	120 kbps (Two telephone circuits (DS0s))
Knox County/Knoxville/Farragut sub-region ▪ Two video images (1.536Mbps each) ▪ One data channel (56kbps) ▪ One voice channel (64kbps)	3.192 Mbps (Two T1s and two telephone circuits (DS0s))
Oak Ridge/Rockwood/Roane County sub-region ▪ Two video images (1.536Mbps each) ▪ One data channel (56kbps) ▪ One voice channel (64kbps)	3.192 Mbps (Two T1s and two telephone circuits (DS0s))
Blount County/Alcoa/Maryville sub-region ▪ Two video images (1.536Mbps each) ▪ One data channel (56kbps) ▪ One voice channel (64kbps)	3.192 Mbps (Two T1s and two telephone circuits (DS0s))
Sevier County/Pigeon Forge/Sevierville/Gatlinburg sub-region ▪ One data channel (56kbps) ▪ One voice channel (64kbps)	120 kbps (Two telephone circuits (DS0s))
Internet (1.536Mbps)	1.536 Mbps (One T1)
Kiosks (56kbps each) on an ISDN circuit for quick updates	256 kbps (Two ISDN lines to

	serve multiple kiosks)
TV/Radio information links (approx. 15 at 56kbps dial-up)	840 kbps (Fractional T1)
TDOT Nashville Headquarters ▪ Two data channels (56kbps each) ▪ One video conference circuit (128kbps)	240 kbps (Two ISDN lines or equivalent)

8 ITS Standards

ITS Standards are fundamental to the establishment of an open ITS environment that achieves the goals originally envisioned by the U.S. Department of Transportation. Standards facilitate deployment of interoperable systems at local, regional, and national levels without impeding innovation as technology advances and new approaches evolve.

The U.S. Department of Transportation's ITS Joint Program Office is supporting SDOs (Standards Development Organizations) with an extensive, multi-year program of accelerated standards development to facilitate successful ITS deployment. The program is supporting and accelerating the ITS consensus-based volunteer standards processes that are underway in the U.S.

The National ITS Architecture is a reference framework that spans all of these standards activities and provides a means of detecting gaps, overlaps, and inconsistencies between the standards. Standards Requirements, based on the Logical and Physical Architecture, provide a requirements starting point for the standards activities and a tool for measuring their output. Standards Requirements have been allocated to standards development activities in the following organizations:

- AASHTO (American Association of State Highway and Transportation Officials)
- ANSI (American National Standards Institute)
- ASTM (American Society for Testing and Materials)
- IEEE (Institute of Electrical and Electronics Engineers)
- ITE (Institute of Transportation Engineers)
- NEMA (National Electrical Manufacturers Association)
- SAE (Society of Automotive Engineers)

Although each standards activity is allocated to a single Standards Development Organizaton (SDO) in this mapping, it should be noted that many of the standards efforts are collaborative between multiple SDOs (e.g., NTCIP Joint Steering Committee is comprised of representatives from AASHTO, ITE and NEMA).

There are several excellent resources on the World Wide Web for those who want to learn more about ITS standards. The ITS America Standards Home Page provides access to standards information relating to all aspects of ITS. It also contains links to the organizations involved and, where possible, provides rapid access to published standards documents. The U.S. DOT Joint Program Office Standards site provides current status on the standards acceleration program.

These general sources are supplemented by sites that provide additional detail for a particular standards area. There is also a web site that focuses on the National Transportation Communications for ITS Protocol (NTCIP) standards family. The table below provides links to SDO home pages (e.g., IEEE) as well as specific ITS Standards efforts (e.g., TCIP). Other SDOs of interest include EIA, ISO, NEMA, and NIST.

Standard Development Organizations (SDO) Home Page	ITS Standards Specific Sites
AASHTO	• NTCIP Web Site
ANSI	• CVO Standards
ASTM	• DSRC Links
IEEE	• Standards Coordinating Committee on ITS
ITE	• Traffic Management Data Dictionary and Message Sets for External Traffic Management Center Communications • TCIP
SAE	• ITS Standards Index

9 Regional Stakeholders

Listed below are the regional stakeholders for the Knoxville region.

Anderson County

CAC

City of Alcoa

City of Gatlinburg

City of Knoxville

City of Maryville

City of Oak Ridge

City of Pigeon Forge

City of Rockwood

City of Sevierville

ETHRA

Federal Highway Administration

Jefferson County

Knox County

Knoxville Area Transit

Metropolitan Planning Commission

National Park Service

Roane County

Sevier County

Tennessee Dept of Transportation

Tennessee Highway Patrol

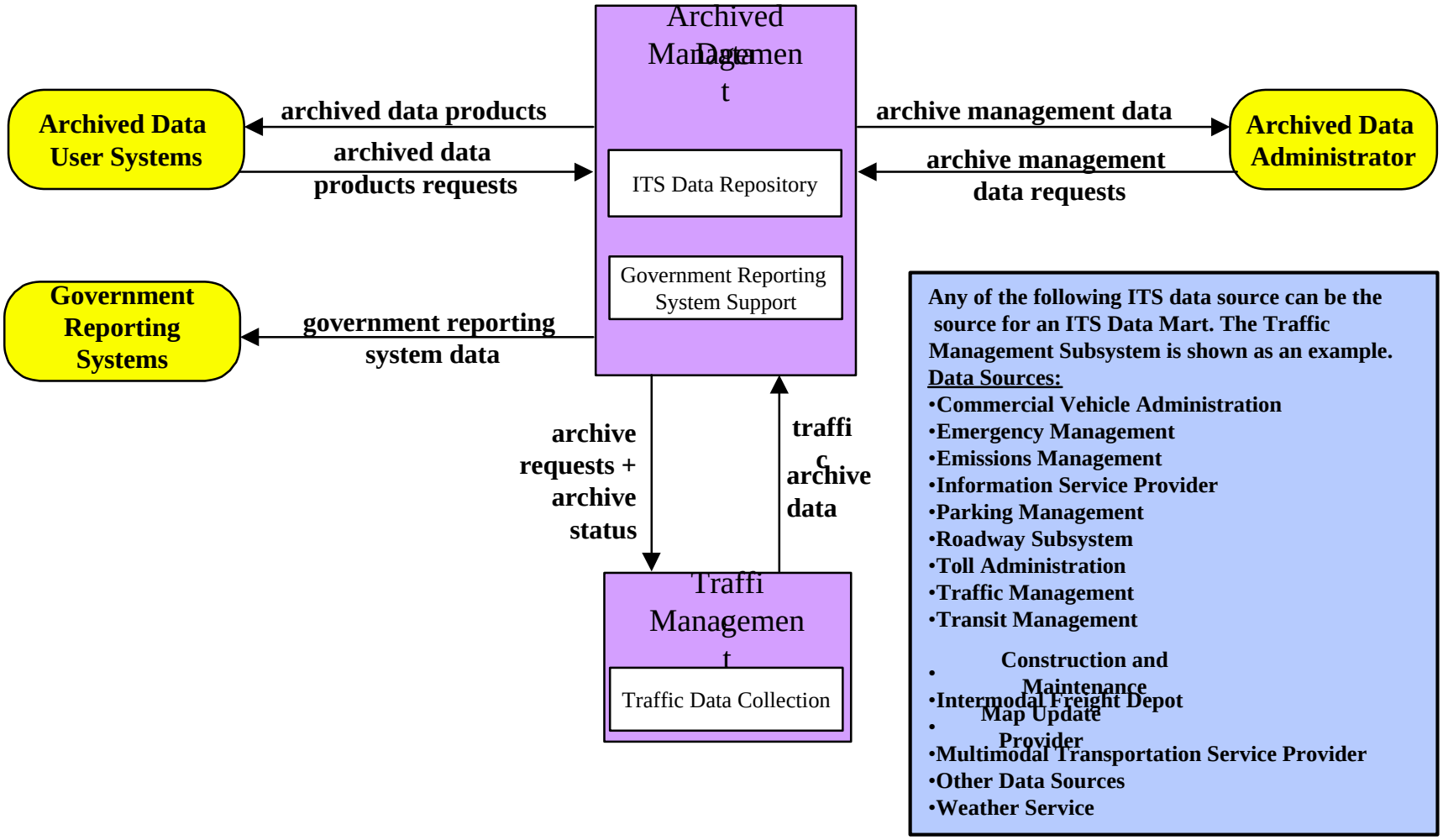
Town of Farragut

Vanderbilt University

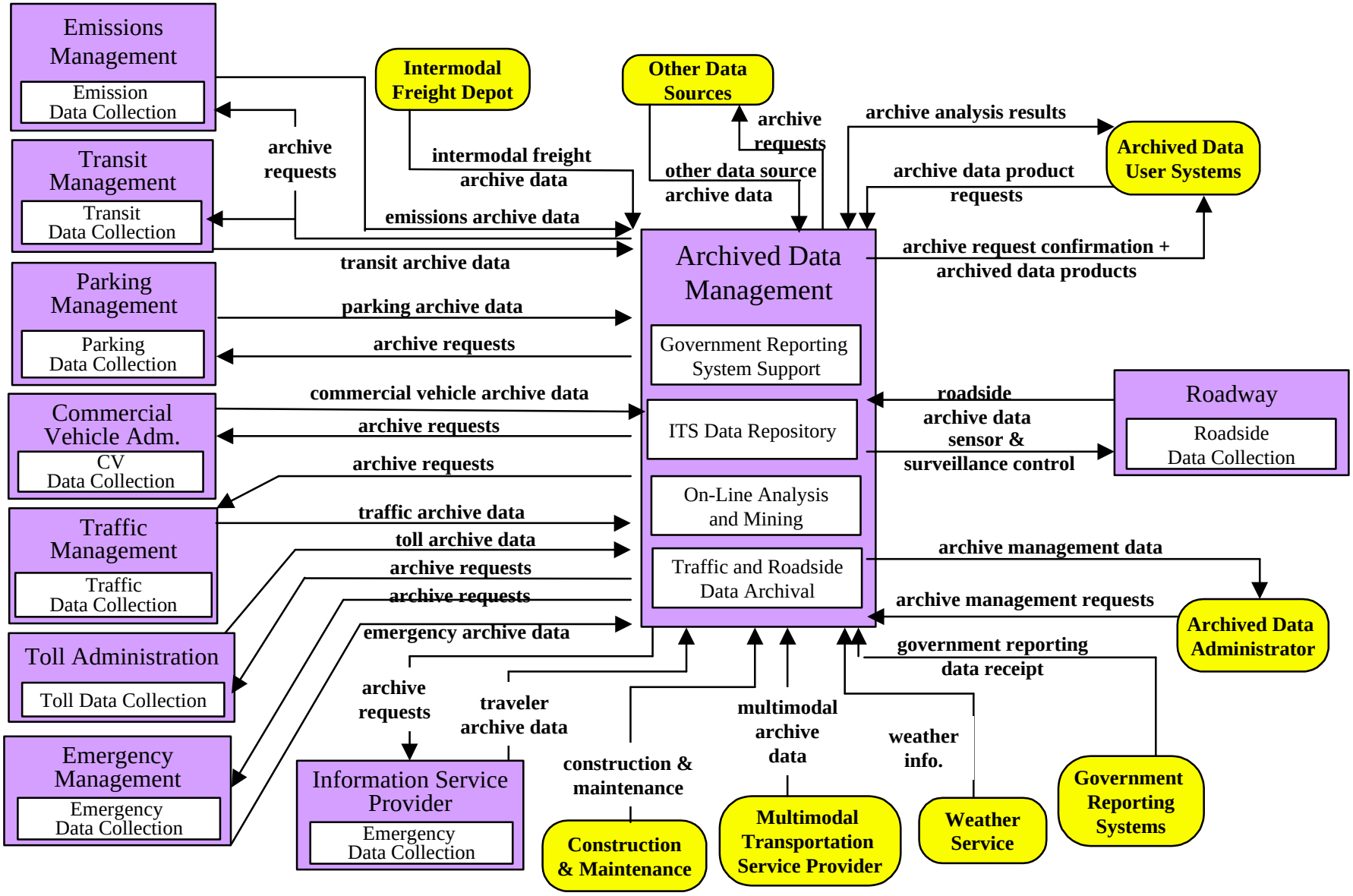
Knoxville Regional Architecture

Market Packages

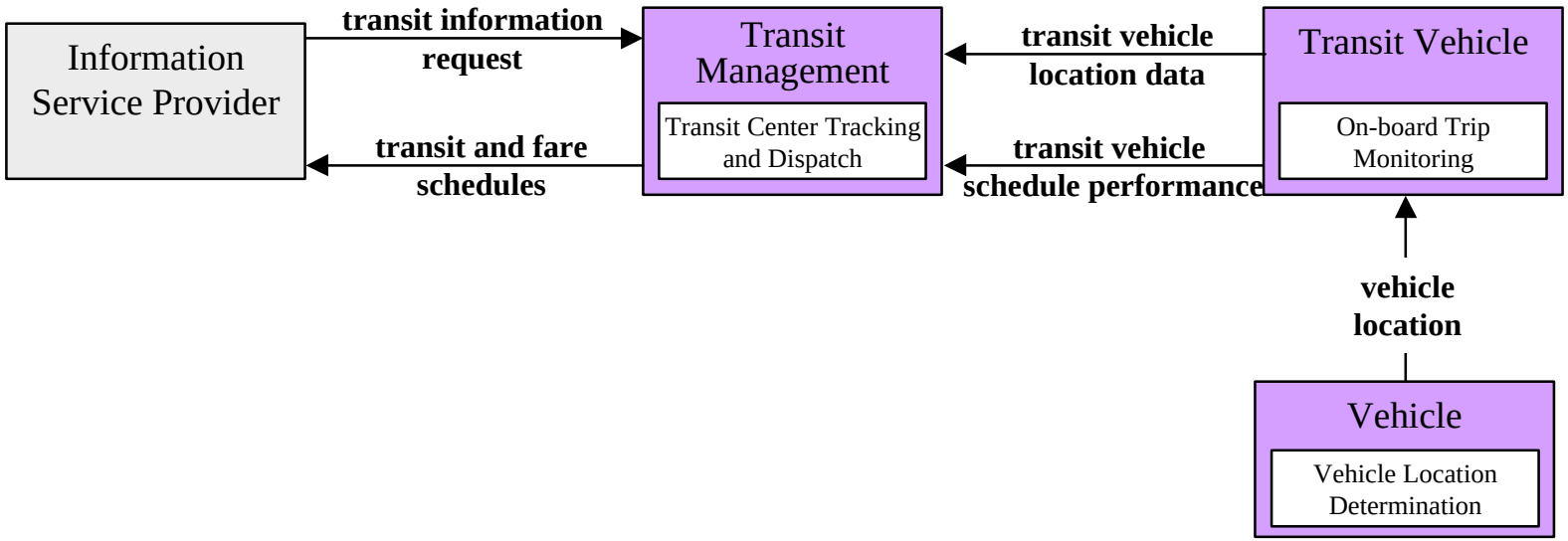
AD1 - ITS Data Mart



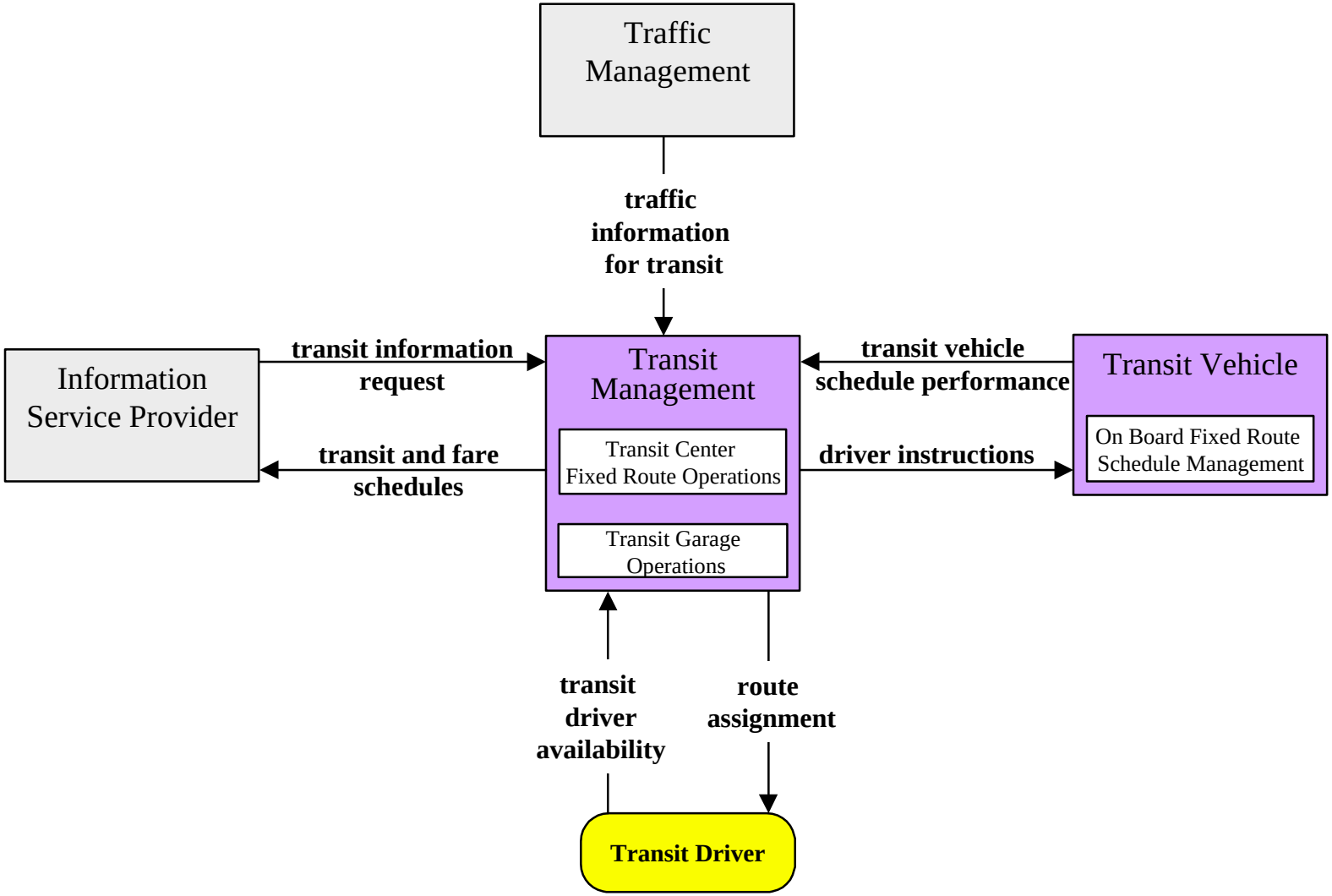
AD2 - ITS Data Warehouse



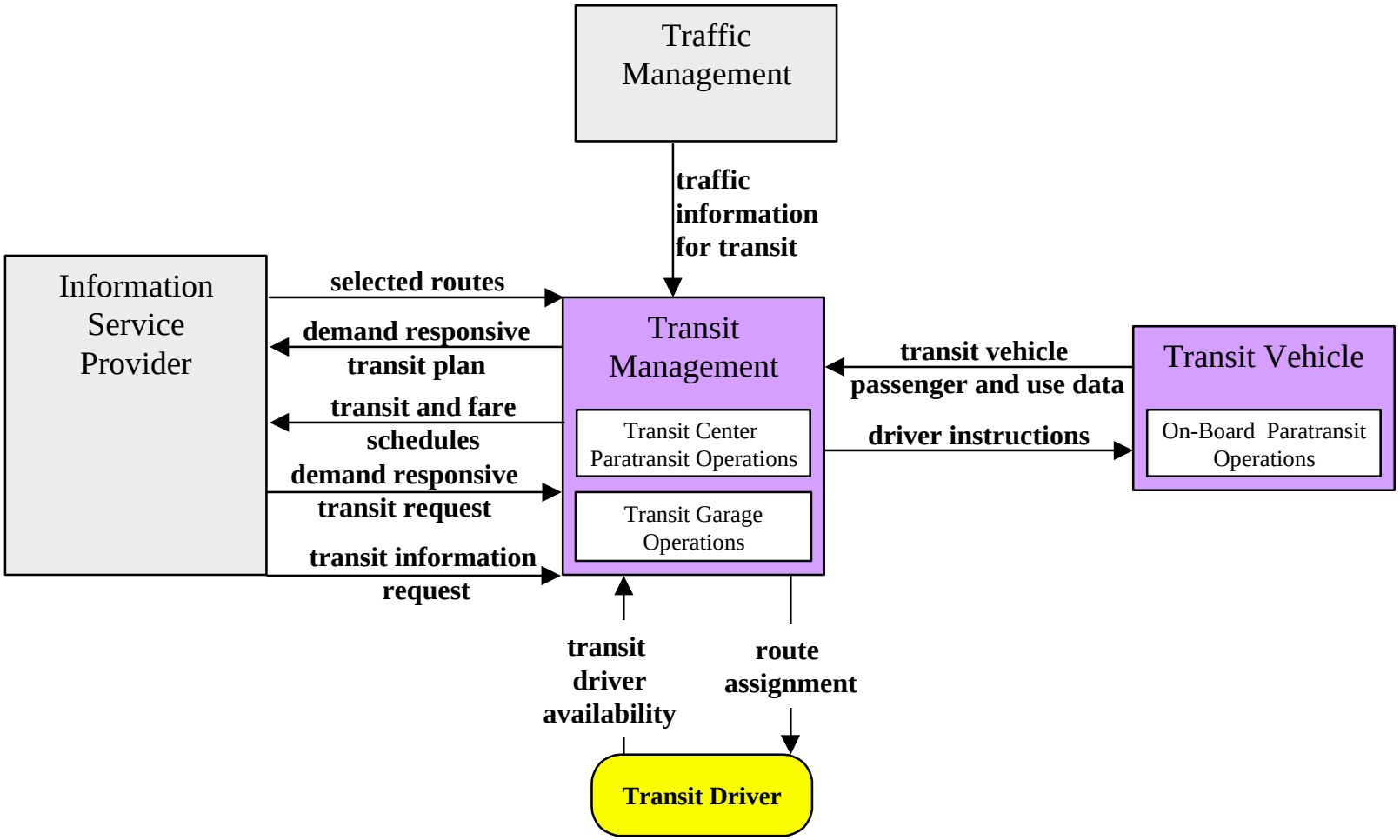
APTS1 - Transit Vehicle Tracking



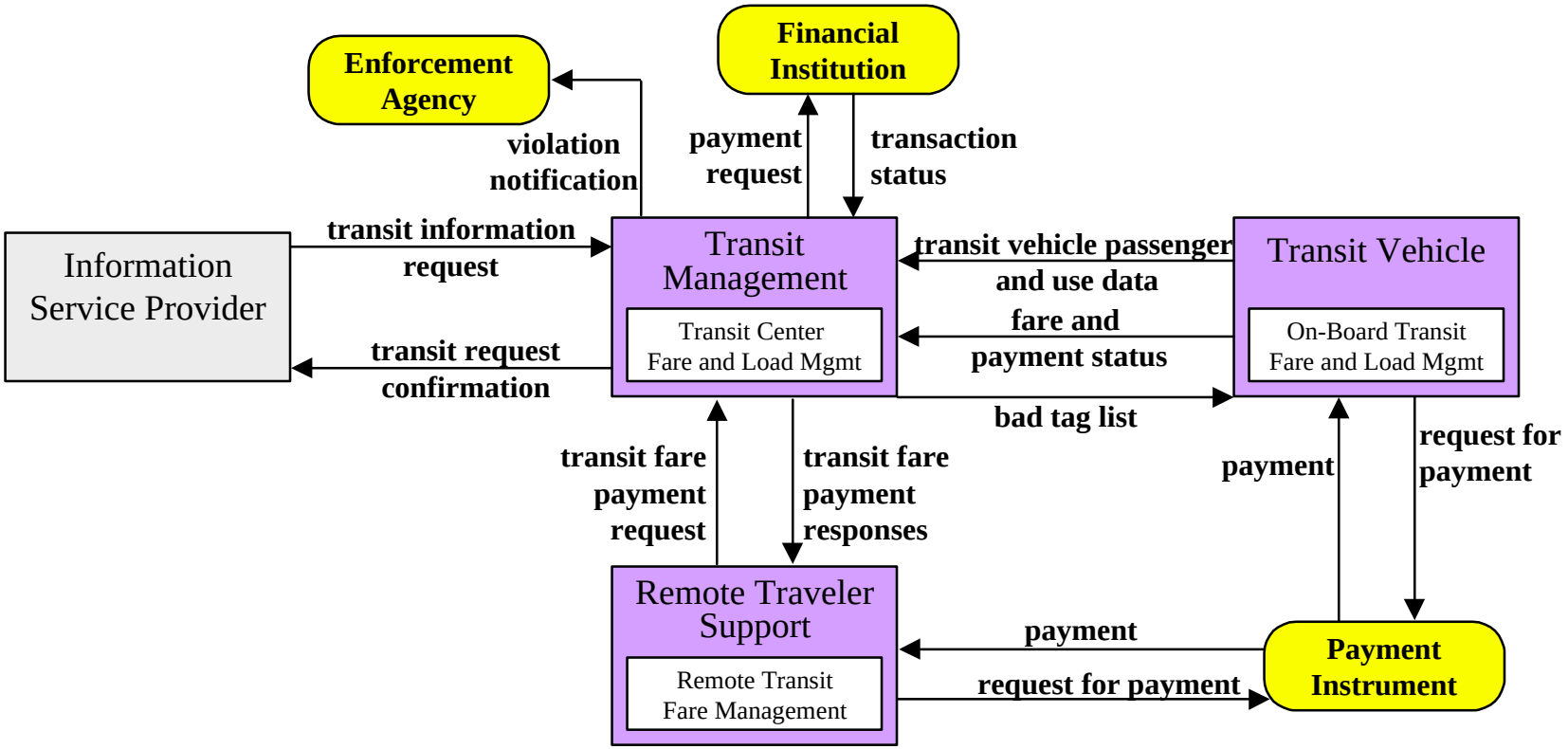
APTS2 - Transit Fixed-Route Operations



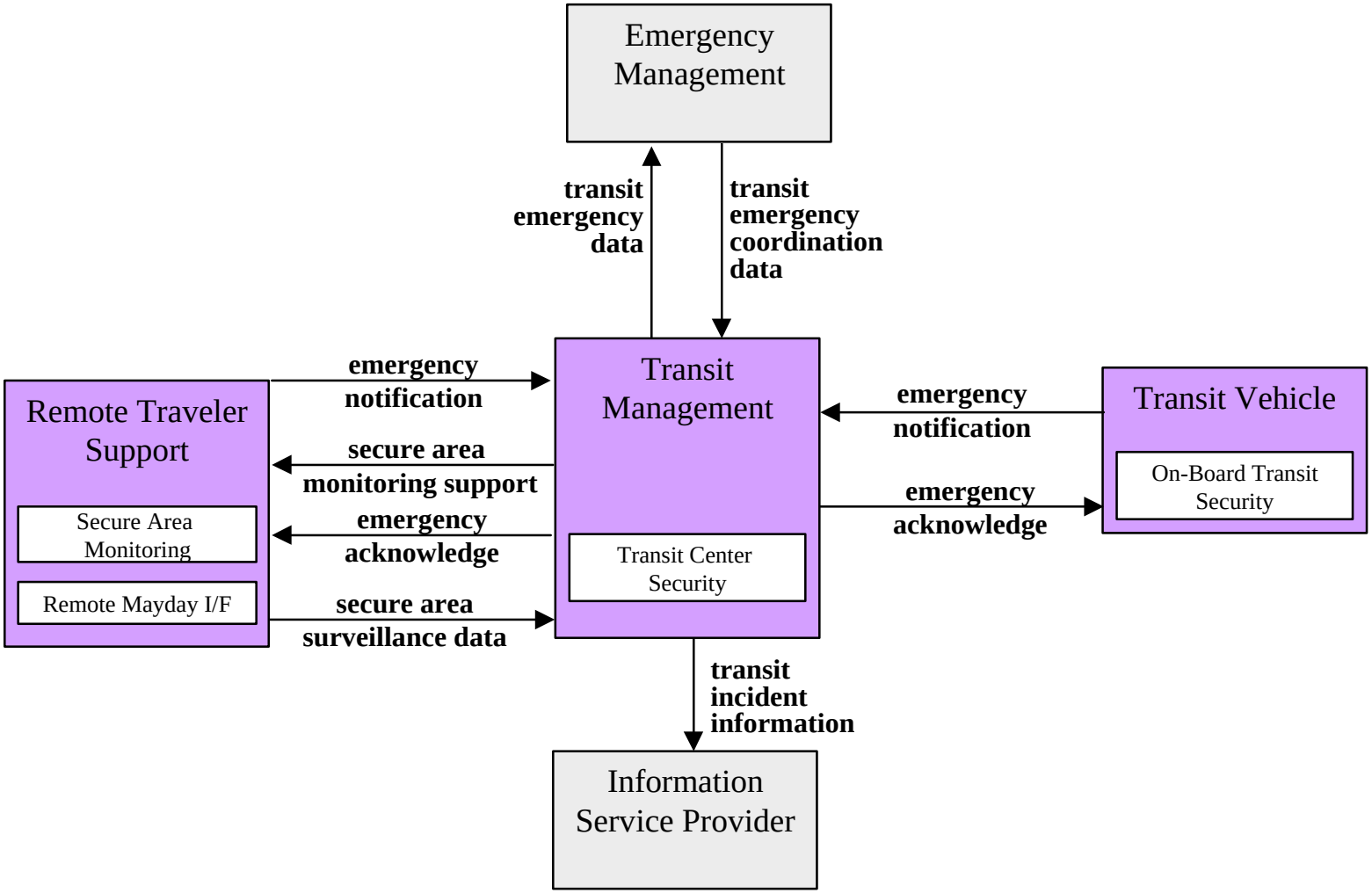
APTS3 - Demand Response Transit Operations



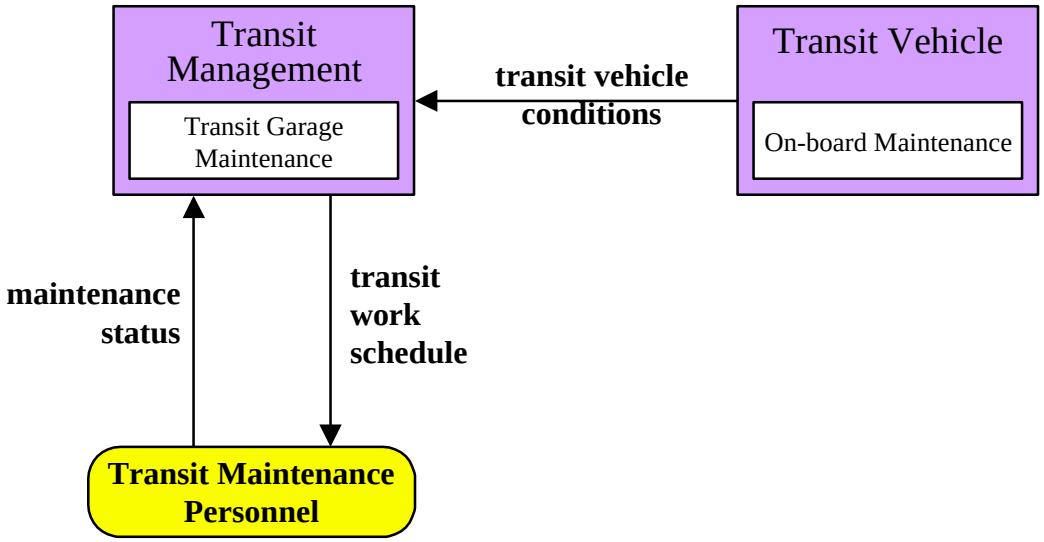
APTS4 Transit Passenger and Fare Management



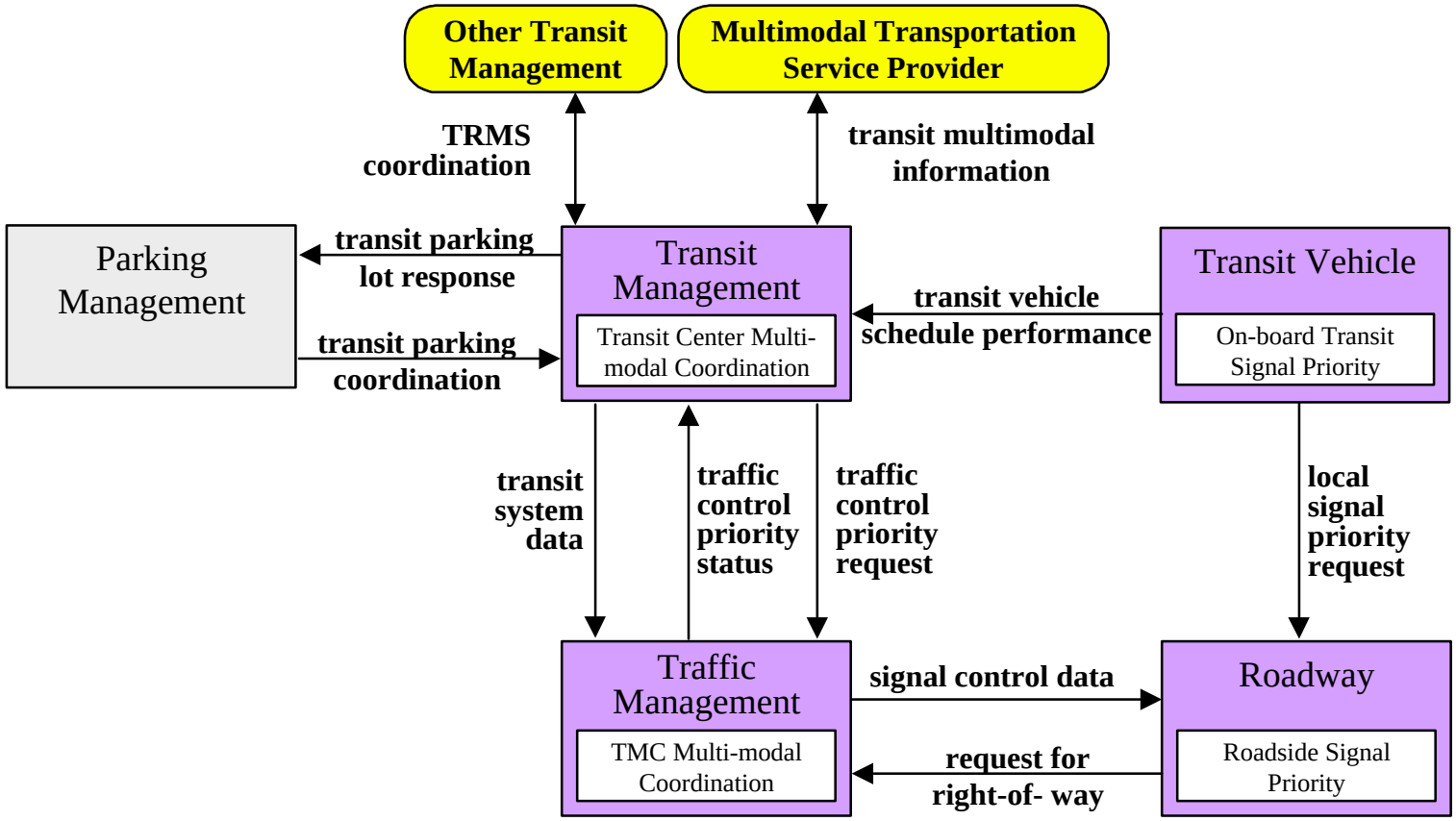
APTS5 - Transit Security



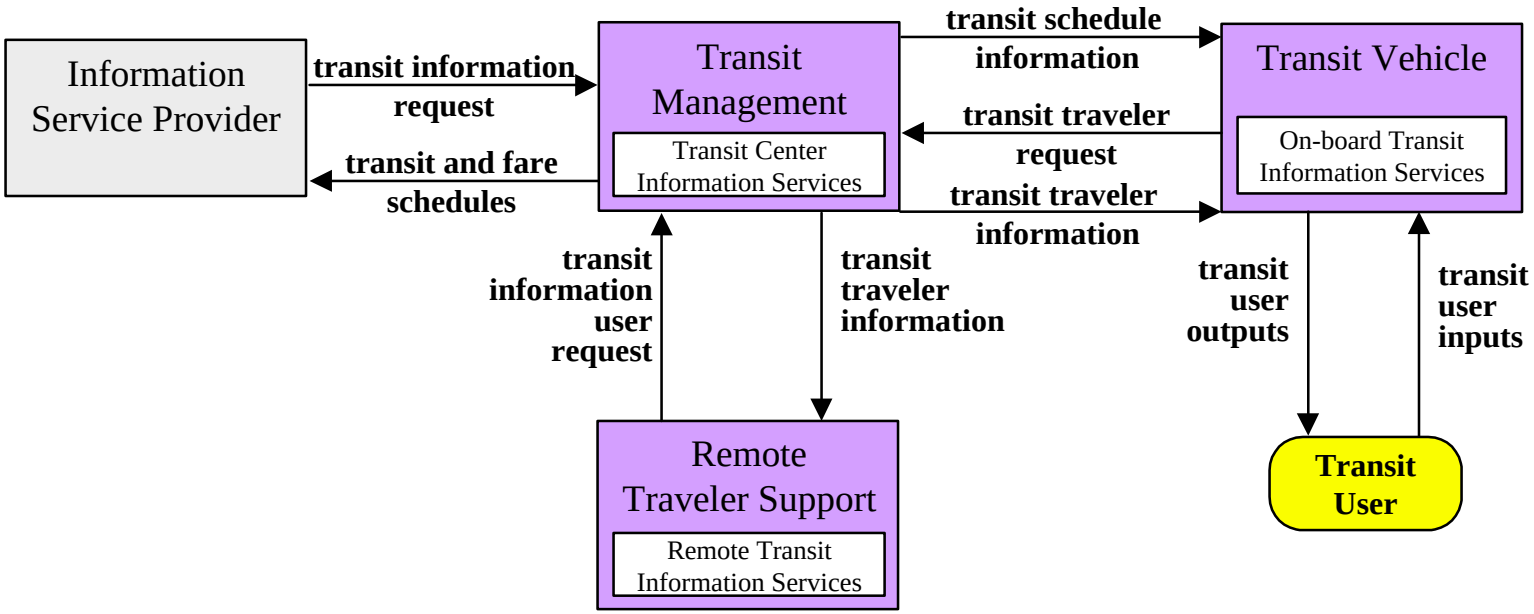
APTS6 - Transit Maintenance



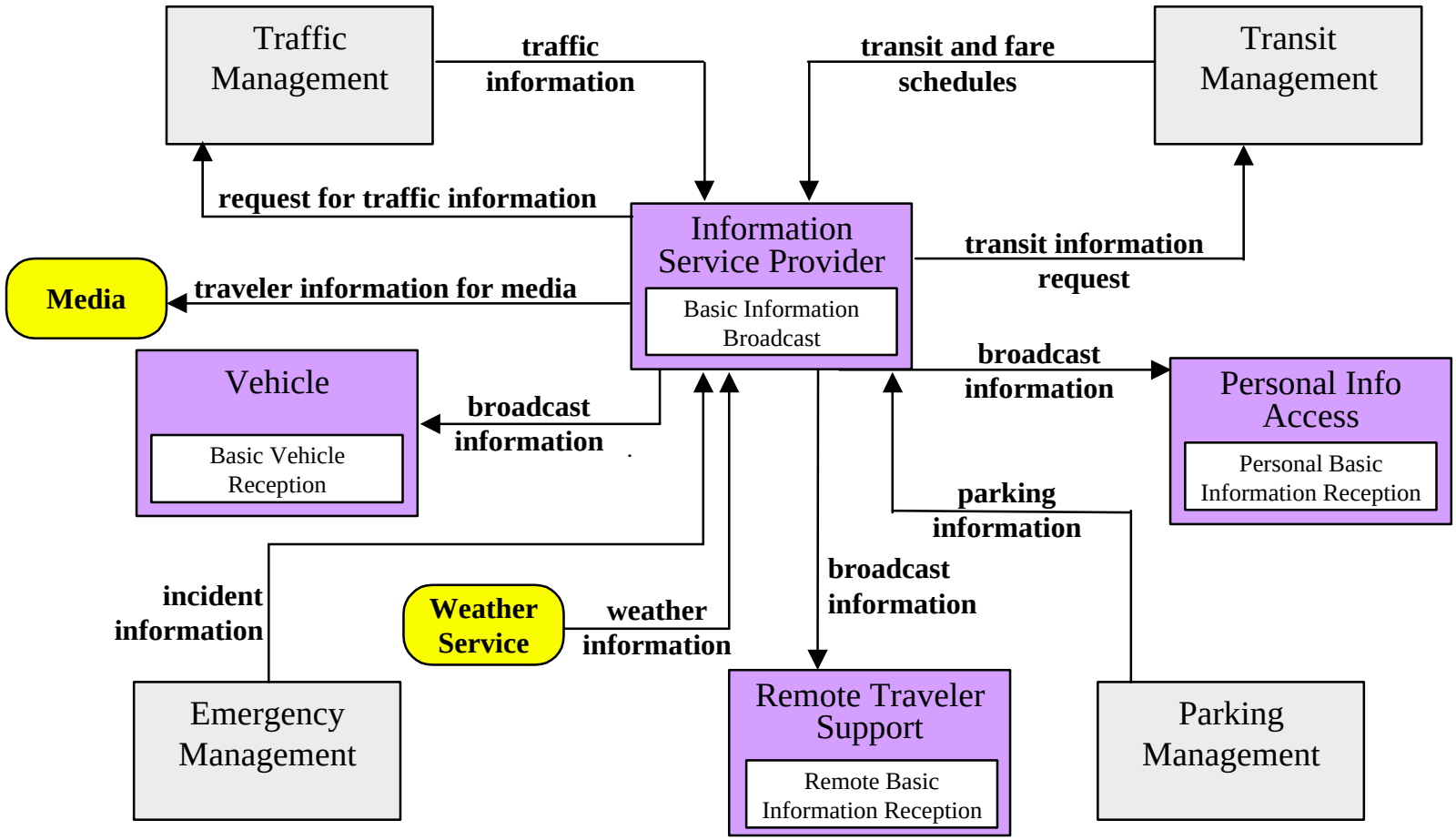
APTS7 - Multi-Modal Coordination



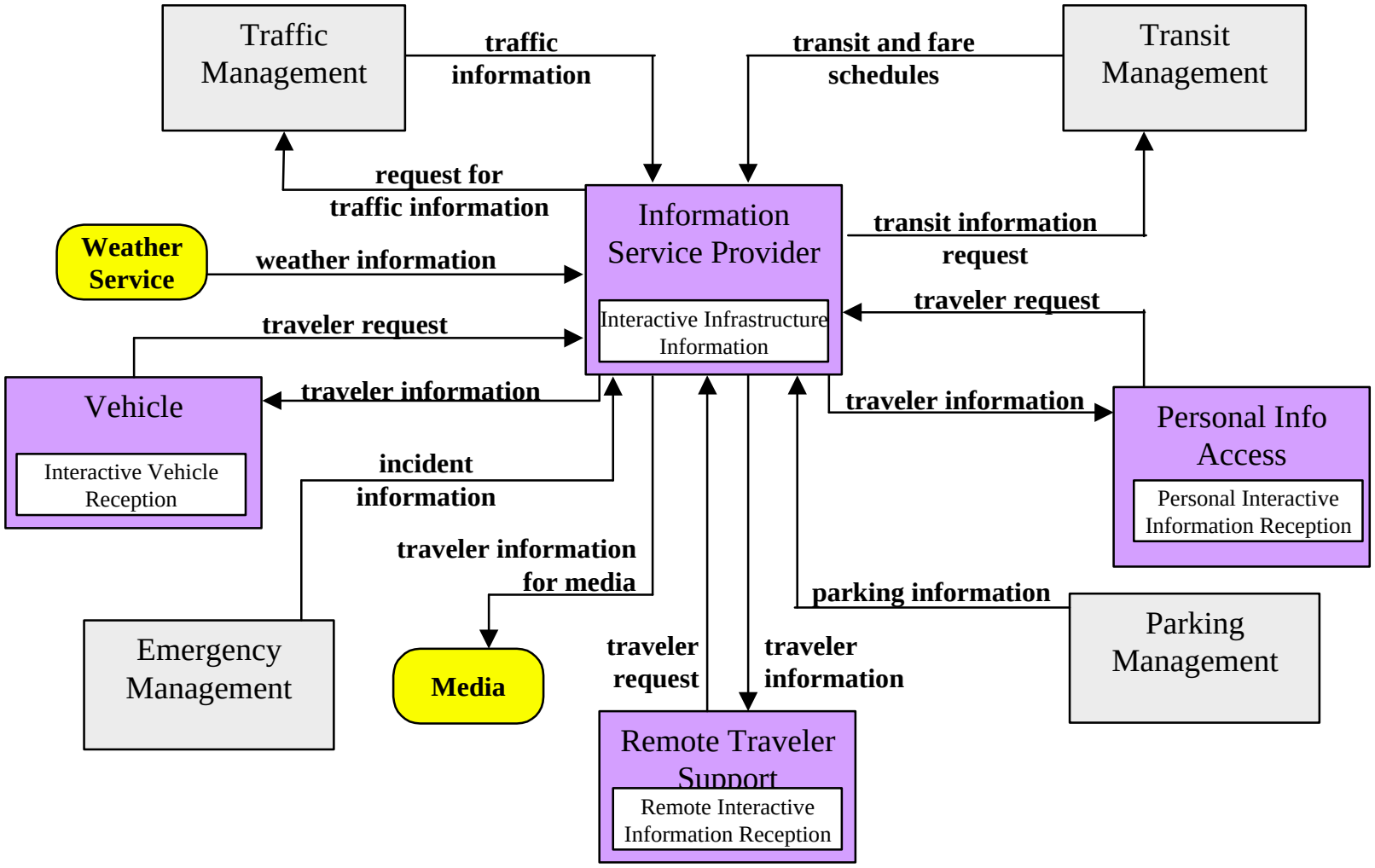
APTS8 - Transit Traveler Information



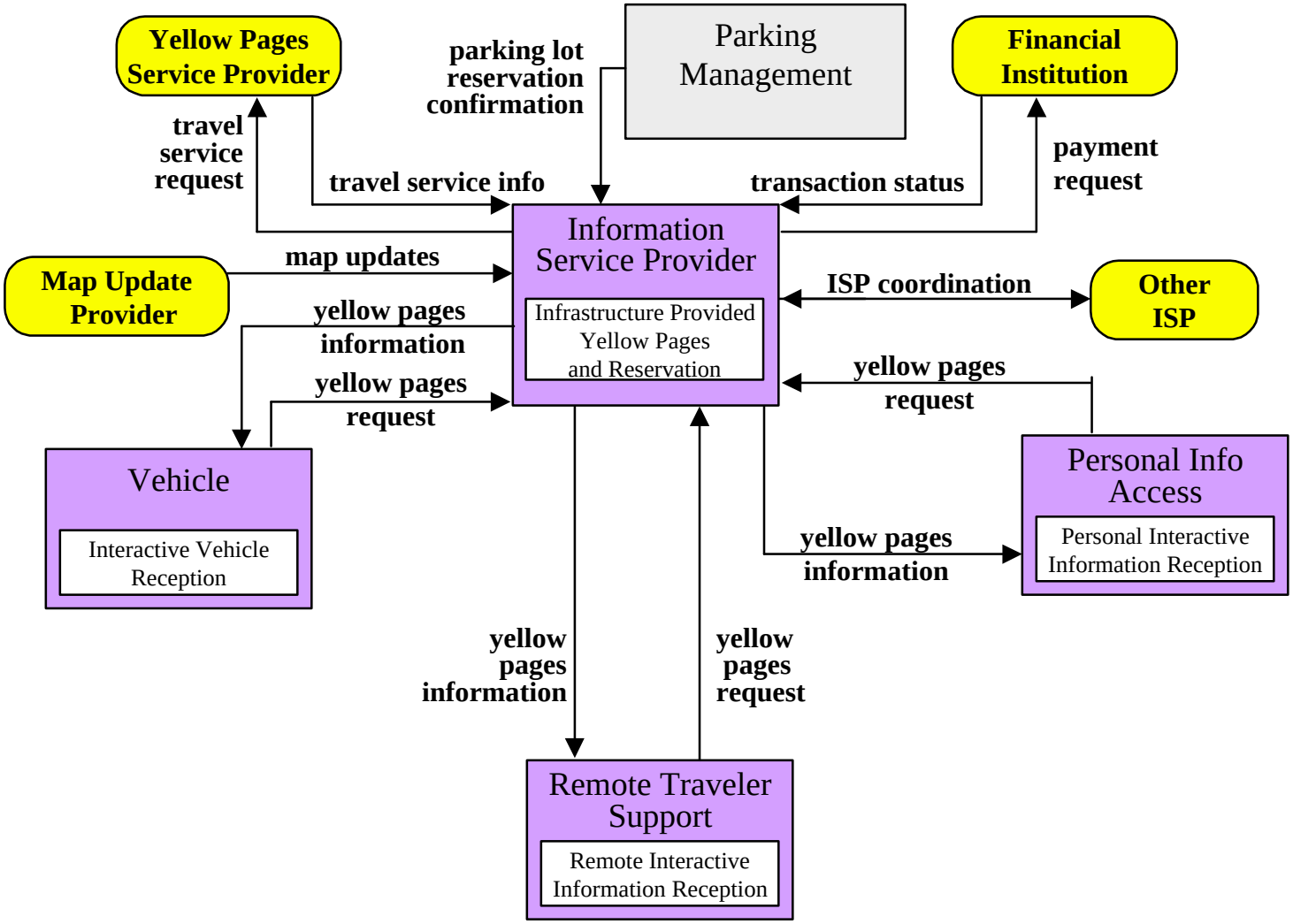
ATIS1 - Broadcast Traveler Information



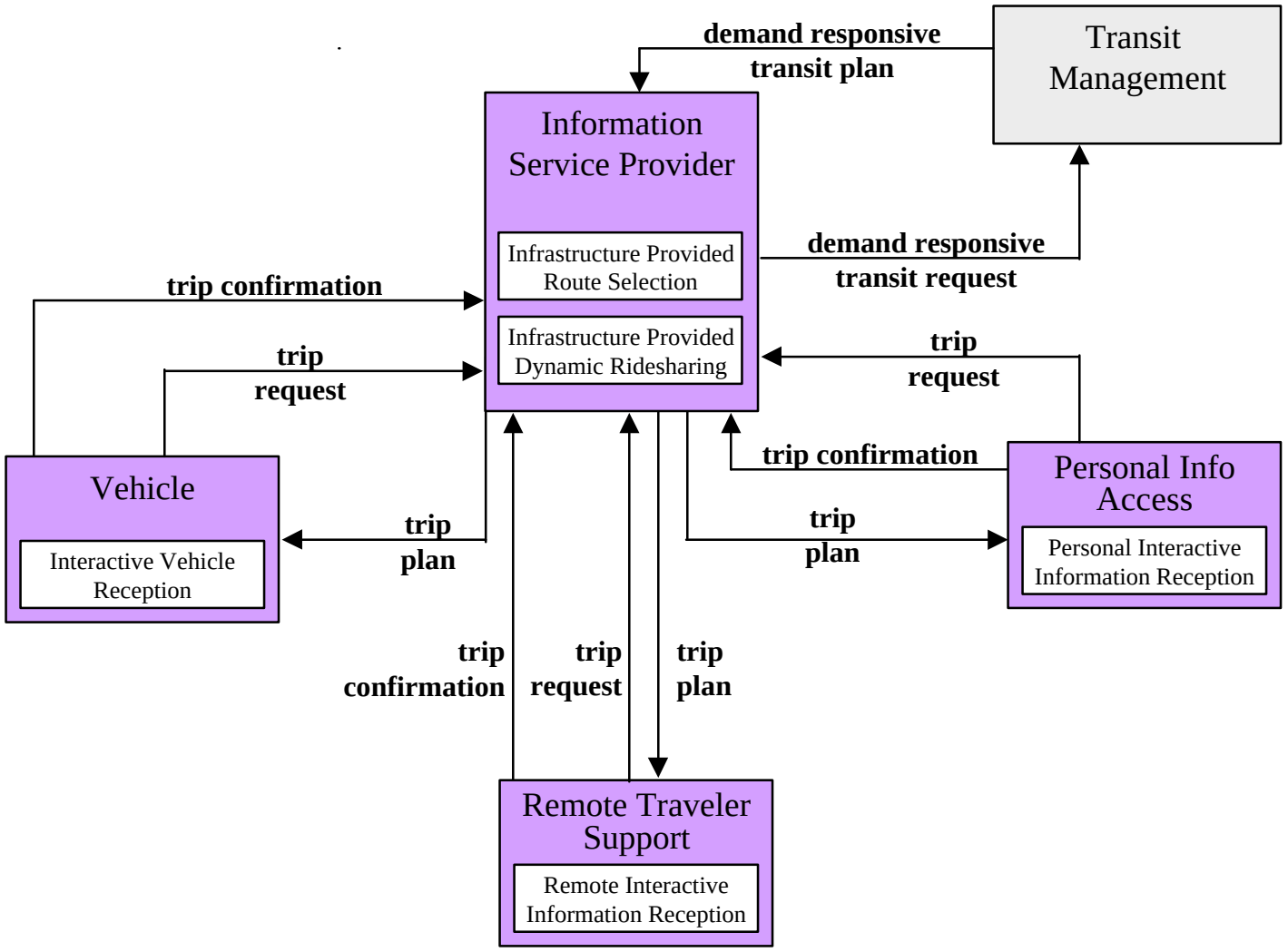
ATIS2 - Interactive Traveler Information



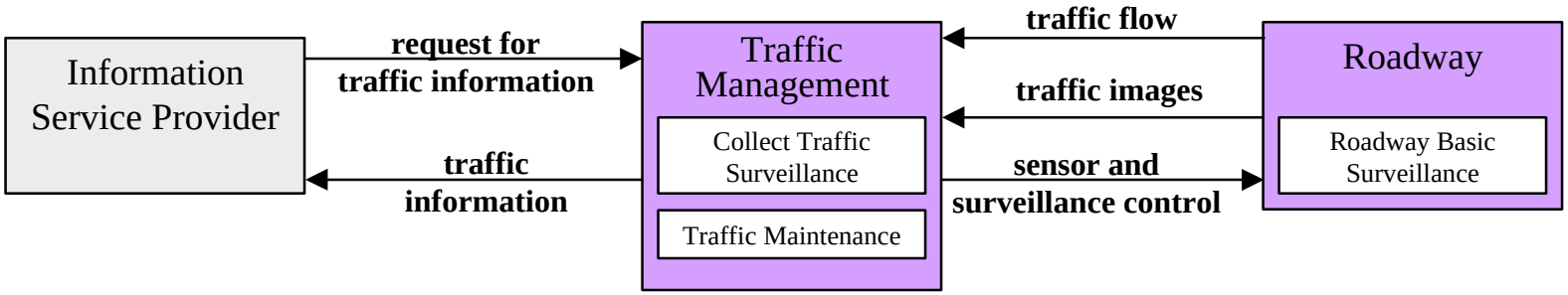
ATIS7 - Yellow Pages and Reservation



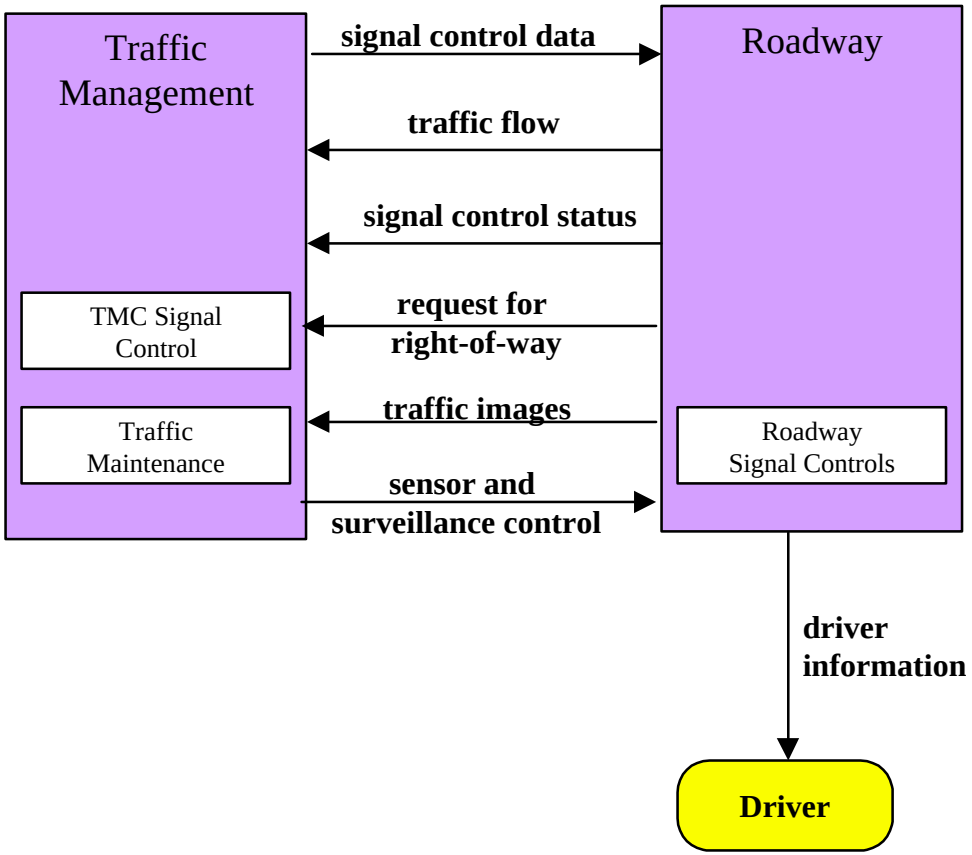
ATIS8 - Dynamic Ridesharing



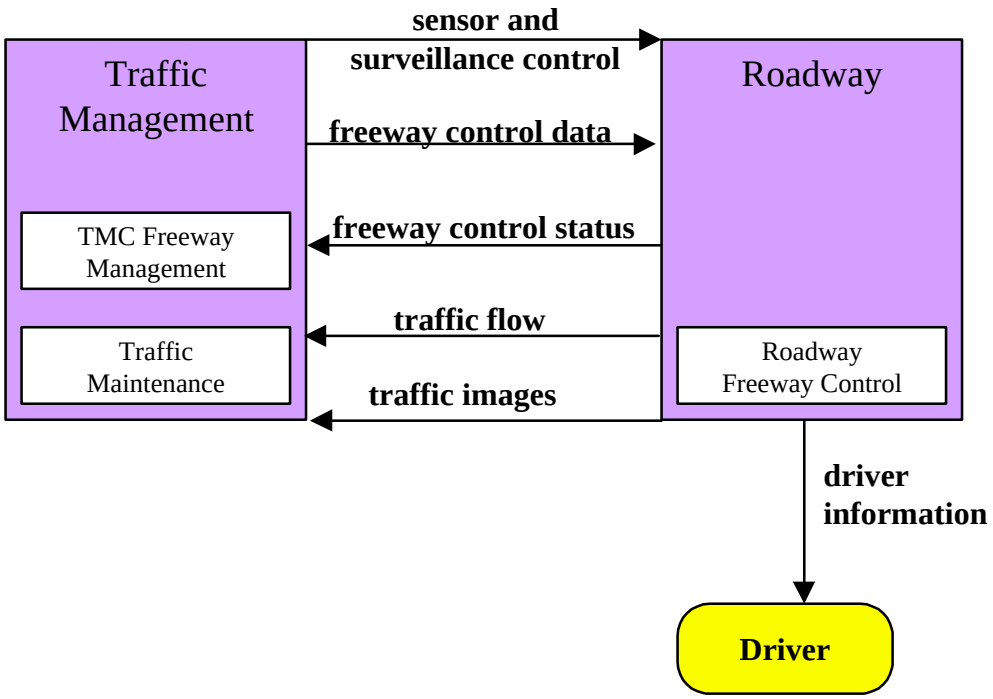
ATMS01 - Network Surveillance



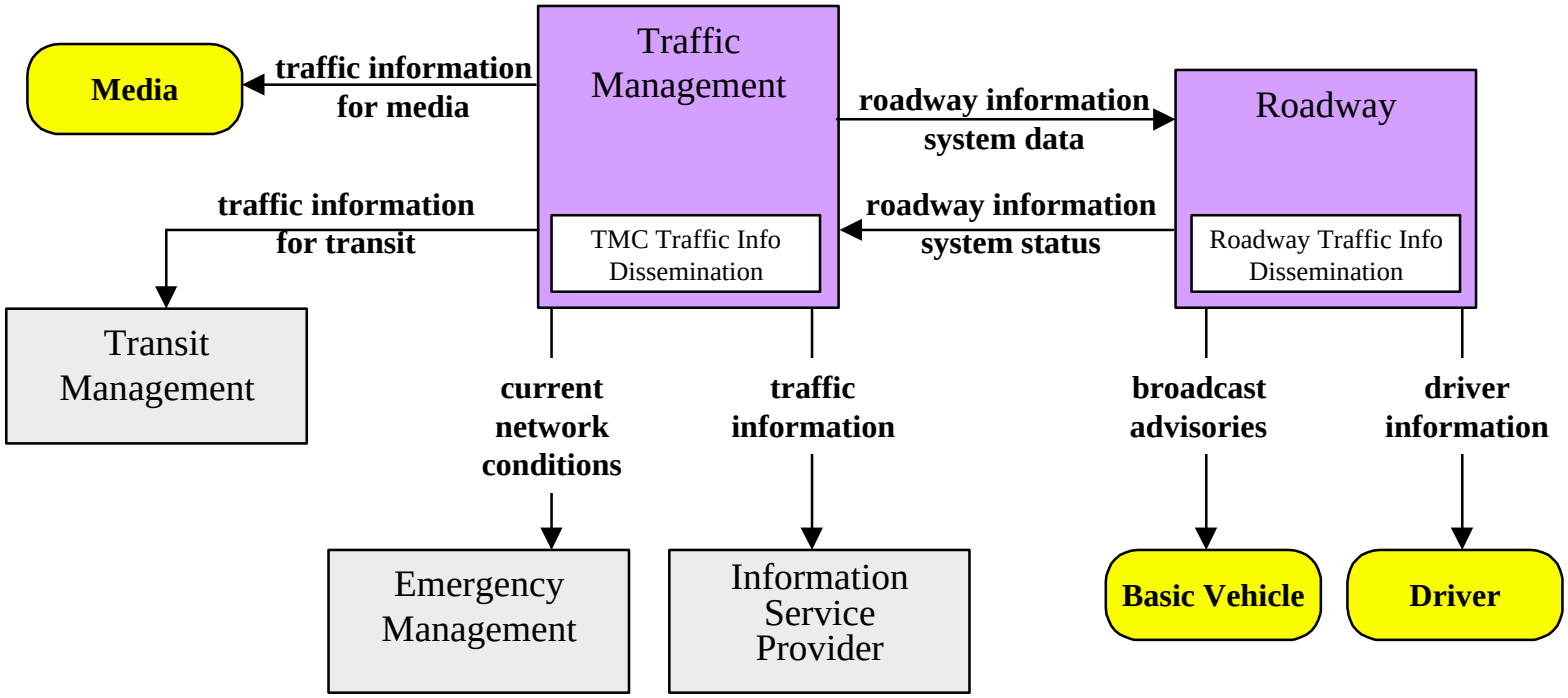
ATMS03 - Surface Street Control



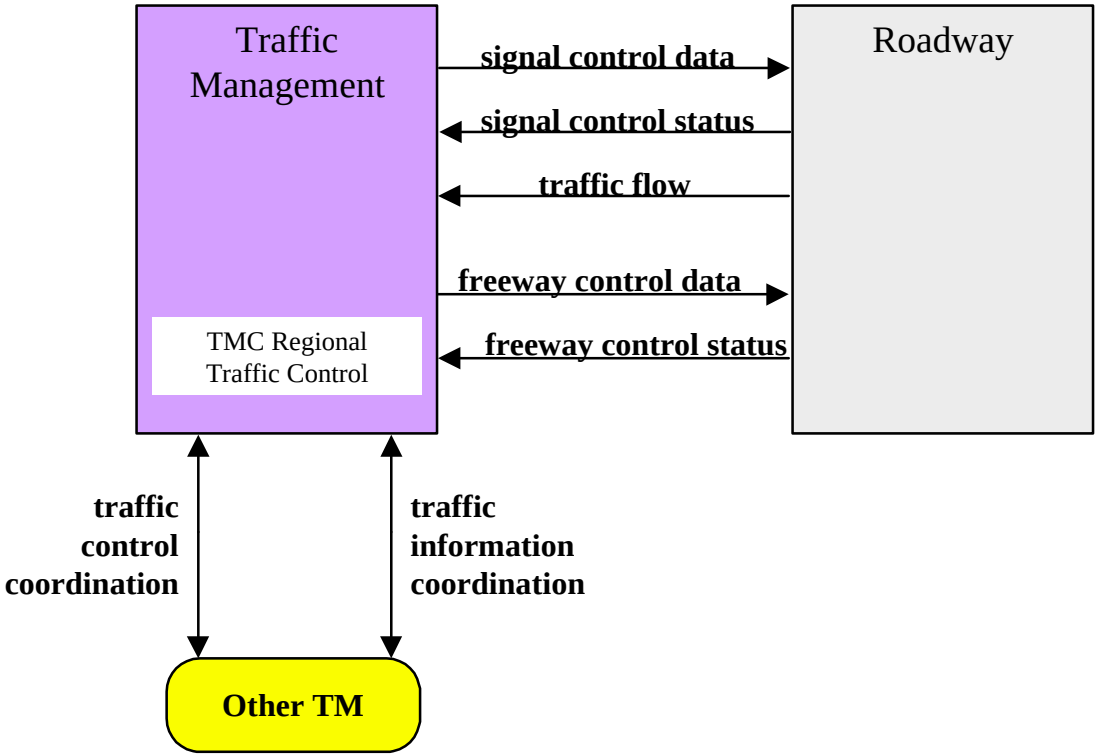
ATMS04 - Freeway Control



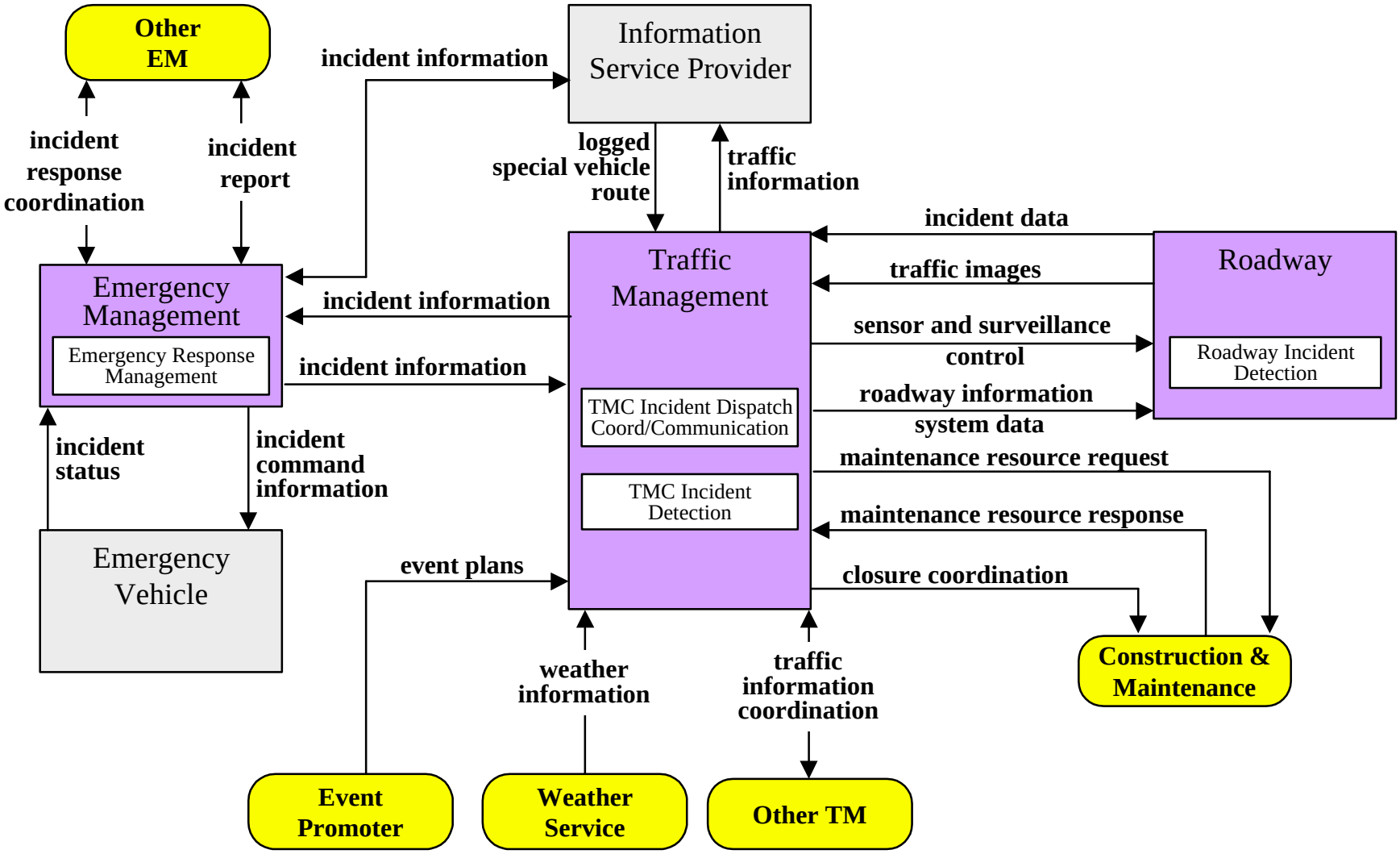
ATMS06 Traffic Information Dissemination



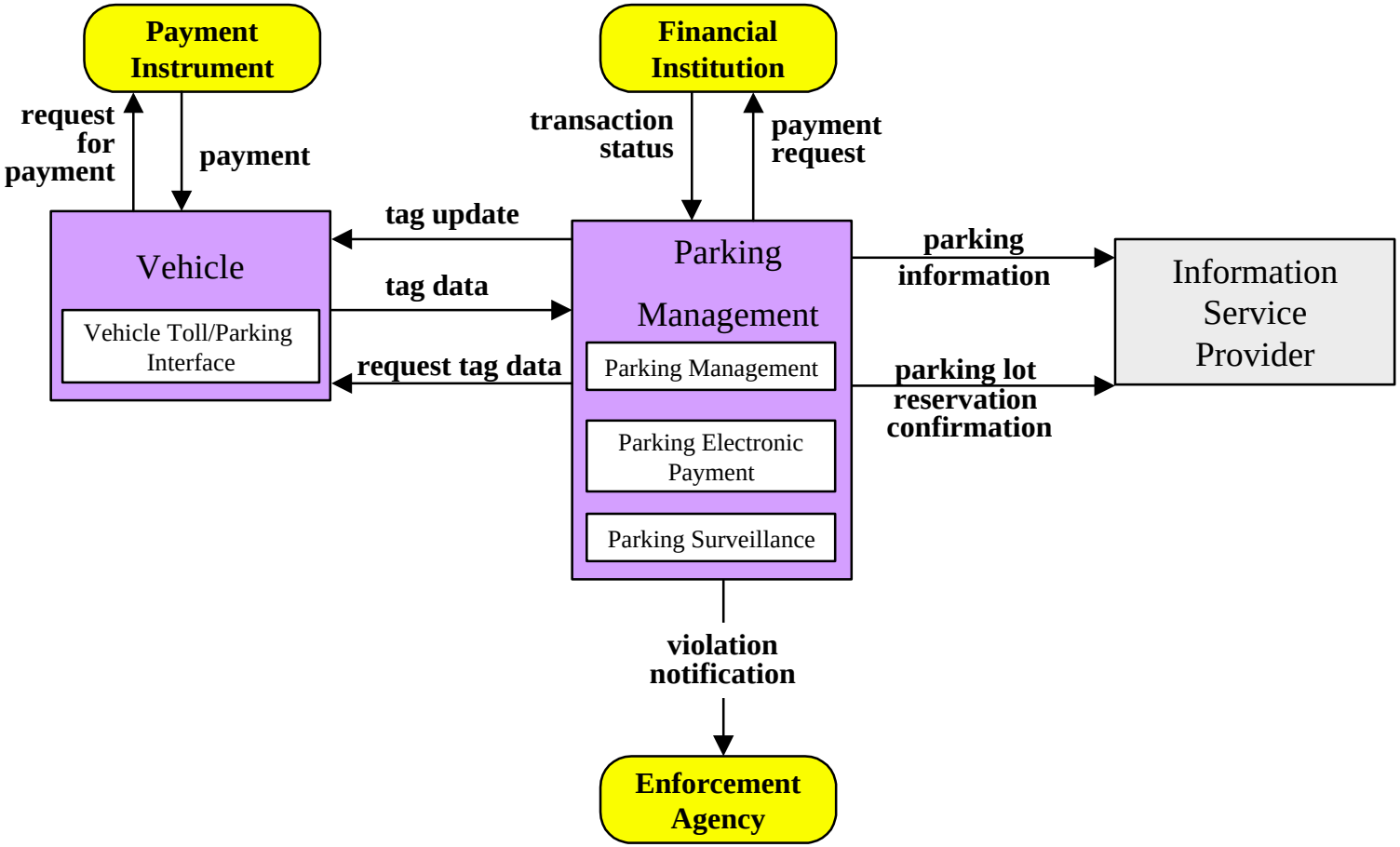
ATMS07 - Regional Traffic Control



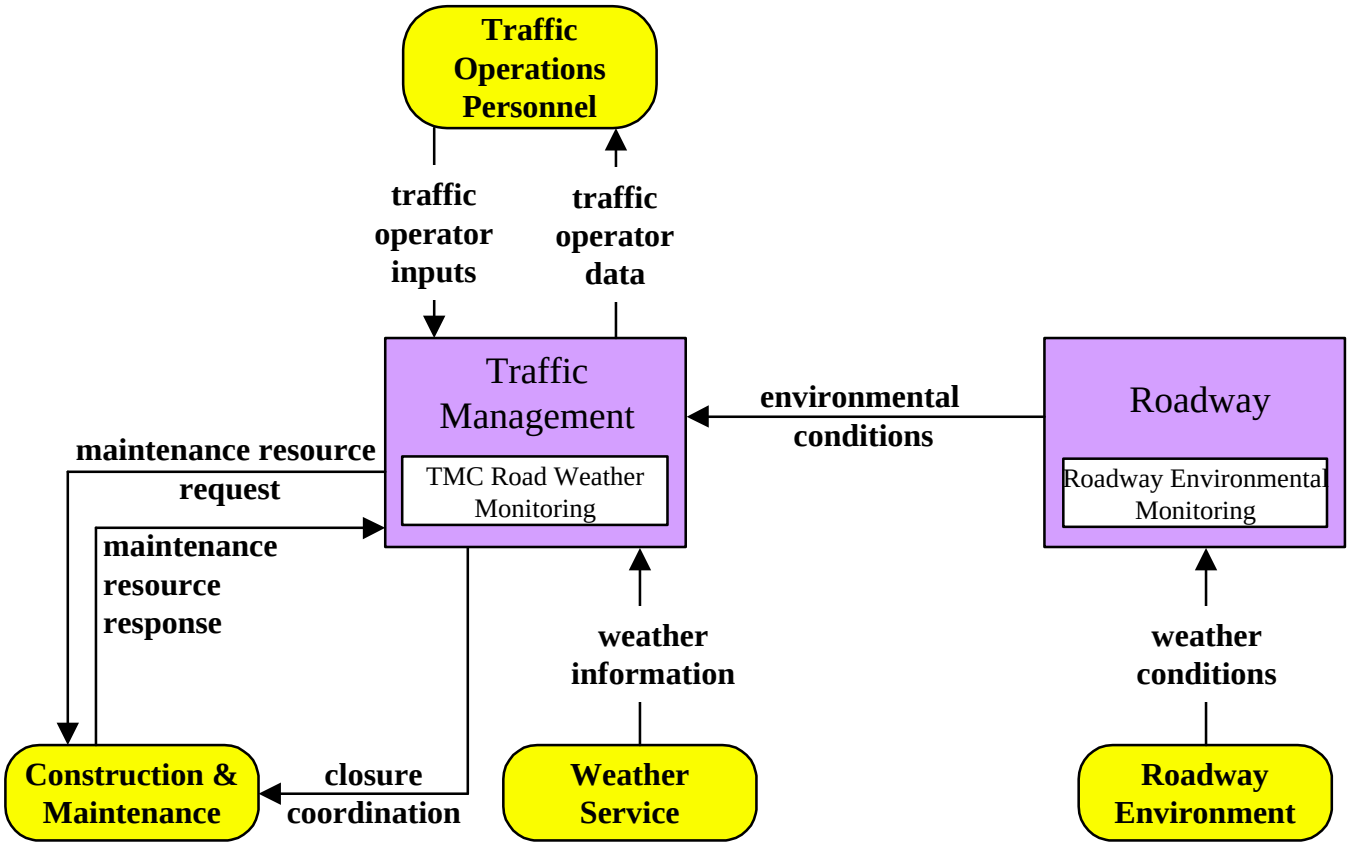
ATMS08 - Incident Management System



ATMS16 - Parking Facility Management



ATMS18 - Road Weather Information System



ATMS19 - Regional Parking Management