COLORADO DEPARTMENT OF TRANSPORTATION

COLORADO DEPARTMENT OF TRANSPORTATION – REGION 2 INTELLIGENT TRANSPORTATION SYSTEMS ARCHITECTURE

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1. INTRODUCTION

1.1 Overview

The Colorado Department of Transportation (CDOT) has recognized the importance of deploying intelligent transportation systems (ITS) to improve the productivity of the transportation system and to provide services that enhance the mobility and safety of Colorado's traveling public.[1] CDOT is deploying ITS related projects throughout the state as part of an integrated whole. Statewide projects include the enhancement of the Colorado Transportation Management System (CTMS) to provide statewide traveler information services and the installation of a high-speed fiber optic communication network along I-25 and I-70 under the shared resources wire line project. Both of these ITS initiatives have implications for ITS deployment in CDOT Region 2 which covers the southeast corner of Colorado. Two significant projects in CDOT Region 2 are the deployment of the Pueblo freeway management system and the center-to-center link between the Colorado Transportation Management Center (CTMC) in Lakewood and the Traffic Operations Center operated by the City of Colorado Springs. This document addresses how these existing, planned, and potential ITS project in CDOT Region 2 will be incorporated into integrated ITS deployment.

The defining resource for providing guidance to state and local jurisdictions for ITS projects is the National ITS Architecture. This resource was developed for the U.S. Department of Transportation (US DOT) to serve as a common framework for planning, defining, and integrating intelligent transportation systems. Final Regulations issued by the U.S. Department of Transportation[2] require the development of Regional ITS Architecture to serve as a regional framework for ensuring institutional agreement and technical integration for the implementation of ITS projects. All projects that use federal highway trust funds are subject to this requirement. The Regional ITS Architecture and individual ITS projects must conform to the National ITS Architecture. First, this report documents the project level ITS Architecture for the rural Pueblo FMS and the CTMC to Colorado Springs TOC interface. Building on these projects, stakeholder involvement and other statewide ITS initiatives, CDOT Region 2 Regional ITS Architecture was developed. The Region 2 ITS Architecture provides a framework the planned projects and provides guidance for deploying future ITS project in the region.

1.2 Process for Development of the Region 2 ITS Architecture

The process employed for the development of the CDOT Region 2 ITS Architecture is depicted in Figure 1-1. The effort builds upon an inventory of existing and planned ITS deployments in the region (upper left hand corner of Figure 1-1). These projects provide a baseline for future deployments and identify ITS activities that should be accommodated by the Region 2 ITS Architecture. Statewide project are also incorporated into the process. Relevant statewide ITS initiatives are described in the Section 2 of this report.

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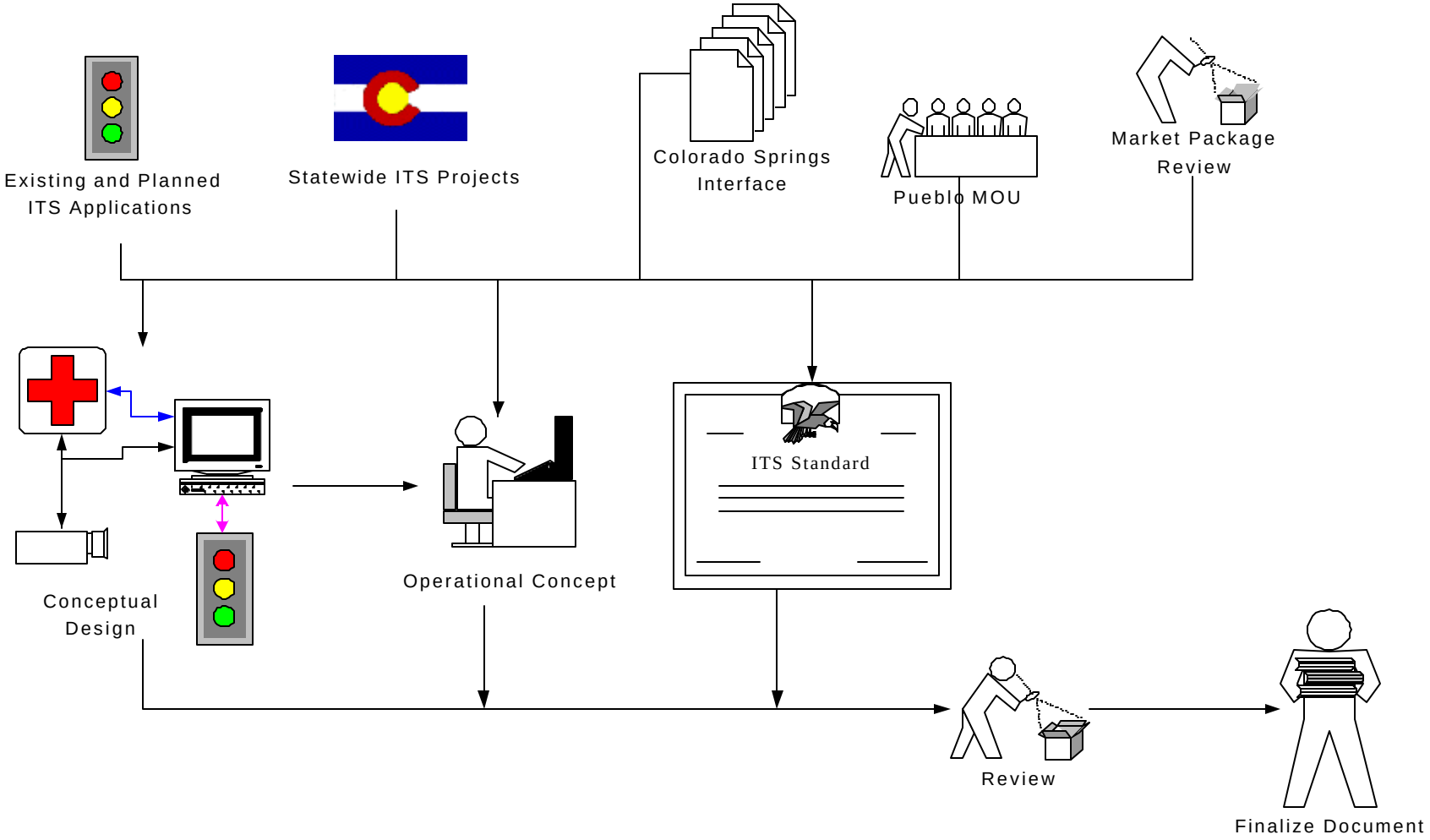
[1] Colorado Department of Transportation, Intelligent Transportation Systems Strategic Business Plan - Executive Summary, March 2001

[2] January 8, 2001, U.S. Department of Transportation, Federal Highway Administration, 23 CFR Part 940, FHWA Docket No. FHWA-99-5899 (http://www.its.dot.gov/aconform/archrule_final_1.htm)

Figure 1-1: CDOT REGION 2 ITS DOCUMENTATION PROCESS



The City of Colorado Springs, in cooperation with CDOT, has deployed an advanced traffic management system (ATMS) on both the local arterial and freeway network. The City and CDOT have been actively engaged in an effort to electronically link the Colorado Springs ATMS and the CTMC in Lakewood. A project level ITS Architecture has been developed. The Region 2 ITS Architecture development process also captures this extensive investment.

The state and local transportation and emergency management organizations in the Pueblo area have been working together to develop a rural freeway management system (FMS) to monitor traffic conditions, detect incidents, provide traveler information and coordinated responses to incidents. The collaborative effort has resulted in a completed detailed design and a memorandum of understanding (MOU) and a project design for deployment. This significant ITS application is also included in the development of the Region 2 ITS Architecture.

The Region 2 ITS Architecture was developed to capture these existing and planned efforts and provide guidance for the integration of these ITS applications. The process also analyzed potential future ITS deployments through a stakeholder review and identification of ITS market packages that best fit the needs and requirements of the Region. In the National ITS Architecture, 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.[3] The market packages also include a depiction relationship and data flow between different entities providing the "service" provided by the deployment of the market package.

Based on this set of inputs, three parallel tasks were undertaken:

- **Develop Operation Concept**: The Operational Concept defines the institutional relationships among the organizations in the region required for the deployment and operation of a regional integrated transportation management and information system. The operational concept establishes the roles and responsibilities between organizations including responsibilities for operation and maintenance and the level of information, status, and control sharing among the entities.
- **Develop Conceptual Design**: The Conceptual Design provides high-level guidance in the definition of system functional requirements, interface requirements, and information exchanges.
- **Develop Standards**: Standards and common equipment that is required for interoperability and integration were identified.

Together the results of these analyses were used to develop the Region 2 ITS Architecture documented in this report.

[3] US DOT, National ITS Architecture, Version 3.04

1.3 Organization of the Report

Following the introduction, the report is divided into four sections as follows:

1. **Section 2 – Background**: This section provides information on the context of ITS Architecture development and ITS projects impacting Region 2.
2. **Section 3 – Pueblo Freeway Management System**: This section documents the project level ITS Architecture for this specific project.
3. **Section 4 – Colorado Springs Center-to-Center Interface**: The center-to-center interface between the CDOT CTMC and the TOC at Colorado Springs is discussed in this section including the documentation of the project level ITS Architecture.
4. **Section 5 – Region 2 ITS Architecture**: This final section documents the Regional ITS Architecture for CDOT Region 2.

These last three sections provide the information required by the Federal Highway Administration (FHWA) for the documentation of Regional ITS Architectures.

2. BACKGROUND

This section provides background information on the National ITS Architecture, the final FHWA rulemaking regarding the development of Regional ITS Architectures and information of key ITS projects that impact CDOT Region 2 ITS deployments.

2.1 National ITS Architecture

The National ITS Architecture provides a common framework for planning, defining, and integrating intelligent transportation systems. It is a mature product that reflects the contributions of a broad cross-section of the ITS community (transportation practitioners, systems engineers, system developers, technology specialists, etc.) over a five-year period. The architecture defines:

- The functions (e.g., gather traffic information or request a route) that are required for ITS.
- The physical entities or subsystems where these functions reside (e.g., the roadside or the vehicle).
- The information flows that connect these functions and physical subsystems together into an integrated system.[4]

Although the architecture is not technology-specific, it is function-specific. The architecture is employed to structure the planning and design process along with the general functions of ITS systems. The architecture further defines these functions into two categories: physical, and logical.

2.1.1 Physical Architecture

The physical architecture provides a framework for the physical elements of ITS systems; these elements include cars, people, computers, buses, trucks, etc. Figure 2-1, National ITS Architecture Subsystems, provides an illustration of the physical architecture. The physical elements are broken into large groups called **subsystem categories**. These are functional categories that describe what their member physical entities (subsystems) do.

The four major subsystem categories are:

1. **Traveler Subsystems**: Systems or applications that provide information to travelers (e.g., traffic conditions).
2. **Center Subsystems**: Systems or applications that process and use information to control the transportation network (e.g., signal timing).
3. **Vehicle Subsystems**: Systems or applications that provide driver information and safety on vehicle platforms (e.g., in-vehicle signing).
4. **Roadside Subsystems**: Systems or applications that process and provide vehicle system data (e.g., traffic signals).

[4] US DOT, National ITS Architecture, Version 3.04

The bubbles (or sausages) between the subsystem categories represent the communications medium. For example, the Roadway subsystem (within the "Roadside" subsystem category) could potentially be communicating with the Vehicle, the Transit Vehicle, the Commercial Vehicle, and the Emergency Vehicle subsystems (within the "Vehicle" subsystem category) via short-range wireless links.

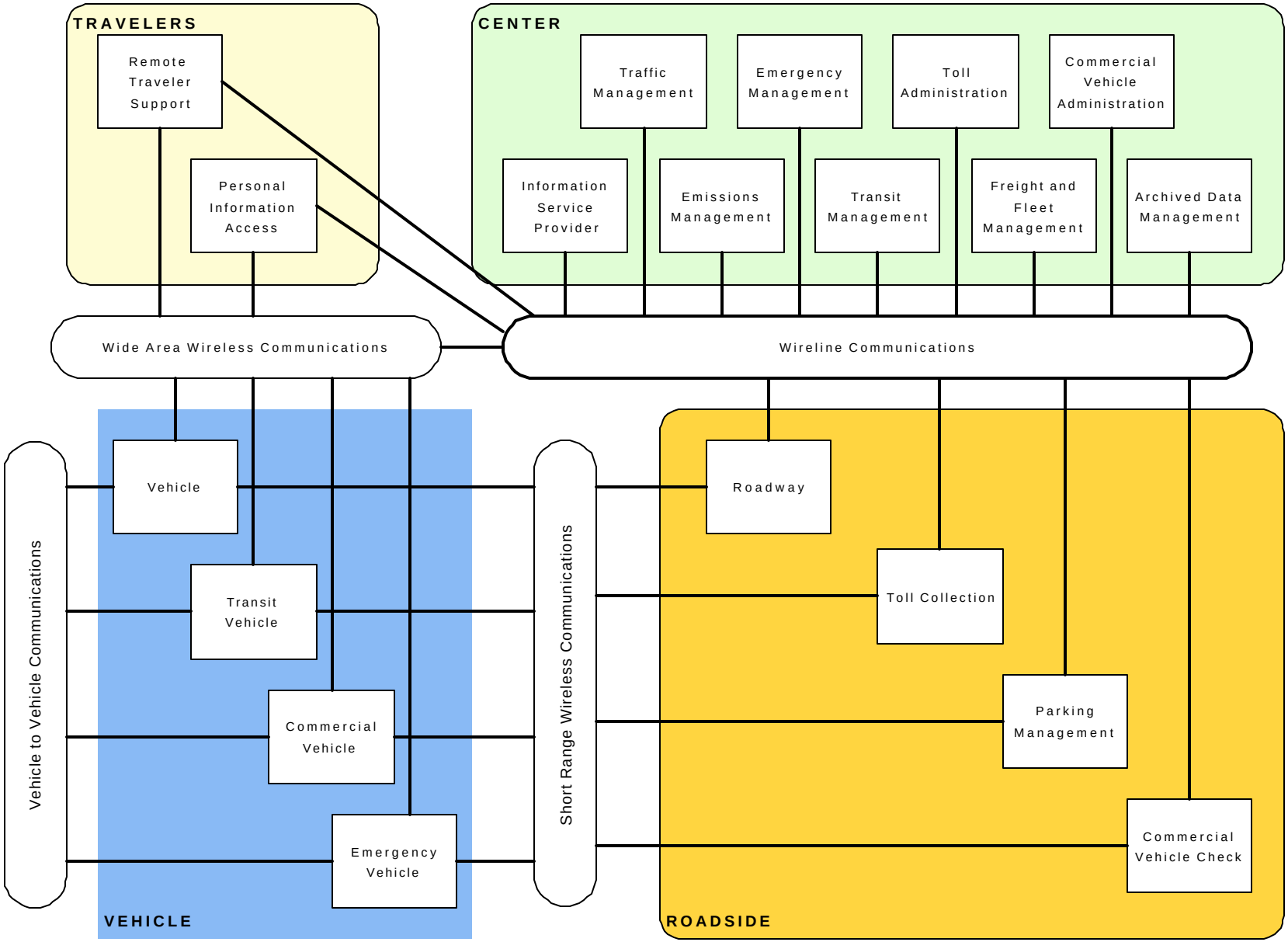
2.1.2 Architecture Flow

An architecture flow is simply the information that is exchanged between subsystems and terminators in the Physical Architecture. Each architecture flow contains one or more data flows from the Logical Architecture. These architecture flows and their communication requirements define the interfaces which form the basis for much of the ongoing standards work in the National ITS Architecture program. The current US DOT guidelines require that the ITS Architecture be developed at a sufficient level of detail to show subsystems and architecture flows.

2.1.3 Terminators

Terminators are generally defined as people, systems and general environment that is outside the boundary of ITS but still impacting ITS systems. Interfaces between subsystems and terminators need to be defined, but there are no ITS-related functional requirements associated with terminators. Since regional architectures are usually developed from a specific agency(s)' perspective, a subsystem that is out of the control of the entity's perspective is called a terminator. This is done to illustrate whom has/wants control of the proposed services.

Figure 2-1: National ITS Architecture Subsystems



2.1.4 Market Packages

While the physical architecture components, such as subsystems and architecture flows, provide a good tool for organizing the ITS design process, they are difficult to discuss with anyone who is not familiar with the National ITS Architecture. 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 utilize 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. Equipment Packages group like processes of a particular subsystem together into an "implementable" package. The Market Packages also help in the design process by categorizing improvements and can serve as another check to make sure areas are not over or under covered.

For example, the Market Package "Regional Traffic Control (ATMS07)" is made up of the subsystems "Traffic Management" and "Roadway", as well as the terminator "Other TM" (see Figure 2-2 on the following page). The service to be provided is regional traffic control. In order to do this, the entity must have control or access to processes under traffic management and roadway. The specific process needed is "TMC Regional Traffic Control." This Equipment Package provides capabilities for analyzing, controlling, and optimizing area-wide traffic flow. These capabilities provide for wide area optimization integrating control of a network signal system with control of freeway, considering current demand as well as expected demand with a goal of providing the capability for real-time traffic adaptive control while balancing inter-jurisdictional control issues to achieve regional solutions. The terminator "Other TM" shows that the information collected must be accessible by other traffic management centers. The architecture flow indicates that "traffic information coordination" and "traffic control coordination" will be exchanged between the "Traffic Management" subsystem and "Other TM" terminator.

Architecture flows represent the information flows between subsystems and terminators. These flows can be broken down further into data-flows and process specifications. This breakdown defines more and more detailed information exchanges between the subsystems and terminators. This level of detail becomes more useful in the project design and implementation stages.

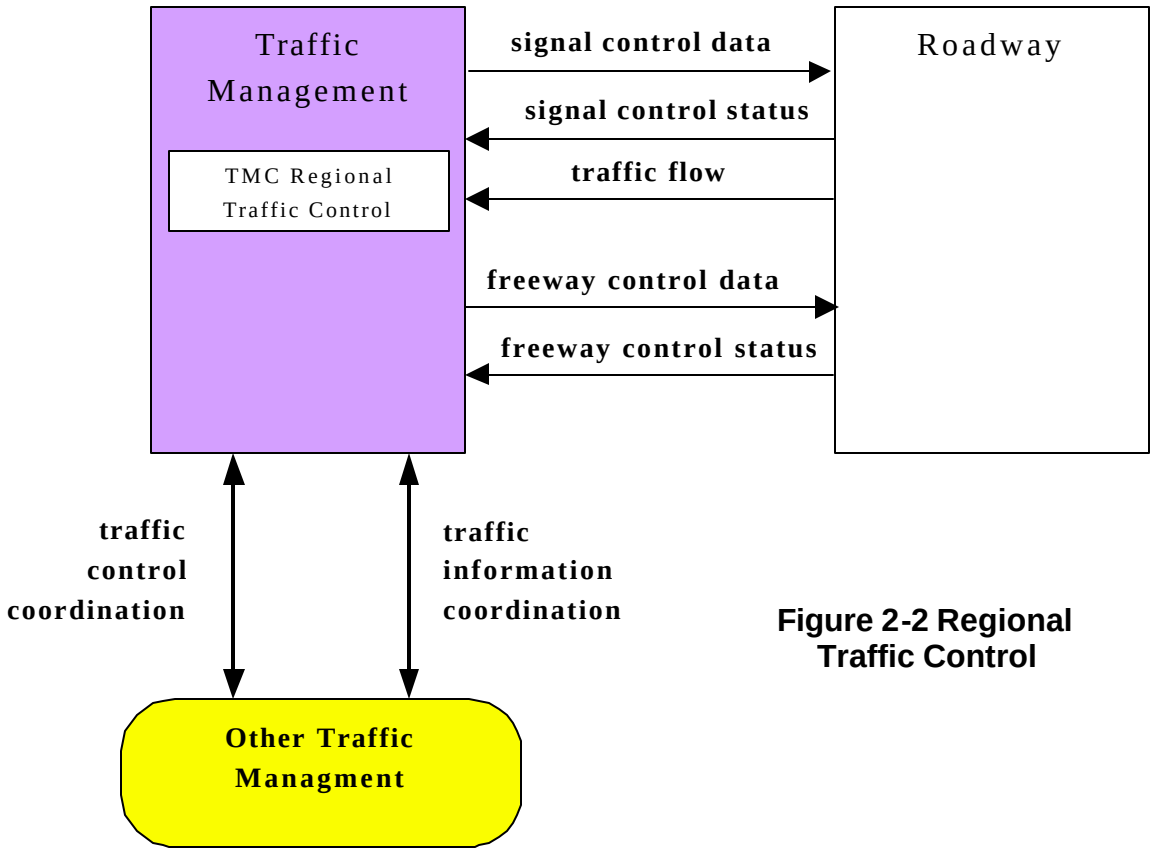


Figure 2-2 Regional Traffic Control

2.2 Federal Highway Administration Regulations

FHWA has issued a final rulemaking to implement section 5206(e) of the Transportation Equity Act for the 21st Century (TEA-21). This section required ITS projects funded through the highway trust fund to conform to the National ITS Architecture and applicable standards. Conformance with the National ITS Architecture is defined as development of a Regional ITS Architecture and the subsequent adherence of ITS projects to the Regional ITS Architecture. The Regional ITS Architecture is based on the National ITS Architecture and consists of several parts including the system functional requirements and information exchanges with planned and existing systems and subsystems along with identification of applicable standards. The Regional ITS Architecture would be tailored to address the local situation and ITS investment needs.[5] The rule becomes effective on April 8, 2001.

Regional ITS Architecture is to serve as a guide for the development of ITS projects and programs and be consistent with ITS strategies and projects contained in applicable transportation plans. Regional ITS Architecture means a regional framework for ensuring institutional agreement and technical integration for the implementation of ITS projects or groups of projects.

[5] January 8, 2001, U.S. Department of Transportation, Federal Highway Administration, 23 CFR Part 940, FHWA Docket No. FHWA-99-5899 (http://www.its.dot.gov/aconform/archrule_final_1.htm)

The Regional ITS Architecture must include the following elements:

- Description of the Region or Project
- Identification of Stakeholders
- Operational Concept
- Agreements
- System Functional Requirements
- Interface Requirements and Information Exchanges
- Identification of ITS Standards
- Sequence of Projects Required for Implementation[6]

The size of the region should reflect the breadth of the integrations effort and is left to the discretion of the cooperating organizations.

2.3 Colorado Transportation Management System Deployment

The Colorado Transportation Management System (CTMS) is a statewide transportation management and traveler information system, which is operated from the CTMC in Lakewood. The CDOT ITS Office manages and operates the CTMC. The current CTMS deployment program will expand, enhance and augment deployment and integration of the state's ITS infrastructure. In addition to deploying additional field devices, CDOT recognizes that the integration of ITS control centers; enhanced communication networks; and control, monitoring, and information dissemination are the keys to the ultimate success of the CTMS. To that end, the CTMS deployment program has been developed with a two-fold purpose in mind:

1. To deploy additional ITS field devices and communications infrastructure (to increase the overall amount, reliability and flow of available data).

2. To increase overall level of system integration (to enhance the timeliness and utility of the data for CTMS operators, other traffic management centers in the state, and the traveling public).

The program will not include the widespread deployment of field devices (such as the DMS, HAR, CCTV and call boxes recommended in recent studies). It will jump start integration of existing and planned devices and high-speed and low-speed communications as well as boost exchange of data between centers. In addition to limited communications and interface development, the CTMS deployment program will include widespread, complex software development and the integration of hardware, software and communications elements.

CDOT views this project as critical to the success of the ITS program in the state for a number of reasons. One of the ongoing barriers to additional ITS systems integration and growth has been the lack of a "central" Advanced Traffic Management System (ATMS) and Advanced Traveler Information System (ATIS) software at the CTMC to which other centers and agencies can connect. The implementation of "central" software for the CTMC will allow CDOT to proceed with system integration, modular growth and connections to other centers and agencies. In addition, the new CTMC

[6] January 8, 2001, U.S. Department of Transportation, Federal Highway Administration, 23 CFR Part 940, FHWA Docket No. FHWA-99-5899 (http://www.its.dot.gov/aconform/archrule_final_1.htm)

building funds will provide the physical platform for that growth through the provision of the office, systems, and equipment space needed to allow such a migration path.

In the interim, CDOT envisions continued ITS implementation before wide-scale statewide integration can be achieved with the new CTMS software. CDOT is moving ahead with integration-preparation and information sharing activities between control centers while software procurement and other integration work proceeds. Other work activities will likely include additional integration of devices using the high-speed and low-speed communication networks, integration of the networks themselves, and enhancement of the CDOT website to include more detailed travel information as it becomes available.

2.4 Colorado Shared Resources Project

CDOT is in the early stages of a project to install high-speed communications statewide along highway rights-of-way. Initial projects include I-70 Denver to Kansas; Denver Metro; I-70 Denver to Utah; and I-25 Denver to New Mexico. The first two projects are under construction, with the latter two scheduled for start of construction later in 2001. Completion of these projects will allow CDOT to connect ITS devices statewide and provide high-speed connections to Colorado Springs and Region 2 in Pueblo.

2.5 Pueblo Freeway Management System Project

The Pueblo Freeway Management System (FMS) will enable the Colorado State Patrol (CSP), The City of Pueblo Police Department (PPD), and CDOT (both Region 2 and CTMC) to remotely monitor roadway conditions status and deliver travel information to the motorists along sections of I-25 and US 50 near the City of Pueblo. This project is an outgrowth of a joint incident management plan. CCTV and DMS equipment will be installed in strategic locations along the highway to monitor, assess, and respond to incidents. CCTV cameras will be utilized to assess incident status while DMSs will be utilized to alert motorists of an incident.

2.6 Colorado Springs Traffic Operations Center Interface Project

The purpose of this project is to develop a center-to-center (C2C) interface and communications link between the CTMC and Colorado Springs TOC. The link would allow the CTMC and TOC to monitor and operate each other's ITS field equipment subject to the establishment of operational agreements between CDOT and the City of Colorado Springs. The link would also allow the transmission of traffic and incident data between the two centers and provide for human resource sharing efficiency in that CTMC personnel will be available to assist the City in monitoring the Colorado Springs system during off hours (The CTMC is a 24-hour operation while the TOC is normally open only between the hours of 6 AM to 6 PM on weekdays.)

The Advanced Traffic Management System (ATMS) at the TOC controls cameras, automatic traffic recorders (ATR), and DMS. In addition, the City operates a separate Traffic Signal Control System (TSCS), which controls City of Colorado Springs and CDOT (Region 2) signals, but is not integrated into the ATMS. This project will include the integration of the TSCS and the ATMS; followed by the integration of the combined system to the CTMC. The project will include:

- Development of a Theory of Operations for interactions between the two centers (complete).
- Development of functional requirements for interactions between the two centers (complete).

- Design and installation of a physical communication link between the two centers (underway).
- Development of a center-to-center (C2C) interface.
- Development of user interfaces and any supporting application software.
- Integration of all elements.

The CTMC-TOC interface will likely be used as a pattern or model for the future interfacing of additional systems to the CTMC.

2.7 Colorado Commercial Vehicle Information System and Networks (CVISN) Deployment

The bulk of commercial vehicle regulatory activity occurs at the state level where responsibilities are shared among CDOT, Colorado State Patrol, Department of Revenue, and Public Utilities Commission. To add to the complexity, trucks that travel outside the state are subject to the regulations of the states in which they travel. The US Department of Transportation, Federal Motor Carrier Safety Administration (FMCSA) has embarked on a program called CVISN (Commercial Vehicle Information Systems and Networks). CVISN refers to the collection of information systems and communications networks that support commercial vehicle operations (CVO). "These include information systems owned and operated by governments, motor carriers, and other stakeholders. FMCSA CVISN program is not trying to create a new information system, but rather to create a way for existing and newly designed systems to exchange information through the use of standards and available communications infrastructure. The CVISN program provides a framework or "architecture" that will enable government agencies, the motor carrier industry, and other parties engaged in CVO safety assurance and regulation to exchange information and conduct business transactions electronically. The goal of the CVISN program is to improve the safety and efficiency of commercial vehicle operations."[7]

The agencies in Colorado who are responsible for aspects of CVO are participating in the implementation of CVISN and it will include the following set of market packages:

MARKET PACKAGE	STATUS
Electronic Clearance	Yes
CV Administrative Processes	Yes
International Border Electronic Clearance	Not applicable
Weigh-In-Motion	Yes
Roadside CVO Safety	Yes
On-board CVO Safety	Yes
HAZMAT Management	Yes

Ports of Entry along I-25 and I-70 have already been equipped with the hardware, software and communications capabilities to support the PrePass Program. This program allows trucks with proper credentials and the correct weight to bypass weigh stations. Automatic Vehicle Identification (AVI)

[7] Kim E. Richeson, Introductory Guide to CVISN (POR-99-7186) Preliminary Version P.2, February 2000

transponders are used to identify trucks and the weigh-in-motion (WIM) sensors measure truck weight (Currently, the south bound POE at Trinidad is only equipped with AVI readers).The installation of high-speed communications along I-25 will improve the communications link to the ports of entry in the corridor and allow for the distribution of traveler information at these locations.

2.8 Implications

The final rule making by FHWA provides the guidance for the development of Region 2 ITS Architecture. The ITS projects described above must all be integrated into an overall regional ITS Architecture. The architecture will provide the technical and institutional framework for incorporating planned projects into a larger vision for Region 2 and the rest of the state.

3. PUEBLO FREEWAY MANAGEMENT SYSTEM PROJECT ITS ARCHITECTURE

The physical design of the Pueblo Freeway Management System has already been completed. Using this design and the project memorandum of understanding (MOU), this section documents the project level ITS Architecture. This project level architecture is one of the building blocks for the development of the Region 2 ITS Architecture and is a condition of the federal funds used for design and deployment of the project.

3.1 Description of Project

The Pueblo Freeway Management System (FMS) will enable Colorado State Patrol (CSP), City of Pueblo Police Department (PPD), CDOT Region 2, and CDOT CTMC to remotely monitor incident and event status and deliver travel information to the motorists along sections of I-25 and US50 running through the City of Pueblo. This project grew from the development of a joint incident management plan. CCTV and DMS equipment will be installed in strategic locations along the freeway to monitor, assess, and respond to incidents and events. CCTV cameras will be utilized to detect and assess incidents while messages will be displayed on DMSs to alert motorists of incidents. A communications network will be established linking the agencies to share information. All four organizations will have the ability to display messages on DMSs. Inter-agency agreements will determine which agency has priority in a given situation. The equipment implemented under the scope of the Pueblo FMS will enhance the ability of the current workforce to utilize existing resources and facilities to provide travel information as well as incident response and incident management.

3.2 Identification of Stakeholders

The Pueblo FMS will involve three entities: CDOT, City of Pueblo, and CSP. Each entity will provide a portion of the funding for deploying the project and will share operational responsibilities.

- **Colorado Department of Transportation**: Federal funds have been granted to the City of Pueblo for design and construction of the Pueblo FMS. In order to access these funds, the State must provide matching funds for the project. CDOT will provide the necessary matching funds. CDOT Region 2 will be the lead agency for the design and construction of the project. The staff from the ITS Office (that operates the CTMC) will provide technical support and disseminate traveler information generated by the project to travelers throughout the corridor.
- **City of Pueblo**: The City of Pueblo will utilize federal funds to support the design and construction of the Pueblo FMS. The City will transfer all available federal funds to the State. The City will participate in the review of the design and construction of the project.
- **Colorado State Patrol**: CSP will participate in the review of the design and construction of the project. Upon completion, CSP will provide non-stop operation of incident detection equipment and CCTV cameras and will have primary control of DMS.

3.3 Operational Concept

The Pueblo FMS operational concept defines the institutional relationships among the organizations in the region required for the deployment and operation. The operational concept establishes the roles and

responsibilities of these organizations, including responsibilities for operation and maintenance and the level of information, status, and control sharing among the entities.

The roles of each organization have been identified during the conceptual development and design portion of the project. The responsibilities listed below define the Pueblo FMS operational concept.

The CSP shall operate to provide the following:

- Provide 24-hr per day, 7-day per week monitoring of the system.
- Provide traveler information in the event of a major regional incident.
- Post DMS messages for major regional incidents (CSP has DMS priority in the event of a major regional incident).
- Post DMS messages regarding traveler information in coordination with CDOT.
- Notify Region 2 Maintenance of any damaged facilities (incident damage).
- Provide a secure facility to house FMS control equipment.
- Act as the communications center for CDOT Region 2.

The City of Pueblo Police Department shall operate to provide the following:

- Provide 24-hr per day, 7-day per week system monitoring.
- Perform local traffic operations for I-25, US 50, and SH 47.
- Notify Region 2 Maintenance of any damaged facilities (incident damage).
- Maintain current jurisdiction on I-25 and on local arterials.

The City of Pueblo shall operate to provide the following:

- Provide general traveler information through Pueblo in coordination with CDOT and CSP.
- Post DMS messages regarding traveler information (CDOT and CSP will have priority).
- Provide a secure facility to house FMS control equipment.

The CDOT Region 2 shall be responsible for a number of duties including:

- Provide general traveler information through the Pueblo area and for the entire corridor.
- Operate all traffic signal systems for the signals under State control.
- Provide a secure facility to house FMS control equipment.

General responsibilities include:

- In the event of an incident, any entity intending to alter a DMS message shall notify the other agencies of the expected change.
- Any entity activating a DMS to display incident or travel related information, must return the DMS to its original state upon resolution of the incident or diminished need for travel information and notify other agencies of the DMS's return to original state.

- An interagency agreement will determine which agency has priority in given situations (The specific operational procedures are not addressed in this document).

3.4 Agreements

Agreements are established to clearly define responsibilities among the involved parties. The level of formality generally increases as risks escalate and when financial transactions take place. Formality will also increase when the performance or lack of performance on the part of one organization impacts the operations of another. For example, if an agency maintains and operates the traffic signals of another agency, failure to restore a failed traffic signal in a timely fashion could have a significant impact. As different systems are linked together, they will depend upon each other. The clear definition of responsibilities for all parties will help ensure smooth operations.

Project agreements are commonly contained within a Memorandum of Understanding (MOU) to be signed by the involved parties. In such a case, the MOU defines the roles and responsibilities of the involved parties and may detail all phases of the project.

An MOU has been developed to document the agency responsibilities for the Pueblo FMS. This MOU clearly defines the roles and responsibilities of CDOT, City of Pueblo, and Colorado State Patrol, as they pertain to funding, design, construction, operation, and maintenance of the Pueblo FMS.

3.5 System Functional Requirements, Interface Requirements and Information Exchanges

The project stakeholders have completed the design of the Pueblo FMS, which required the determination of an operational concept, roles and responsibilities. In this subsection, the design is translated into the terminology employed by the National ITS Architecture. The Pueblo FMS ITS Architecture can be represented using a combination of various market packages. Each of the specific physical design elements and/or information or control sharing requirements of the project can be depicted as one or more market packages. The National ITS Architecture utilizes market packages to categorize specific types and combinations of equipment packages and architecture flows. Each market package is defined by its corresponding subsystems, equipment packages, and architecture flows. The resulting Pueblo FMS ITS Architecture will document system functional requirements, interface requirements, and information exchanges of the project.

The review of the sixty-three market packages contained in the National ITS Architecture identified the following market packages as applicable to the Pueblo FMS project. Table 3-1 provides market packages by stakeholder. Full definitions of each market package are found in Appendix B of this report.

Table 3-1: Pueblo FMS Market Packages by Stakeholder

MARKET PACKAGE	MARKET PACKAGE NAME	CDOT REGION 2	PUEBLO TRANSPORTATION	PUEBLO POLICE	CSP	CDOT ITS OFFICE
ATIS1	Broadcast Traveler Information					✓
ATIS2	Interactive Traveler Information					✓
ATMS01	Network Surveillance	✓	✓			
ATMS06	Traffic Information Dissemination	✓	✓	✓	✓	✓

MARKET PACKAGE	MARKET PACKAGE NAME	CDOT REGION 2	PUEBLO TRANSPORTATION	PUEBLO POLICE	CSP	CDOT ITS OFFICE
ATMS08	Incident Management System	✓	✓	✓	✓	✓
ATMS18	Road Weather Information System	✓				
EM1	Emergency Response			✓	✓	

Broadcast Traveler Information: In this market package, traveler information is distributed in one direction - to the traveler. An example would be sending a fax alert concerning weather conditions, construction, or major incident. The CDOT ITS Office from the CTMC is responsible for the statewide-automated dissemination of traveler information and who provide this function for the Pueblo FMS. The other organization would provide the needed details of the occurrence to the CDOT ITS Office. The CTMC, in National ITS Architecture terms, is acting as an Information Service Provider (ISP).

Interactive Traveler Information allows the traveler to request specific information. An example would be an Internet web page. Again, the CTMC provides this service but requires detailed information from the other organizations.

Network Surveillance reflects the flow of information from the equipment that will be physically mounted along the roadway such as the CCTV cameras for the monitoring of traffic conditions and incidents along sections of I-25 and US 50. The Pueblo FMS will have the ability to control sensor and surveillance equipment remotely. Network surveillance will provide one source of information regarding roadway conditions for distribution by the CTMC. Both CDOT Region 2 and Pueblo Transportation will have this capability.

Traffic Information Dissemination allows traffic information to be disseminated to drivers and vehicles using roadway equipment such as dynamic message signs for the case of the Pueblo FMS. Generally, only traffic management centers (TMCs) operated by transportation agencies (such as CDOT Region 2, CTMC, and Pueblo Transportation) would have this capability. The project operational concept dictates that both PPD and CSP have the capability control traffic information dissemination functions. Both PPD and CSP have the ability post messages on the DMSs installed as part of the project. Such differences are indicated on the Pueblo FMS ITS Architecture diagram.

Incident Management System describes the flow of incident information between the emergency management centers (EMC), like PPD and CSP, and TMCs. The EMCs provide a key source of incident information as part of their normal duties. Patrol cars and citizens report incidents to EMCs. The second source of incident information is from roadway equipment that is used to detect an incident, Incident information is then sent to TMCs for distribution to EMCs and ISPs (CTMC). Incident detection will occur first at the roadway and then flow to the TMC. The TMCs are the only entity communicating directly with roadway equipment.

Road Weather Information System reflects the flow of environmental conditions information from the roadway to TMCs. Region 2 receives weather and weather related pavement condition information.

Emergency Response provides the computer-aided dispatch systems, emergency vehicle equipment, and wireless communications that enable safe and rapid deployment of appropriate resources to an

emergency.[8] This function is already being performed by CSP and PPD. This project will enable the ability to share incident information with the three TMCs.

Based upon the project design and the identification of the applicable market packages, a project level ITS Architecture was developed. Figure A-1 (in Appendix A) presents the diagram. The diagram illustrates, subsystems, equipment packages and architecture flows (to and from) for each organization and relevant subsystem. For example, in the lower right hand corner of the diagram is the CDOT Region 2 traffic management center. In the box is listed the six equipment packages required for the deployment of the Pueblo FMS for Region 2. TMC incident detection provides the capability for the Region 2 TMC to detect incidents. TMC traffic information dissemination provides the ability to control DMSs. In the upper center portion of the diagram is a box labeled PPD/CSP that depicts both emergency management centers. From an ITS Architecture viewpoint, both organizations have the same functionality and thus only one box is provided. Note that the two EMCs have the ability to detect incidents (TMC incident detection) and post messages to a DMS (TMC traffic information dissemination) just as the TMCs do. Pueblo Transportation is shown on the upper left hand side of the diagram. The only equipment package that is not included at the Pueblo TMC versus the Region 2 TMC is the ability to interface with roadway weather sensors. At the middle bottom of the diagram is the CDOT ITS Office. CTMC has the ability to provide broadcast and interactive traveler information and also control DMSs. Other subsystems on the diagram include the roadway (where equipment will be deployed) and three locations for travelers to receive information – vehicle, remote traveler support (kiosks, etc), and personal information access (PCs, phones, etc).

3.6 Identification of ITS Standards

Standards specify how to do things consistently. "ITS standards are specifications that define how transportation system components interconnect and interact within the overall framework of the National ITS Architecture. They specify how different technologies, products, and components interconnect and interoperate among the different systems so that information can be shared automatically."[9] The key point is that standards and common equipment help to enable the deployment of an integrated ITS system throughout the region and the state by allowing different systems to speak to each other. This section identifies ITS standards and equipment that support regional and statewide interoperability.

The common standards and equipment being deployed as part of this project include:

- **Shared Resources Fiber Optic Network**: As part of the statewide shared resources project by ADESTA, a high speed fiber optic cable will be installed along I-25 from Denver to New Mexico. This will provide the communication link between CTMC and the Pueblo FMS.
- **Common Communications Equipment**: **E**ach center that is part of the Pueblo FMS will be equipped with a Nortel JungleMUX communications mutiplexer that will allow video and data to be sent over the shared resources fiber optic network back to the CTMC in Lakewood. This will allow for the direct sharing of video and data between the two systems. CTMC will then be able to distribute Pueblo area condition information to the entire corridor using its established, coordinated distribution mechanisms.

[8] US DOT, National ITS Architecture, Version 3.04
[9] Frequently Asked Questions About ITS Standards, US DOT ITS Standards Website, http://www.its-standards.net/FAQ.htm

- **Common DMS Equipment**: Any future DMS installed along the corridor, including those used on the immediate approaches to the tunnel, will be deployed using a single statewide NTCIP center-to-field protocol, which is currently under development. This protocol will enable the joint control of the DMS from both locations. The Pueblo FMS participants will be able to post messages on the DMS that relate to local conditions and the CTMC will be able to post corridor wide messages.
- **Common CCTV Equipment**: CDOT has adopted Panasonic CCTV cameras and switchers as the statewide common equipment standard. Panasonic cameras and switches will be installed as part of this program.

Ultimately, the FMS components will be integrated into the upgraded CTMS that will be deployed over the next several years by CDOT ITS Office. The Pueblo FMS users will have access to the CTMS over shared workstations that will in turn control field equipment. The level of control and access will be based upon the MOU among the Pueblo FMS participants. Pueblo FMS equipment will be integrated into the overall statewide system. The use of common equipment will ease this future integration effort.

4. COLORADO SPRINGS TRAFFIC OPERATIONS CENTER-TO-CENTER PROJECT ITS ARCHITECTURE

One objective of the statewide CTMS project was to establish mechanisms for the sharing of information and control between the CTMC and other local traffic management centers. This project was undertaken to establish an electronic link between the CTMC and the City of Colorado Springs Traffic Operations Center (TOC). The operational concept and functional requirements for this link have been completed. This section of the document summarizes this previous activity.

4.1 Description of Project

A major accident occurs on I-25 at the north end of Colorado Springs. The staff at the Colorado Springs TOC to assess the severity of the incident and its potential impact uses CCTV cameras. The incident scene manager determines that the freeway will be closed in one direction for at least four hours. The joint incident response strategy developed by CDOT and Colorado Springs' staff is activated. Dynamic message signs (DMSs) in both the Colorado Springs and Denver area alert en-route motorists of the blockages. A predetermined traffic signal timing plan for Colorado Springs is implemented to increase capacity on parallel arterial routes.

Direct communication links for traffic information and video to CDOT CTMC provide real time information on the incident. Staff at both the TOC and the CTMC is able to monitor conditions and update traveler alerts through their individual computer workstations.

Using this real time data and images, the CDOT website is updated to highlight this major incident. Video images and traffic condition information illustrates to Internet users the extent of the resulting congestion. Automatically incident alerts are transmitted to email and fax subscribers. These timely alerts cause travelers to delay travel and alter routes resulting in significantly less congestion and no additional accidents in the queue behind the accident.

This scenario could be a common example of traffic management along the I-25 corridor in the future. The establishment of a direct, electronic link between CDOT CTMC and Colorado Springs TOC would enable the joint sharing of control, data, and images from roadside equipment. This link between the two traffic management centers will be implemented in two phases. The first phase will involve the exchange of workstations and live traffic video. The second phase would involve the establishment of a direct center-to-center (C2C) interface between the systems using the emerging ITS standards.

4.2 Identification of Stakeholders

The Colorado Springs TOC will involve two entities, The Colorado Department of Transportation and the City of Colorado Springs. Both entities will provide a portion of the funding and support for the project. The roles and responsibilities of these stakeholders have been defined in the Colorado Springs Theory of Operations.[10]

[10] Colorado Department Of Transportation, Colorado Springs TOC to CDOT CTMS Interface - Theory Of Operations, Technical Memorandum, prepared IBI Group, December 11, 1999

4.3 Operational Concept

The Colorado Springs TOC operational concept provides a basis for center-to-center (C2C) interface requirements between Colorado Springs and CTMC. The operational concept goals and objectives are summarized below:

- Enable bi-directional sharing of information including traffic, incident and weather data.
- Provide bi-directional access to CCTV video images and camera control.
- Allow images and data to be available on the CDOT and Colorado Springs websites.
- Allow live video images from CDOT and Colorado Springs to be available for broadcast by commercial television stations and public access cable television subject to access agreements.
- Provide bi-directional control of devices including DMSs. (Control will be limited to a sub-set of each agency's devices.)
- Provide the ability to implement predetermined responses to scheduled events and incidents in the Colorado Springs area.
- Provide the ability for coordinated incident management.
- Provide the ability for CDOT to monitor the Colorado Spring system (i.e., device status).
- Consider the Colorado Springs TOC as the regional node for connectivity between other traffic management centers in the southeast corner of the state.

4.4 Agreements

A working agreement has been established for providing this C2C connection. Under this agreement Colorado Springs and CDOT ITS will first share workstations and then move toward full integration as the updated CTMS comes on line.

4.5 System Functional Requirements, Interface Requirements and Information Exchanges

The system functional requirements, interface requirements, and information exchanges have been defined in the functional requirements document[11] developed for this project. The three primary functions identified during this analysis are:

1. **Provide Traffic Surveillance**: This process enables traffic surveillance, data storage, and communication with other TMCs.
2. **Provide Device Control**: This process enables traffic control through devices such as signal controllers, DMS, HAR, CCTV cameras, and freeway ramp meter controllers.

[11] Colorado Department of Transportation, Colorado Springs TOC to CDOT CTMS Interface - Functional Requirements, Technical Memorandum, prepared by IBI Group, April 2000.

3. **Manage Incidents**: This process is responsible for incident management. This includes detection, recording and managing of both current incidents and planned events, and generating the responses to incidents, as they become current.

Conceptually, the Colorado Springs C2C link project ITS Architecture is represented using an architecture flow diagram. The Colorado Springs flow diagram is contained in Appendix A, Figure A-2. The architecture flow diagram that has been developed for the Colorado Springs TOC is based upon the ITS National Architecture and illustrates the flow of information between the agencies. The architecture flow diagram also identifies each of the equipment packages that will be required to meet the system functional requirements.

4.6 Identification of ITS Standards

The common equipment being deployed as part of this project include:

- **Shared Resources Fiber Optic Network**: As part of the statewide shared resources project by ADESTA, a high speed fiber optic cable will be installed along I-25 from Denver to New Mexico. This will provide the communication link between CTMC and Colorado Springs. This will replace the telephone link between the two centers.
- **Common Communications Equipment**: The Colorado Springs TOC FMS will be equipped with a Nortel JungleMUX communications mutiplexer that will allow video and data to be sent over the shared resources fiber optic network back to the CTMC. This will allow for the direct sharing of video and data between the two centers. The CTMC will then be able to distribute Pueblo area tunnel condition information to the entire corridor using its established, coordinated distribution mechanisms.
- **Common DMS Equipment**: Any future DMS installed along the corridor will be deployed using a single statewide NTCIP center-to-field protocol, which is currently under development. This protocol will enable the joint control of the DMS from both locations. The Colorado Springs TOC will be able to post messages on the DMS that related to local conditions and the CTMC will be able to post corridor wide messages.

The C2C link between CTMC and Colorado Springs TOC will be the first of its type in the state. A detailed analysis[12] was conducted to recommend which National Transportation Communications for ITS Protocol (NTCIP) C2C standard is best suited for the interface between the Colorado Springs TOC and CTMC. The two protocols developed by the ITS community are based on ***Data Exchange Between Systems*** (DATEX) and ***Common Object Request Broker Architecture*** (CORBA). Many factors are considered in making this decision because this choice will have far reaching implications for the future direction of ITS deployments in the state.

The NTCIP protocol, which is being developed specifically for center-to-center communications, is *TS 3.CLE National Transportation Communications for ITS Protocol - Class E Profile for Center-to-Center Communications*. According to the National Electrical Manufacturers Association (NEMA),

[12] Colorado Department of Transportation, Colorado Springs TOC to CDOT CTMS Interface - NTCIP Center-to-Center Protocol Analysis, prepared by IBI Group, June 1, 2000

"this communications protocol profile is established to connect a transportation management center (TMC) to other TMCs and information service providers. The profile will include a data transmission protocol and a message set standard."[13]

The document assessed which protocol is better suited for this particular application. The availability of two protocols implies that one protocol is better suited to certain circumstances. The following factors were considered:

- Characteristics of systems to be linked
- Functions to be supported
- System life cycle considerations
- System performance
- Communications infrastructure and demand

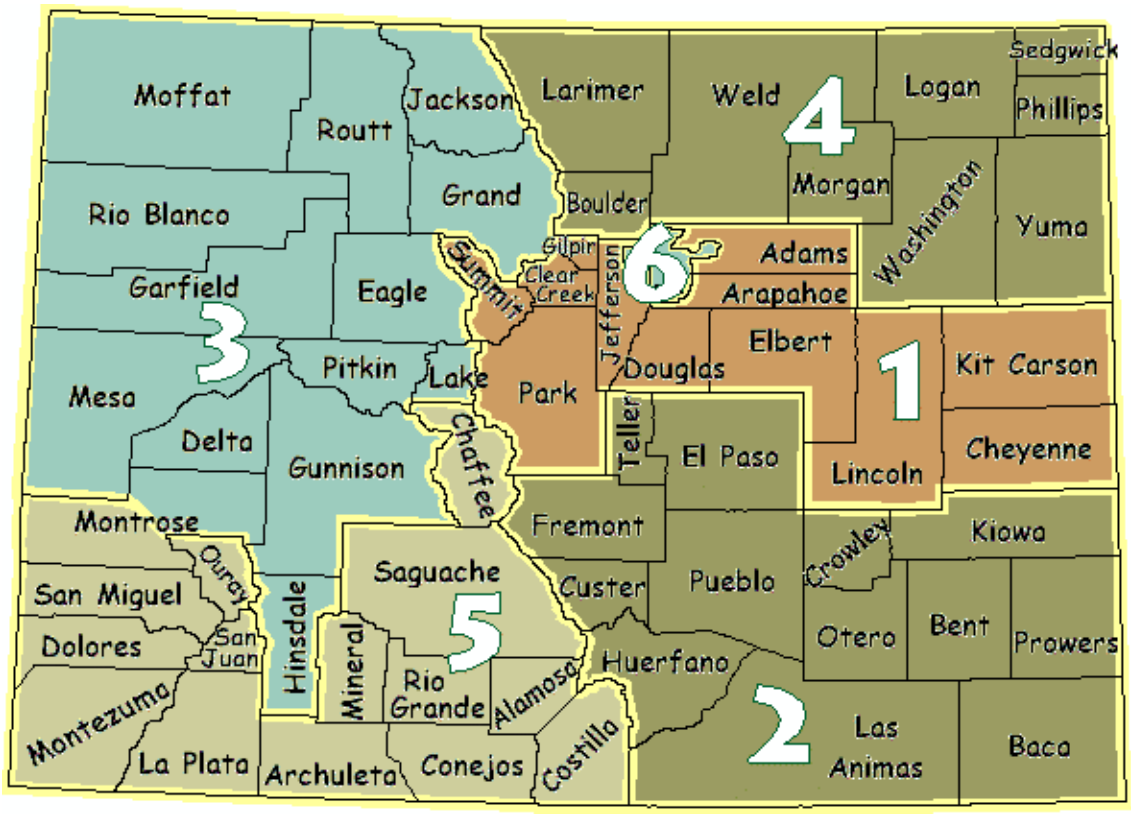
Based upon the analysis, the use of the DATEX standard was recommended.

[13] http://www.nema.org/standards/ntcip/devel.html, *Joint AASHTO/ITE/NEMA Committee on the NTCIP's Working Group on Center-to-Center (C2C) Communications, chaired by Warren Tighe, DKS Associates*

5. CDOT REGION 2 ITS ARCHITECTURE

The statewide ITS initiatives, Pueblo FMS, and Colorado Springs C2C project provide a baseline for the development of CDOT Region 2 ITS Architecture. The Region 2 ITS Architecture provides an institutional and technical framework for the deployment of ITS applications in the region and must integrate these existing efforts into an overall ITS Architecture. This section builds on the projects and project ITS Architectures discussed above to develop the Regional ITS Architecture.

5.1 Description Of The Region



CDOT Regions

CDOT Region 2 encompasses the southeast quarter of the State of Colorado. The major cities in the region are Colorado Springs and Pueblo. Major highways on the National Highway System include I-25, US 50, US 287, and US 24. The only interstate highway is I-25 running north and south through the Region 2 and connecting Denver, Colorado Springs, and Pueblo. US 50 extends east from Pueblo to the state line where it continues into Kansas.

With the exception of Colorado Springs and Pueblo, Region 2 is primarily rural in character. Amongst the counties in Region 2, El Paso County and Pueblo County boast the highest population counts, collectively responsible for over eighty percent of the entire CDOT Region 2 population. The population of Region 2 was estimated to have reached approximately 778,000 as of 1999.

5.2 Identification Of Stakeholders

The development of the CDOT Region 2 ITS Architecture focused on primary stakeholders found along the I-25 corridor. The stakeholders include:

- CDOT ITS Office (operator of the CTMC)
- CDOT Region 2
- Colorado State Patrol
- City of Pueblo
- City of Colorado Springs

As part of the development of the Pueblo FMS and the Colorado Spring C2C Project, extensive stakeholder meetings were conducted to determine the roles and responsibilities of each organization. These roles and responsibilities are discussed in the previous sections. Using these efforts as a baseline, additional stakeholder sessions were conducted in Pueblo to determine the potential future ITS requirements. The results of all of these stakeholder sessions are reflected in this document.

The Region 2 ITS Architecture incorporates the deployment of the Colorado State Commercial Vehicle Information Systems and Networks (CVISN). This separate effort included the following stakeholders:

- Colorado Motor Carriers Association
- Colorado State Patrol
- Department of Regulatory Agencies, Public Utilities Commission
- Department of Revenue, Information Technology Division (ITD)
- Department of Revenue, Motor Carrier Services (MCS)
- Department of Revenue, Motor Vehicle Division (MVD)
- Department of Transportation, Commercial Vehicle Operations

If future ITS applications are considered in Region 2, then consultations with additional stakeholders will be required as part of the planning and project development process. The final FHWA rule making encourages the updating and the regional ITS Architecture to reflect changing conditions. Potential future stakeholders would include:

- County and Local City Public Works Departments
- Local Transit Agencies
- County and Local Emergency Response Organizations

5.3 Operational Concept

The operational concept portion of the Region 2 ITS Architecture defines the institutional relationships among the organizations in the region required for the deployment and operation of a regional integrated transportation management and information system. The operational concept establishes the roles and responsibilities between organizations including responsibilities for operation and maintenance and the level of information, status, and control sharing among the entities.

In the National ITS Architecture, 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.[14] The market packages also include a depiction relationship and data flow between different entities providing the "service" provided by the deployment of the market package. For example, the incident management system market package requires that traffic management and emergency management centers exchange information. This implies that an operational concept and an institutional relationship be established between the two organizations that are cooperating. The identification of which market packages are and will be deployed in Region 2 leads the way to define an operational concept for the Regional ITS Architecture.

Table 5-1 shows all the market packages that are encompassed by the Region 2 ITS Architecture. The market packages are listed by organization. The selected market packages are based upon existing and planned ITS projects and consultation with regional stakeholders on potential future ITS applications.

Most market packages do not require interaction with other organizations, and can be generally implemented as stand-alone applications locally. In these cases, the market package itself defines the operational concept for deployment.

However, several market packages have been identified as requiring jurisdictional interaction and the need to define regional operational concepts. These market packages are:

- Freeway Control
- Traffic Information Dissemination
- Incident Management System
- Broadcast and Interactive Traveler Information
- Regional Traffic Control
- Road Weather Information System
- Data Archiving
- Commercial Vehicle Operations (CVO) Applications
- Transit Applications

Each of these market packages requires an operational concept that will involve multiple jurisdictional relationships. In several cases, multiple traffic and emergency management agencies will need to form relationships with each other to define specific roles and responsibilities for the deployment of the market package.

[14] US DOT, National ITS Architecture, Version 3.04

Table 5-1: CDOT Region 2 Market Packages by Stakeholder

	Market Package	CDOT Region 2	Pueblo Transportation	Pueblo Police	CSP	CDOT ITS Office	Colorado Springs	CVISN
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		✓				✓	
APTS8	Transit Traveler Information		✓				✓	
ATIS1	Broadcast Traveler Information	✓	✓			✓	✓	
ATIS2	Interactive Traveler Information	✓	✓			✓	✓	
ATMS01	Network Surveillance	✓	✓				✓	
ATMS02	Probe Surveillance						✓	✓
ATMS03	Surface Street Control	✓	✓				✓	
ATMS04	Freeway Control	✓	✓				✓	
ATMS06	Traffic Information Dissemination	✓	✓	✓	✓	✓	✓	
ATMS07	Regional Traffic Control	✓	✓			✓		
ATMS08	Incident Management System	✓	✓	✓	✓	✓	✓	
ATMS13	Standard Railroad Grade Crossing	✓					✓	
ATMS16	Parking Facility Management		✓					
ATMS18	Road Weather Information System	✓				✓	✓	
CVO03	Electronic Clearance							✓
CVO04	CV Administrative Processes							✓
CVO06	Weigh-In-Motion							✓
CVO07	Roadside CVO Safety							✓
CVO10	HAZMAT Management				✓			✓
EM1	Emergency Response			✓	✓			
EM2	Emergency Routing			✓	✓			
EM3	Mayday Support			✓	✓			

Relationships between agencies embody two main components: 1) what roles and responsibilities does each agency play in the relationship and 2) what kinds of information is shared. Seven types of roles or responsibilities have been identified to describe agency-to-agency relationships:

- **Coordination**: The comparison of the transportation plans, programs, and schedules of one agency with related plans, programs, and schedules of other agencies and adjustment of plans, programs and schedules to achieve general consistency.
- **Cooperation**: The parties involved in carrying out the planning and/or project development processes work together to achieve a common goal or objective.
- **Consultation**: One party confers with another party, in accordance with an established process, about an anticipated action and then keeps that party informed about actions taken.
- **Information Sharing**: The exchange of data, and device status information between parties, for the purpose of coordinated responses, planning, and analysis.
- **Control Sharing**: The ability, through operational agreements, to allow for one party to control another party's field devices to properly respond to incident, event, weather, or traffic conditions.
- **Operations**: One party fully operates field equipment of a second party, typically because the second party does not operate a control center.
- **Maintenance**: One party maintains the field equipment of a second party.

Along with these seven roles and responsibilities are associated information types that are typical for agency-agency exchange. Five primary types of information exchanges were identified:

- **Video**: The dissemination of video feeds and still images from one party's field cameras to another party.
- **Data**: The dissemination of data gathered from one party's field devices to another party. Data can include, but is not limited to, traffic data, weather data, parking data, transit data, etc.
- **Command**: The ability for one party to control second party's field devices. Command can include, but is not limited to, changing DMS/HAR messaging, changing traffic signal timings, PTZ camera control, etc.
- **Request**: The ability for one party to solicit either data, or a command change, such a DMS messaging or signal timings, from another party.
- **Status**: The ability for one party to monitor another parties field devices, and receive such information as current signal timing/response plan, current message sets, etc.

5.3.1 Freeway Control

This market package provides the communications and roadside equipment to support ramp control, lane controls, and interchange control for freeways. Coordination and integration of ramp meters are included as part of this market package.[15] In Region 2, this function is currently shared between CDOT Region 2

[15] US DOT, National ITS Architecture, Version 3.04

and Colorado Springs along I-25 in the Colorado Springs area. This joint control could be expanded, if the Colorado Springs TOC becomes the regional TMC for the southeastern portion of the state. In the Pueblo area, joint control and information sharing could be established. The operational concept is summarized in Table 5-2 below.

Table 5-2: Freeway Control – Operational Concept

FROM	TO	RELATIONSHIP	INFORMATION
Colorado Springs	Freeway	Operations	Command Request
Freeway	Colorado Springs TOC	Operations	Video Data Status
CDOT Region 2	Colorado Springs	Information Sharing Control Sharing	Video Data Command Request Status
Colorado Springs	CDOT Region 2	Information Sharing Control Sharing	Video Data Command Request Status
Freeway	CDOT Region 2	Maintenance	Status
CDOT Region 2	Pueblo	Information Sharing Control Sharing	Video Data Command Status
Pueblo	CDOT Region 2	Information Sharing Control Sharing	Video Data Command Request

5.3.2 Traffic Information Dissemination

This market package allows traffic information to be disseminated to drivers and vehicles using roadway equipment such as dynamic message signs.[16] This ability to post messages on DMSs from multiple locations is the extension of the Pueblo FMS and the Colorado Springs C2C projects. The operational concept is summarized in Table 5-3 below.

[16] US DOT, National ITS Architecture, Version 3.04

Table 5-3: Traffic Information Dissemination– Operational Concept

FROM	TO	RELATIONSHIP	INFORMATION
CDOT CTMS CDOT Region 2 Colorado Springs CSP Pueblo Pueblo PD	Roadside	Operations Control Sharing	Command Request
Roadside	CDOT CTMS CDOT Region 2 Colorado Springs CSP Pueblo Pueblo PD	Operations	Data Status
State Roads	CDOT Region 2	Maintenance	Status
Local Roads	Colorado Springs	Maintenance	Status
Local Roads	Pueblo	Maintenance	Status

5.3.3 Incident Management System

This market package manages both predicted and unexpected incidents so that the impact to the transportation network and traveler safety is minimized. Requisite incident detection capabilities are included in the freeway control market package and through the regional coordination with other traffic management and emergency management centers, and weather service entities. Information from these diverse sources are collected and correlated by this market package to detect and verify incidents and implement an appropriate response.[17] Again, the operations concept builds on the Pueblo FMS and Colorado Springs C2C work. The required relationships are presented in Table 5-4.

Table 5-4: Incident Management System – Operational Concept

FROM	TO	RELATIONSHIP	INFORMATION
CDOT CTMS CDOT Region 2 Colorado Springs Pueblo	Roadside	Operations Control Sharing	Command Request
Roadside	CDOT CTMS CDOT Region 2 Colorado Springs Pueblo	Operations	Video Data Status

[17] US DOT, National ITS Architecture, Version 3.04

FROM	TO	RELATIONSHIP	INFORMATION
CDOT CTMS CDOT Region 2 Colorado Springs Pueblo	CDOT CTMS CDOT Region 2 Colorado Springs Pueblo	Information Sharing	Video Data Request Status
CDOT CTMS CDOT Region 2 Colorado Springs Pueblo	CSP Pueblo PD Colorado Springs PD	Information Sharing	Video Data Request Status
CSP Pueblo PD Colorado Springs PD	CDOT CTMS CDOT Region 2 Colorado Springs Pueblo	Information Sharing Control Sharing	Data Command Request
CSP Pueblo PD Colorado Springs PD	CSP Pueblo PD Colorado Springs PD	Information Sharing	Data Request
State Roads	CDOT Region 2	Maintenance	Status
Local Roads	Colorado Springs	Maintenance	Status
Local Roads	Pueblo	Maintenance	Status

5.3.4 Broadcast and Interactive Traveler Information

Broadcast Traveler Information provides users with a basic set of advanced traveler information services. It involves the collection of traffic conditions, advisories, general public transportation, parking information, incident information, and weather information, and the near real time dissemination of this information over a wide area through existing infrastructures and low cost user equipment. Interactive Traveler Information provides tailored information in response to a traveler request.[18] The CDOT ITS Office through CTMC is primarily responsible for this function, but receives information from multiple sources for dissemination. Table 5-5 provides the operational concept for CDOT Region 2.

Table 5-5: Broadcast and Interactive Traveler Information – Operational Concept

FROM	TO	RELATIONSHIP	INFORMATION
CDOT CTMS Colorado Springs Pueblo	Remote Traveler Support Personal Info Access Vehicle	Information Sharing	Data
Remote Traveler Support Personal Info Access Vehicle	CDOT CTMS Colorado Springs Pueblo	Information Sharing	Request
CDOT CTMS CDOT Region 2 Colorado Springs Pueblo	CDOT CTMS Colorado Springs Pueblo	Information Sharing	Video Data

[18] US DOT, National ITS Architecture, Version 3.04

FROM	TO	RELATIONSHIP	INFORMATION
CDOT CTMS Colorado Springs Pueblo	CDOT CTMS CDOT Region 2 Colorado Springs Pueblo	Information Sharing	Video Data Request
CDOT CTMS Colorado Springs Pueblo	CSP Pueblo PD Colorado Springs PD	Information Sharing	Data Request
CSP Pueblo PD Colorado Springs PD	CDOT CTMS Colorado Springs Pueblo	Information Sharing	Data

5.3.5 Regional Traffic Control

Regional Traffic Control provides for the sharing of traffic information and control among traffic management centers to support a regional control strategy. The nature of optimization and extent of information and control sharing is determined through working arrangements between jurisdictions. This package relies principally on roadside instrumentation supported by the Surface Street Control and Freeway Control market packages and adds hardware, software, and wire line communications capabilities to implement traffic management strategies which are coordinated between allied traffic management centers."[19] In the Colorado Springs area, Colorado Springs already controls the traffic signals on the state and local roadway network. The implementation of the C2C connection and the statewide CTMS will provide CDOT Region 2 with the capability to access the Colorado Springs traffic signal control system. In the Pueblo area, CDOT Region 2 and Pueblo share a common central traffic control system, but maintain independent control over their respective signals. The operational concept is detailed in Table 5-6 below.

Table 5-6: Regional Traffic Control – Operational Concept

FROM	TO	RELATIONSHIP	INFORMATION
CDOT CTMS CDOT Region 2 Colorado Springs Pueblo	CDOT CTMS CDOT Region 2 Colorado Springs Pueblo	Information Sharing Control Sharing	Data Command Request Status
State Roads	CDOT Region 2	Maintenance	Status
Roadside	Colorado Springs	Maintenance	Status
Local Roads	Pueblo	Maintenance	Status

5.3.6 Roadway Weather Information System

Roadway Weather Information System "monitors current and forecast road and weather conditions using a combination of weather service information and data collected from environmental sensors

[19] US DOT, National ITS Architecture, Version 3.04

deployed on and about the roadway. The collected road weather information is monitored and analyzed to detect and forecast environmental hazards such as icy road conditions, dense fog, and approaching severe weather fronts. This information can be used to more effectively deploy road maintenance resources, issue general traveler advisories, and support location specific warnings to drivers using"[20] CDOT website, DMSs, interactive voice response telephone system and other weather alert information Dissemination mechanisms. CDOT CTMS is establishing a statewide weather information network that will provide Internet-based access to information gathered by the roadside weather sensors to state and local jurisdictions. The operational concept is described in Table 5-7 below.

Table 5-7: Roadway Weather Information System – Operational Concept

FROM	TO	RELATIONSHIP	INFORMATION
CDOT CTMS CDOT Region 2	Roadside	Operations	Command Request
Roadside	CDOT CTMS CDOT Region 2	Operations Maintenance	Data Status
CDOT CTMS	CDOT Region 2 Colorado Springs Pueblo	Information Sharing	Data Status
CDOT Region 2 Colorado Springs Pueblo	CDOT CTMS	Information Sharing	Request

5.3.7 Data Archiving

A need has been identified to enable transportation management systems to capture and archive information for future analysis and planning. The National ITS Architecture market package that supports this concept locally is the ITS Data Mart. "This market package provides a focused archive that houses data collected and owned by a single agency, district, private sector provider, research institution, or other organization. This focused archive typically includes data covering a single transportation mode and one jurisdiction that is collected from an operational data store and archived for future use."[21] Each agency will have the responsibility of archiving their individual data internally, playing the role of the ITS Data Mart for their local data. From a statewide standpoint an ITS Data Warehouse supports the collection of data from multiple agencies from varying jurisdictions and modes. The CDOT ITS Office will have the role of archiving data, while supporting the management of creating consistent data formats.

5.3.8 Commercial Vehicle Operations (CVO) Applications

The Operational Concept for commercial vehicle operations applications is defined by the Colorado CVISN implementation plan. Current information is found at the Colorado CVISN website (http://www.state.co.us/gov_dir/revenue_dir/MCS_dir/cvisn.htm).

[20] US DOT, National ITS Architecture, Version 3.04
[21] US DOT, National ITS Architecture, Version 3.04

5.3.9 Transit Applications

In the future, local transit agencies in Colorado Springs, Pueblo and other communities will consider the deployment of ITS related applications. Most of the potential transit technology deployments will only involve activities performed internally by the individual transit agency. However, the larger transit agencies in Pueblo and Colorado Springs may wish to share travel and weather information with the local and state traffic management centers.

The National ITS Architecture market package that supports this concept is Multi-Modal Coordination. This market package is defined as: "This market package establishes two way communications between multiple transit and traffic agencies to improve service coordination. Inter-modal coordination between transit agencies can increase traveler convenience at transfer points and also improve operating efficiency. Coordination between traffic and transit management is intended to improve on-time performance of the transit system to the extent that this can be accommodated without degrading overall performance of the traffic network."[22] The potential relationships are detailed in Table 5-8 below.

Table 5-8: Transit Applications – Operational Concept

FROM	TO	RELATIONSHIP	INFORMATION
Colorado Springs TOC CDOT CTMS CDOT Region 2	Colorado Springs Transit	Information Sharing	Video Data Request
Colorado Springs Transit	Colorado Springs TOC CDOT CTMS CDOT Region 2	Information Sharing	Video Data Request
Pueblo TMC CDOT CTMS CDOT Region 2	Pueblo Transit	Information Sharing	Video Data Request
Pueblo Transit	Pueblo TMC CDOT CTMS CDOT Region 2	Information Sharing	Video Data Request

5.4 Agreements

The baseline agreements required for interagency cooperation have been developed as part of the Pueblo FMS and Colorado Springs C2C projects. As the projects are implemented and the updated CTMS comes on-line, the rules of engagement will need to be reviewed and updated.

The following is an annotated checklist of elements to consider in the development of an agreement for ITS operations and maintenance. Not all elements are relevant to exchange of information. The level of specificity will depend on the nature of the information link.

- Operational Concept (A layman's introduction to the nature and purpose of the agreement.)
- Duties of Responsible Organizations (A summary of duties and responsibilities.)

[22] US DOT, National ITS Architecture, Version 3.04

- Data Sharing (Aspects of sharing data to be considered.)
  - Provision of Data
  - Data Rights
  - Data Reuse
  - Data Identification
  - Data Availability
  - Data Accuracy
- Control Sharing (Aspects of sharing control to be considered with rights and priorities being clearly understood.)
  - Provision of Control
  - Control Rights
  - Control Restrictions
  - Control Priority
  - Control Availability
- Connections (Defines how the connection is made.)
  - Provision of Equipment
  - Physical Access Point
  - Demarcation Point
  - Security
  - Configuration Management
  - Standards and Protocols
- System Documentation
- Operations
  - Contacts
  - Hours of Operations
  - Responsibilities
- Maintenance
  - Contacts
  - Hours of Operations
  - Responsibilities
  - Response Time
- Liability
  - Indemnity
  - Damage to Equipment
  - Liability
- Ownership
  - Equipment
  - Software
  - Intellectual Property
- Coordination
  - Notification

  - Periodic Reporting
  - Pre-Change Coordination Meeting
- Dispute Resolution
- Termination of Agreement
- Compensation

5.5 System Functional Requirements, Interface Requirements and Information Exchanges

The CDOT Region 2 ITS Architecture is a combination of multiple ITS efforts. The system functional requirements, interface requirements, and information exchanges for the CDOT Region 2 ITS Architecture incorporate aspects of both the Pueblo FMS and the Colorado Springs C2C ITS project architectures. The CDOT Region 2 ITS Architecture uses the National ITS Architecture as a basis for the development of a number of architecture flow diagrams that represent the system functional requirements, interface requirements, and information exchanges for the region. Previous sections of this report have illustrated how the National ITS Architecture can be used to develop architecture diagrams that depict subsystems, equipment packages, and architecture flows for a given ITS design.

The CDOT Region 2 system will incorporate a total of seven entities including CDOT Region 2, Pueblo Transportation, Pueblo Police, CSP, CDOT ITS Office, Colorado Springs, and CVISN. Due to the complexity and magnitude of the complete CDOT Region 2 ITS Architecture, a number of separate architecture diagrams have been developed. One diagram has been developed for each entity within the region. Potential links to transit agencies in Colorado Springs and Pueblo are provided. The architecture flow diagrams summarize the flow of information between each of the entities within CDOT Region 2 as well as the interface requirements for each of these entities. These diagrams also identify each of the equipment packages that will be required to meet the system functional requirements for the region. The required equipment packages are indicated on each of the architecture diagrams. These equipment packages are based upon the market packages that will be deployed for the region. Appendix A contains each of the entity architecture flow diagrams as follows:

- Figure A-3: CDOT Region 2 ITS Architecture - CDOT Region 2 View
- Figure A-4: CDOT Region 2 ITS Architecture - - Pueblo Transportation View
- Figure A-5: CDOT Region 2 ITS Architecture - Pueblo Police View
- Figure A-6: CDOT Region 2 ITS Architecture - Colorado State Patrol View
- Figure A-7: CDOT Region 2 ITS Architecture - CDOT ITS Office Architecture
- Figure A-8: CDOT Region 2 ITS Architecture - Colorado Springs View
- Figure A-9: CDOT Region 2 ITS Architecture - CVISN View

For clarity, the Archived Data Management architecture flows have been removed from each of the CDOT Region 2 entity diagrams. These flows have been compiled into a single architecture flow diagram. This diagram combines market packages, representing the architecture flows from a market package perspective rather than the perspective of a specific entity. The ITS Data Mart market package will be implemented for all CDOT Region 2 entities with the exception of the Pueblo Police Department and CVISN. CDOT ITS Office will act as the ITS Data Warehouse. Appendix A - Figure A-10 provides the CDOT Region 2 ITS Architecture – Archived Data Management View.

5.6 Identification of ITS Standards

The CDOT Region 2 ITS Architecture will build upon the common equipment and standards identified for the statewide ITS initiatives, Pueblo FMS, and Colorado Springs C2C projects. These include:

- Shared Resources Fiber Optic Network
- Common Communications Equipment
- Common DMS Equipment
- NTCIP 1203 Object Definitions for Dynamic Message Signs (DMS)
- NTCIP 2304 Application Profile for Data Exchange ASN.1 (DATEX – ASN) Center-to-Center Protocol

However, as the updated CTMS comes on line and the C2C applications are developed along with other new ITS projects, the emerging ITS standards should be reviewed for applicability to each project and how they can support regional integration and interoperability. Table 5-1 provided the set of market packages that have been or most likely will be deployed in CDOT Region 2. These market packages were compared against applicable ITS standards. The results are present in Appendix B. Market packages are shown on the right by type and the standards are presented alphabetically across the top. Applicable standards by market package are indicated by check marks. US DOT maintains an up-to-date summary on the status of ITS standards (http://www.its-standards.net/). This summary document provides an explanation of each standard and provides additional contact information to obtain more details. However, because ITS standards are under active development, information is being updated regularly at the US DOT website and should be consulted for the latest information. The table provides an overview of relevant standards and can serve as a starting point for determining applicable ITS standards to be used during project development. Key standards that will support interoperability are discussed below.

5.6.1 Common Standards

There are a series of standards that define terms, message sets and foundation standards that cut across many market packages. These standards form the basis for interoperability among systems by defining a common set of terms and message sets. Key standards that should be adopted and used by regional jurisdictions in the development of ITS applications include:

- **Data Dictionary for Advanced Traveler Information System (ATIS)**: A minimum set of medium- independent data elements needed by potential information service providers to deploy ATIS services and provide the basis for future interoperability of ATIS devices.
- **Message Set for Advanced Traveler Information System (ATIS)**: A basic message set using the data elements from the ATIS data dictionary needed by potential information service providers to deploy ATIS services and to provide the basis for future interoperability of ATIS devices.
- **Message Sets for External TMC Communication (MS/ ETMCC)**: A message set standard for communication between traffic management centers and other ITS centers, including information service providers, emergency management systems, emissions management systems, and transit management systems.

- **National Location Referencing Information Report**: A basis for location referencing standardization activities by various application communities and Standards Development Organization(s) (SDOs).
- **Standard for Common Incident Management Message Sets (IMMS) for use by EMC**: Standards describing the form and content of the incident management messages sets for emergency management systems (EMS) to traffic management systems (TMS) and from emergency management systems to the emergency telephone system (ETS) or (E911).
- **Standard for Data Dictionaries for Intelligent Transportation Systems**: A set of meta entities and meta attributes for ITS data dictionaries, as well as associated conventions and schemas, that enable describing, standardizing, and managing all ITS data.
- **Standard for Functional Level Traffic Management Data Dictionary (TMDD)**: This document contains data elements for roadway links and for incidents and traffic- disruptive roadway events. It includes data elements for traffic control, ramp metering, traffic modeling, video camera control traffic, parking management and weather forecasting, as well as data elements related to detectors, actuated signal controllers, vehicle probes, and dynamic message signs.
- **Standard for Traffic Incident Management Message Sets for Use by EMCs**: Enables consistent standardized communications among Incident Management Centers, Fleet and Freight Management Centers, Information Service Providers, Emergency Management Centers, Planning Subsystems, Traffic Management Centers and Transit Management Centers.

These key baseline standards are critical for the deployment of a wide range of market packages because they establish the common vocabulary that allows different systems to speak with each other.

5.6.2 National Transportation Communications for ITS Protocol

National Transportation Communications for ITS Protocol (NTCIP) provides a suite of communications protocols and data definitions for two different types of ITS communications. The first type is between two transportation management centers (or systems) that is called center-to-center (C2C). The second type is the link from a transportation management system or center to a field device like a traffic signal or dynamic message sign. The second type is call center to field (C2F). Additional information on NTCIP standards is found at the following website - http://www.ntcip.org/index.html.

The preferred C2C standard is NTCIP 2304 Application Profile for Data Exchange ASN.1 (DATEX – ASN) Center-to-Center protocol that will be implemented on a statewide basis at this time.

For C2F applications, NTCIP offers the potential for interchangeability and interoperability of equipment from different suppliers on the same system. This family of standards provides both the rules for communicating (called protocols) and the vocabulary (called objects) necessary to allow electronic traffic control equipment from different manufacturers and transportation management centers to operate with each other as a system.[23] Key C2F standards that should be adopted and used by regional

[23] U.S. Department of Transportation, Intelligent Transportation Systems, Standards Fact Sheet, October 1999, AASHTO/ITE/NEMA TS 3.1, National Transportation Communications for ITS Protocol (NTCIP) Overview

jurisdictions are shown in Table 5-9 below. CDOT has already adopted an NTCIP compliant DMS protocol.

5.6.3 Transit Communications Interface Profiles

Institute of Transportation Engineers with funding from the US Department of Transportation's Joint Program Office for ITS is managing the Transit Communications Interface Profiles (TCIP) Project. TCIP is a suite of data interface standards for the transit industry (http://www.tcip.org/). This suite of standards includes the wide range of transit ITS applications. A summary of the TCIP standards is found on the website. As other transit ITS applications are considered for implementation, the emerging TCIP standards should be considered.

Table 5-9: NTCIP Center to Field Standards

NTCIP STANDARD	NAME	DESCRIPTION
NTCIP 1202	Object Definitions for Actuated Traffic Signal Controller Units	Specifications for objects that are specific to actuated signal controllers and definitions of standardized object groups that can be used for conformance statements.
NTCIP 1203	Object Definitions for Dynamic Message Signs	Defines data that is specific to dynamic message signs including all types of signs that can change state, such as blank- out signs, changeable signs, and variable signs.
NTCIP 1204	Object Definitions for Environmental Sensor Stations & Roadside Weather Information System	Definitions of objects that are specific to environmental sensor stations (ESS) and object groups, which can be used for conformance statements.
NTCIP 1205	Data Dictionary for Closed Circuit Television (CCTV)	A database for Closed Circuit Television systems. The format of the database is identical to other NTCIP devices and uses ASN. 1 representation. Targeted devices include cameras, lenses, video switches, and positioning controls for aiming and identification, such as videotext overlays.
NTCIP 1206	Data Collection and Monitoring Devices	Specifies object definitions that may be supported by data collection and monitoring devices, such as roadway loop detectors.
NTCIP 1207	Ramp Meter Controller Objects	Specifications for objects that are specific to ramp metering controller operations.
NTCIP 1208	Object Definitions for Video Switches	Deals with the data needed to control a video switch enabling multiple monitors to view multiple video feeds.

NTCIP STANDARD	NAME	DESCRIPTION
NTCIP 1209	Transportation System Sensor Objects	Object definitions that are specific to and guide the data exchange content between advanced sensors and other devices in an NTCIP network. Advanced sensors include video- based detection sensors, inductive loop detectors, sonic detectors, infrared detectors, and microwave/ radar detectors.
NTCIP 1210	Objects for Signal Systems Master	This standard will define the objects necessary to manage a field master.

5.7 Sequence Of Projects Required For Implementation

There are several ITS projects that will lay the foundation for other planned and future regional ITS applications. The Specific projects that will need to be implemented to support data and control sharing among jurisdictions and agencies are:

- **Pueblo FMS**: The installation of the FMS in the Pueblo area provides the southern anchor for ITS deployment in Region 2 and allows Pueblo area agencies to share information and control. This project also provides a link to the CTMC for the sharing of information and control.
- **Colorado Springs C2C Link**: This first C2C electronic link will provide the basis for future links between the CTMC and other traffic management centers.
- **Shared Resources Fiber Communications Network**: This high-speed fiber backbone communication network is critical for the transfer of information among the participating agencies in Region 2 and beyond.
- **Updated CTMS**: The updating of the CTMS to a fully functional advanced transportation management and traveler information system will provide CTMC with the platform to support future integration with transportation management centers across the state.

6. NEXT STEPS

The CDOT Region 2 ITS Architecture provides a framework for the deployment of ITS applications. The Region 2 Architecture incorporates the existing and planned ITS projects and provides a roadmap for future deployment. Additional planning efforts will be required in the future as transit ITS applications and highway applications off the I-25 corridor are considered. The regional ITS Architecture will need to be updated to reflect these additions.

APPENDIX A

Region 2 ITS Architecture Diagrams

APPENDIX A: REGIONAL ITS ARCHITECTURE DIAGRAMS

APPENDIX B

Market Packages and Applicable Standards

APPENDIX B: MARKET PACKAGES AND APPLICABLE STANDARDS

Figure B-1: Market Packages and Applicable Standards

APPENDIX C

National ITS Architecture Definitions

APPENDIX C: NATIONAL ITS ARCHITECTURE DEFINITIONS

MARKET PACKAGES

ITS Data Mart: This market package provides a focused archive that houses data collected and owned by a single agency, district, private sector provider, research institution, or other organization. This focused archive typically includes data covering a single transportation mode and one jurisdiction that is collected from an operational data store and archived for future use. It provides the basic data quality, data privacy, and meta data management common to all ITS archives and provides general query and report access to archive data users.

ITS Data Warehouse: This market package includes all the data collection and management capabilities provided by the ITS Data Mart, and adds the functionality and interface definitions that allow collection of data from multiple agencies and data sources spanning across modal and jurisdictional boundaries. It performs the additional transformations and provides the additional meta data management features that are necessary so that all this data can be managed in a single repository with consistent formats. The potential for large volumes of varied data suggests additional on-line analysis and data mining features that are also included in this market package in addition to the basic query and reporting user access features offered by the ITS Data Mart.

Transit Vehicle Tracking: This market package provides for an Automated Vehicle Location System to track the transit vehicle's real time schedule adherence and updates the transit system's schedule in real-time. Vehicle position may be determined either by the vehicle (e.g., through GPS) and relayed to the infrastructure or may be determined directly by the communications infrastructure. A two-way wireless communication link with the Transit Management Subsystem is used for relaying vehicle position and control measures. Fixed route transit systems may also employ beacons along the route to enable position determination and facilitate communications with each vehicle at fixed intervals. The Transit Management Subsystem processes this information, updates the transit schedule and makes real-time schedule information available to the Information Service Provider Subsystem via a wireline link.

Transit Fixed-Route Operations: This market package performs automatic driver assignment and monitoring, as well as vehicle routing and scheduling for fixed-route services. This service uses the existing AVL database as a source for current schedule performance data, and is implemented through data processing and information display at the transit management subsystem. This data is exchanged using the existing wireline link to the information service provider where it is integrated with that from other transportation modes (e.g. rail, ferry, air) to provide the public with integrated and personalized dynamic schedules

Demand Response Transit Operations: This market package performs automatic driver assignment and monitoring as well as vehicle routing and scheduling for demand response transit services. This package uses the existing AVL database to monitor current status of the transit fleet and supports allocation of these fleet resources to service incoming requests for transit service while also considering traffic conditions. The Transit Management Subsystem provides the necessary data processing and information display to assist the transit operator in making optimal use of the transit fleet. The Information Service Provider Subsystem may be either be operated by transit management center or be independently owned and operated by a separate service provider. In the first scenario, the traveler

makes a direct request to a specific paratransit service. In the second scenario, a third party service provider determines the paratransit service is a viable means of satisfying a traveler request and uses wireline communications to make a reservation for the traveler.

Transit Passenger and Fare Management: This market package allows for the management of passenger loading and fare payments on-board vehicles using electronic means. The payment instrument may be either a stored value or credit card. This package is implemented with sensors mounted on the vehicle to permit the driver and central operations to determine vehicle loads, and readers located either in the infrastructure or on-board the transit vehicle to allow fare payment. Data is processed, stored, and displayed on the transit vehicle and communicated as needed to the Transit Management Subsystem using existing wireless infrastructure.

Transit Security: This market package provides for the physical security of transit passengers. An on-board security system is deployed to perform surveillance and warn of potentially hazardous situations. Public areas (e.g. stops, park and ride lots, stations) are also monitored. Information is communicated to the Transit Management Subsystem using the existing or emerging wireless (vehicle to center) or wireline (area to center) infrastructure. Security related information is also transmitted to the Emergency Management Subsystem when an emergency is identified that requires an external response. Incident information is communicated to the Information Service Provider.

Transit Maintenance: This market package supports automatic maintenance scheduling and monitoring. On-board condition sensors monitor critical system status and transmit critical status information to the Transit Management Subsystem. Hardware and software in the Transit Management Subsystem processes this data and schedules maintenance activities.

Multi-Modal Coordination: This market package establishes two way communications between multiple transit and traffic agencies to improve service coordination. Intermodal coordination between transit agencies can increase traveler convenience at transfer points and also improve operating efficiency. Coordination between traffic and transit management is intended to improve on-time performance of the transit system to the extent that this can be accommodated without degrading overall performance of the traffic network. More limited local coordination between the transit vehicle and the individual intersection for signal priority is also supported by this package.

Transit Traveler Information: This market package provides transit users at transit stops and on-board transit vehicles with ready access to transit information. The information services include transit stop annunciation, imminent arrival signs, and real-time transit schedule displays that are of general interest to transit users. Systems that provide custom transit trip itineraries and other tailored transit information services are also represented by this market package.

Broadcast Traveler Information: This market package provides the user with a basic set of ATIS services; its objective is early acceptance. It involves the collection of traffic conditions, advisories, general public transportation, toll and parking information, incident information, air quality and weather information, and the near real time dissemination of this information over a wide area through existing infrastructures and low cost user equipment (e.g., FM subcarrier, cellular data broadcast). Different from the market package ATMS6--Traffic Information Dissemination--which provides the more basic HAR and DMS information capabilities, ATIS1 provides the more sophisticated digital broadcast service.

Successful deployment of this market package relies on availability of real-time traveler information from roadway instrumentation, probe vehicles or other sources.

Interactive Traveler Information: This market package provides tailored information in response to a traveler request. Both real-time interactive request/response systems and information systems that "push" a tailored stream of information to the traveler based on a submitted profile are supported. The traveler can obtain current information regarding traffic conditions, transit services, ride share/ride match, parking management, and pricing information. A range of two-way wide-area wireless and wireline communications systems may be used to support the required digital communications between traveler and the information service provider. A variety of interactive devices may be used by the traveler to access information prior to a trip or en-route to include phone, kiosk, Personal Digital Assistant, personal computer, and a variety of in-vehicle devices. Successful deployment of this market package relies on availability of real-time transportation data from roadway instrumentation, probe vehicles or other means.

Network Surveillance: This market package includes traffic detectors, other surveillance equipment, the supporting field equipment, and wireline communications to transmit the collected data back to the Traffic Management Subsystem. The derived data can be used locally such as when traffic detectors are connected directly to a signal control system or remotely (e.g., when a CCTV system sends data back to the Traffic Management Subsystem). The data generated by this market package enables traffic managers to monitor traffic and road conditions, identify and verify incidents, detect faults in indicator operations, and collect census data for traffic strategy development and long range planning. The collected data can also be analyzed and made available to users and the Information Service Provider Subsystem.

Probe Surveillance: This market package provides an alternative approach for surveillance of the roadway network. Two general implementation paths are supported by this market package: 1) wide-area wireless communications between the vehicle and Information Service Provider is used to communicate current vehicle location and status, and 2) dedicated short range communications between the vehicle and roadside is used to provide equivalent information back to the Traffic Management Subsystem. The first approach leverages wide area communications equipment that may already be in the vehicle to support personal safety and advanced traveler information services. The second approach utilizes vehicle equipment that supports toll collection, in-vehicle signing, and other short range communications applications identified within the architecture. The market package enables traffic managers to monitor road conditions, identify incidents, analyze and reduce the collected data, and make it available to users and private information providers. It requires one of the communications options identified above, roadside beacons and wireline communications for the short range communications option, data reduction software, and utilizes wireline links between the Traffic Management Subsystem and Information Service Provider Subsystem to share the collected information. Both “Opt out” and “Opt in” strategies are available to ensure the user has the ability to turn off the probe functions to ensure individual privacy. Due to the large volume of data collected by probes, data reduction techniques are required in this market package which include the ability to identify and filter out-of-bounds or extreme data reports.

Surface Street Control: This market package provides the central control and monitoring equipment, communication links, and the signal control equipment that support local surface street control and/or arterial traffic management. A range of traffic signal control systems are represented by this market

package ranging from static pre-timed control systems to fully traffic responsive systems that dynamically adjust control plans and strategies based on current traffic conditions and priority requests. Additionally, general advisory and traffic control information can be provided to the driver while en-route. This market package is generally an intra-jurisdictional package that does not rely on real-time communications between separate control systems to achieve area-wide traffic signal coordination. Systems that achieve coordination across jurisdictions by using a common time base or other strategies that do not require real time coordination would be represented by this package. This market package is consistent with typical urban traffic signal control systems.

Freeway Control: This market package provides the communications and roadside equipment to support ramp control, lane controls, and interchange control for freeways. Coordination and integration of ramp meters are included as part of this market package. This package is consistent with typical urban traffic freeway control systems. This package incorporates the instrumentation included in the Network Surveillance Market Package to support freeway monitoring and adaptive strategies as an option.

This market package also includes the capability to utilize surveillance information for detection of incidents. Typically, the processing would be performed at a traffic management center; however, developments might allow for point detection with roadway equipment. For example, a CCTV might include the capability to detect an incident based upon image changes. Additionally, this market package allows general advisory and traffic control information to be provided to the driver while en-route.

Traffic Information Dissemination: This market package allows traffic information to be disseminated to drivers and vehicles using roadway equipment such as dynamic message signs or highway advisory radio. This package provides a tool that can be used to notify drivers of incidents; careful placement of the roadway equipment provides the information at points in the network where the drivers have recourse and can tailor their routes to account for the new information. This package also covers the equipment and interfaces that provide traffic information from a traffic management center to the media (for instance via a direct tie-in between a traffic management center and radio or television station computer systems), transit management center, emergency management center, and information service provider.

Regional Traffic Control: This market package advances the Surface Street Control and Freeway Control Market Packages by adding the communications links and integrated control strategies that enable integrated Interjurisdictional traffic control. This market package provides for the sharing of traffic information and control among traffic management centers to support a regional control strategy. The nature of optimization and extent of information and control sharing is determined through working arrangements between jurisdictions. This package relies principally on roadside instrumentation supported by the Surface Street Control and Freeway Control Market Packages and adds hardware, software, and wireline communications capabilities to implement traffic management strategies which are coordinated between allied traffic management centers. Several levels of coordination are supported from sharing of information through sharing of control between traffic management centers.

Incident Management System: This market package manages both predicted and unexpected incidents so that the impact to the transportation network and traveler safety is minimized. Requisite incident detection capabilities are included in the freeway control market package and through the regional coordination with other traffic management and emergency management centers, weather service entities, and event promoters supported by this market package. Information from these diverse sources

are collected and correlated by this market package to detect and verify incidents and implement an appropriate response. This market package provides Traffic Management Subsystem equipment that supports traffic operations personnel in developing an appropriate response in coordination with emergency management and other incident response personnel to confirmed incidents. The response may include traffic control strategy modifications and presentation of information to affected travelers using the Traffic Information Dissemination market package. The same equipment assists the operator by monitoring incident status as the response unfolds. The coordination with emergency management might be through a CAD system or through other communication with emergency field personnel. The coordination can also extend to tow trucks and other field service personnel.

Standard Railroad Grade Crossing: This market package manages highway traffic at highway-rail intersections (HRIs) where operational requirements do not dictate more advanced features (e.g., where rail operational speeds are less than 80 miles per hour). Both passive (e.g., the crossbuck sign) and active warning systems (e.g., flashing lights and gates) are supported. (Note that passive systems exercise only the single interface between the roadway subsystem and the driver in the architecture definition.) These traditional HRI warning systems may also be augmented with other standard traffic management devices. The warning systems are activated on notification by interfaced wayside equipment of an approaching train. The equipment at the HRI may also be interconnected with adjacent signalized intersections so that local control can be adapted to highway-rail intersection activities. Health monitoring of the HRI equipment and interfaces is performed; detected abnormalities are reported to both highway and railroad officials through wayside interfaces and interfaces to the traffic management subsystem. Similar interfaces and services are provided for other types of multimodal crossings (e.g., draw bridges).

Parking Facility Management: This market package provides enhanced monitoring and management of parking facilities. The included equipment assists in the management of parking operations, coordinates with transportation authorities, and supports electronic collection of parking fees. This is performed by sensing and collecting current parking facilities status, sharing the data with information service providers and traffic operations, and automatic fee collection using short range communications with the same in-vehicle equipment utilized for electronic toll collection.

Road Weather Information System: This market package monitors current and forecast road and weather conditions using a combination of weather service information and data collected from environmental sensors deployed on and about the roadway. The collected road weather information is monitored and analyzed to detect and forecast environmental hazards such as icy road conditions, dense fog, and approaching severe weather fronts. This information can be used to more effectively deploy road maintenance resources, issue general traveler advisories, and support location specific warnings to drivers using the Traffic Information Dissemination Market Package.

Fleet Administration: This market package keeps track of vehicle location, itineraries, and fuel usage at the Fleet and Freight Management Subsystem using a cell based or satellite data link and the pre-existing wireless infrastructure. The vehicle has a processor to interface to its sensor (e.g., fuel gauge) and to the cellular data link. The Fleet and Freight Management Subsystem can provide the vehicle with dispatch instructions, and can process and respond to requests for assistance and general information from the vehicle via the cellular data link. The market package also provides the Fleet Manager with connectivity to intermodal transportation providers using the existing wireline infrastructure.

Freight Administration: This market package tracks cargo and the cargo condition. This information is communicated with the Fleet and Freight Management Subsystem via the existing wireless infrastructure. Interconnections are provided to intermodal shippers and intermodal freight depots for tracking the cargo from source to destination.

Electronic Clearance: This market package provides for automated clearance at roadside check facilities. The roadside check facility communicates with the Commercial Vehicle Administration subsystem over wireline to retrieve infrastructure snapshots of critical carrier, vehicle, and driver data to be used to sort passing vehicles. This package allows a good driver/vehicle/carrier to pass roadside facilities at highway speeds using transponders and dedicated short range communications to the roadside. The roadside check facility may be equipped with AVI, weighing sensors, transponder read/write devices, computer workstation processing hardware, software, and databases.

CV Administrative Processes: This market package provides for electronic application, processing, fee collection, issuance, and distribution of CVO credential and tax filing. Through this process, carriers, drivers, and vehicles may be enrolled in the electronic clearance program provided by a separate market package which allows commercial vehicles to be screened at mainline speeds at commercial vehicle check points. Through this enrollment process, current profile databases are maintained in the Commercial Vehicle Administration Subsystem and snapshots of this database are made available to the commercial vehicle check facilities at the roadside to support the electronic clearance process.

International Border Electronic Clearance: This market package provides for automated clearance specific to international border crossings. This package augments the electronic clearance package by allowing interface with customs related functions and permitting NAFTA required entry and exit from the US to Canada and Mexico.

Weigh-In-Motion: This market package provides for high speed weigh-in-motion with or without AVI attachment. Primarily this market package provides the roadside with additional equipment, either fixed or removable. If the equipment is fixed, then it is thought to be an addition to the electronic clearance and would work in conjunction with the AVI and AVC equipment in place.

Roadside CVO Safety: This market package provides for automated roadside safety monitoring and reporting. It automates commercial vehicle safety inspections at the Commercial Vehicle Check roadside element. The capabilities for performing the safety inspection are shared between this market package and the On-Board CVO Safety Market Package which enables a variety of implementation options. The basic option, directly supported by this market package, facilitates safety inspection of vehicles that have been pulled in, perhaps as a result of the automated screening process provided by the Electronic Clearance Market Package. In this scenario, only basic identification data and status information is read from the electronic tag on the commercial vehicle. The identification data from the tag enables access to additional safety data maintained in the infrastructure which is used to support the safety inspection, and may also inform the pull-in decision if system timing requirements can be met. More advanced implementations, supported by the On-Board CVO Safety market package, utilize additional vehicle safety monitoring and reporting capabilities in the commercial vehicle to augment the roadside safety check.

On-Board CVO Safety: This market package provides for on-board commercial vehicle safety monitoring and reporting. It is an enhancement of the Roadside CVO Safety Market Package and

includes roadside support for reading on-board safety data via tags. This market package uses the same communication links as the Roadside CVO Safety Market Package, and provides the commercial vehicle with a wireless link (data and possibly voice) to the Fleet and Freight Management and the Emergency Management Subsystems. Safety warnings are provided to the driver as a priority with secondary requirements to notify the Fleet and Freight Management and Commercial Vehicle Check roadside elements.

CVO Fleet Maintenance: This market package supports maintenance of CVO fleet vehicles through close interface with on-board monitoring equipment and AVLS capabilities with in the Fleet and Freight Management Subsystem. Records of vehicle mileage, repairs, and safety violations are maintained to assure safe vehicles on the highway.

HAZMAT Management: This market package integrates incident management capabilities with commercial vehicle tracking to assure effective treatment of HAZMAT material and incidents. HAZMAT tracking is performed by the Fleet and Freight Management Subsystem. The Emergency Management subsystem is notified by the Commercial Vehicle if an incident occurs and coordinates the response. The response is tailored based on information that is provided as part of the original incident notification or derived from supplemental information provided by the Fleet and Freight Management Subsystem. The latter information can be provided prior to the beginning of the trip or gathered following the incident depending on the selected policy and implementation.

Emergency Response: This market package provides the computer-aided dispatch systems, emergency vehicle equipment, and wireless communications that enable safe and rapid deployment of appropriate resources to an emergency. Coordination between Emergency Management Subsystems supports emergency notification and coordinated response between agencies. Existing wide area wireless communications would be utilized between the Emergency Management Subsystem and an Emergency Vehicle to enable an incident command system to be established and supported at the emergency location. The Emergency Management Subsystem would include hardware and software for tracking the emergency vehicles. Public safety, traffic management, and many other allied agencies may each participate in the coordinated response managed by this package.

Emergency Routing: This market package supports dynamic routing of emergency vehicles and coordination with the Traffic Management Subsystem for special priority on the selected route(s). The Information Service Provider Subsystem supports routing for the emergency fleet based on real-time traffic conditions and the emergency routes assigned to other responding vehicles. In this market package, the Information Service Provider Subsystem would typically be integrated with the Emergency Management Subsystem in a public safety communications center. The Emergency Vehicle would also optionally be equipped with dedicated short-range communications for local signal preemption.

Mayday Support: This package allows the user (driver or non-driver) to initiate a request for emergency assistance and enables the Emergency Management Subsystem to locate the user and determine the appropriate response. The Emergency Management Subsystem may be operated by the public sector or by a private sector provider. The request from the traveler needing assistance may be manually initiated or automated and linked to vehicle sensors. The data is sent to the Emergency Management subsystem using wide area wireless communications with voice as an option. Providing user location implies either a location technology within the user device or location determination within the communications infrastructure.

EQUIPMENT PACKAGES

Basic Information Broadcast: This Equipment package provides the capabilities to collect, process, store, bill, and disseminate traveler information including traveler, transit, ridematching, traffic, and parking information. The traveler information shall include maintaining a database of local area services available to travelers with up-to-the-minute information and providing an interactive connectivity between, sponsors, and providers of services. The transit information shall include the latest available information on transit routes and schedules, transit transfer options, transit fares, and real-time schedule adherence. The traffic information shall include latest available information on traffic and highway conditions, and current situation information in real-time including incidents, road construction, recommended routes, current speeds on specific routes, current parking conditions in key areas, schedules for any current or soon to start events, and current weather situations. This Equipment package shall also provide users with real-time travel related information while they are traveling, and disseminate to assist the travelers in making decisions about transfers and modification of trips. These capabilities shall be provided using equipment such as a fixed facility with a communications system such as a data Subcarrier multiplexing device.

Basic Vehicle Reception: This Equipment package shall provide the capability for drivers to interface with the ISP Subsystem Basic Information Broadcast Equipment package and receive formatted traffic advisories including accurate traveling information concerning available travel options and their availability, and congestion information in their vehicle. These capabilities shall be based upon the reception of infrastructure information using in-vehicle devices such as an in-vehicle AM/FM radio with data Subcarrier connected with the existing audio system and a dash-mounted LCD.

Citation and Accident Electronic Recording: The equipment package documents violations and forwards the information to the Commercial vehicle if available and to the CVAS for processing as part of the normal credentials processing package

Collect Traffic Surveillance: This Equipment package collects, stores, and provides electronic access to the traffic surveillance data.

Credentials and Taxes Administration: This Equipment package provides administrative capabilities for commercial vehicle operations including database management and administrator-to-roadside and administrator-to-administrator interfaces. For example, this Equipment package would manage the electronic credentials database for a state, perform reconciliation of mileage and fuel taxes (possibly post trip), and interface with roadsides performing credential checks. This equipment package communicates with similar packages in other CVAS locations to exchange credentials database information. Example locations would be state agency or regional offices that are involved with commercial vehicle operations.

CV Data Collection: This equipment package collects and stores commercial vehicle information that is collected in the course of Commercial Vehicle Administration Subsystem operations. This data can be used directly by operations personnel or it can be made available to other data users and archives in the region.

CV Information Exchange: This equipment package supports the exchange of safety and credentials data among jurisdiction. The package also supports the exchange of safety and credentials data between

agencies (for example, an administrative center and the roadside check facilities) within a single jurisdiction. Data are collected from multiple authoritative sources and packaged into snapshots (top-level summary and critical status information) and profiles (detailed and historical data).

CV Safety Administration: This Equipment package augments the Credentials and Taxes Administration Equipment package with safety data. This package ensures that safety criteria are available for automated roadside safety checks. Supports the collection and review of carrier safety data and determines the carrier safety rating based on criteria supplied by Government Administration

Emergency Call-Taking: This Equipment package supports the emergency call-taker, collecting available information about the caller and the reported emergency, and forwarding this information to other equipment packages that formulate and manage the emergency response. This equipment package receives 9-1-1, 7-digit local access, and motorist call-box calls and interfaces to other agencies to assist in the verification and assessment of the emergency and to forward the emergency information to the appropriate response agency.

Emergency Data Collection: This equipment package collects and stores emergency information that is collected in the course of operations by the Emergency Management Subsystem. This data can be used directly by operations personnel or it can be made available to other data users and archives in the region.

Emergency Dispatch: This Equipment package supports efficient dispatch of emergency vehicles. It tracks emergency vehicles, dispatches these vehicles to an incident, and provides safe and efficient routes based on real-time traffic information.

Emergency Response Management: This Equipment package develops and stores emergency response plans and manages overall coordinated response to emergencies. It tracks the availability of resources and assists in the appropriate allocation of these resources for a particular emergency response. This Equipment package provides coordination between multiple allied agencies before and during emergencies to implement emergency response plans and track progress through the incident. It provides vital communications linkages which provide real-time information to emergency response personnel in the field.

Emissions Data Collection: This equipment package collects and stores air quality and emissions management information that is collected in the course of Emissions Management Subsystem operations. This data can be used directly by operations personnel or it can be made available to other data users and archives in the region.

Fleet Credentials and Taxes Management and Reporting: This Equipment package provides the Fleet and Freight Management Subsystem the capabilities to purchase credentials and file trip reports electronically by the fleet managers, to perform automated enrollment at the roadside facilities, and electronically manage the credentials checking by the roadside commercial vehicle inspectors. The electronic purchase shall be performed in accordance with developing standards such that a single integrated system for electronic payments might develop ensuring that deployment across multiple agency political boundaries is performed without degradation. Inherent to credential management shall be the management of the vehicles, with a prerequisite of the vehicle tracking software from the Fleet Administration Equipment package.

Fleet HAZMAT Management: This Equipment package provides the Fleet and Freight Management Subsystem the capabilities to enhance the Fleet Administration Equipment package functions by adding HAZMAT tracking. The additional requirements to perform this function include enhanced processing and enhanced fleet management software. In order to effectively track HAZMAT cargo, communication interfaces to Information Service Providers, and Emergency Management Subsystems shall be provided, including additional communication software.

Government Reporting Systems Support: This equipment package selects and formats data residing in an ITS archive to facilitate local, state, and federal government data reporting requirements.

HRI Traffic Management: This equipment package monitors highway-rail intersection (HRI) equipment at the roadside which manages highway traffic. Various levels of roadside equipment may be interfaced to, and supported by, this equipment package to include standard speed active warning systems and high speed systems which provide additional information on approaching trains and detect and report on obstructions in the HRI. This equipment package remotely monitors and reports the status of this roadside equipment. A two way interface supports explicitly status requests or remote control plan updates to be generated by this equipment package. Status may also be received periodically in the absence of a request or asynchronously in the event of a detected failure or other unsafe condition at the intersection.

Interactive Infrastructure Information: This Equipment package shall have as prerequisite the capabilities of the Basic Information Broadcast Equipment package. This Equipment package augments the Basic Information Broadcast Equipment package by providing the capabilities for interactive traveler information.

Interactive Vehicle Reception: This Equipment package shall provide the capability for drivers to interface with the ISP Subsystem Infrastructure Equipment packages including the Interactive Infrastructure Information Equipment package, the Infrastructure Provided Route Selection, Yellow Pages and Reservation, and Dynamic Ridesharing Equipment packages. These capabilities shall be provided using the Vehicle Subsystem equipment.

ISP Data Collection: This equipment package collects and stores traveler information that is collected in the course of operation of the ISP subsystem. This data can be used directly by operations personnel or it can be made available to other data users and archives in the region.

ISP Probe Information Collection: This Equipment package supports the collection of vehicle probe data by the ISP. It provides the capability to accept and process probe vehicle information. This capability shall be provided through the use of additional hardware and probe vehicle control and tracking software.

ITS Data Repository: This equipment package collects data and data catalogs from one or more data sources and stores the data in a focused repository that is suited to a particular set of ITS data users. This equipment package includes capabilities for performing quality checks on the incoming data, error notification, and archive to archive coordination. This equipment package supports a broad range of implementations, ranging from simple data marts that collect a focused set of data and serve a particular user community to large-scale data warehouses that collect, integrate, and summarize transportation data from multiple sources and serve a broad array of users within a region.

Mayday Support: This Equipment package receives Mayday messages, determines an appropriate response, and either uses internal resources or contacts a local agency to provide that response. The nature of the emergency is determined based on the information in the mayday message as well as other inputs. This package effectively serves as an interface between automated mobile mayday systems and the local public safety answering point for messages which require a public safety response.

On-Board Cargo Monitoring: This Equipment package provides the Commercial Vehicle Subsystem the capability to monitor both interstate and intrastate cargo safety such that enforcement and HAZMAT response teams can be provided with timely and accurate information. This includes only the equipment on board the cargo container such as a communication device, possibly the addition of a cell-based radio, and equipment for the processing and storage of cargo material. This can also include optional sensors for temperature, pressure, load leveling, or acceleration depending upon the items monitored. It is already expected that the cargo location devices such as GPS equipment and an integration processor already exist. These items are presented as part of the On-board Trip Monitoring Equipment package.

On-Board CV Electronic Data: This Equipment package provides the Commercial Vehicle Subsystem the capability for two-way data exchange between the vehicle and the roadside facility with the transmission of information such as status of driver, vehicle, and carrier IDs and cargo information. The driver, vehicle and carrier are identified via the tag so that actual weight from roadside mainline weigh-in-motion may be checked. This includes only the equipment on the commercial vehicle including a processor/tag for identification, especially a HAZMAT identification. The actual reading and processing required for the credential checking and weigh-in-motion will be performed by the roadside.

On-Board EV En Route Support: This Equipment package provides capabilities that support safe and expedient arrival on the incident scene. This package provides dispatch and routing information, tracks the vehicle, and preempt signals via short range communication directly with traffic control equipment at the roadside.

On-Board EV Incident Management Communication: This Equipment package provides a direct interface between the emergency vehicle and incident management personnel.

On-Board Fixed Route Schedule Management: This Equipment package provides the capabilities for automated planning and scheduling, by collecting data for schedule generation. Capability shall also be provided to automatically determine optimum scenarios for schedule adjustment. This Equipment package also supports the capability for two-way voice communication between the transit vehicle driver and a facility, two-way data communication between the transit vehicles and a facility, on-board safety sensor data to be transmitted from the transit vehicles to a facility, and data transmission from individual facilities to a central facility for processing/analysis if desired.

On-Board Maintenance: This Equipment package provides the capability to use transit vehicle mileage data to automatically generate preventative maintenance schedules for each specific bus by utilizing vehicle tracking data and storing with a trip computer. It also provides the capability for real-time condition monitoring on board the vehicle, and transmission of this information via two-way communication to the management center.

On-Board Paratransit Operations: This equipment package forwards paratransit dispatch requests to the driver and forwards acknowledgements to the center. It coordinates with, and assists the driver in managing multi-stop runs associated with demand responsive, flexibly routed transit services.

On-Board Transit Fare and Load Management: This Equipment package provides the capability to collect data required to determine accurate ridership levels and implement variable and flexible fare structures. Support shall be provided for the traveler for use of a fare medium for all applicable surface transportation services, to pay without stopping, have payment media automatically identified as void and/or invalid and eligibility verified, and allow for third party payment. In addition, capability to provide expansion into other uses for payment medium such as retail and telephone and for off-line billing for fares paid by agencies shall be supported. This Equipment package also supports the capability for two-way voice communication between the transit vehicle driver and a facility, two-way data communication between the transit vehicles and a facility, sensor data to be transmitted from the transit vehicles to a facility, and data transmission from individual facilities to a central facility for processing/analysis if desired. These capabilities require integration with an existing On-board Trip Monitoring Equipment package.

On-Board Transit Information Services: The Equipment package furnishes enroute transit users with real-time travel-related information. Current information that can be provided to transit users includes transit routes, schedules, transfer options, fares, real-time schedule adherence, current incidents, weather conditions, and special events are provided. In addition to tailored information for individual transit users, this equipment package also supports general annunciation and/or display of general schedule information, imminent arrival information, and other information of general interest to transit users.

On-Board Transit Security: This Equipment package provides the capability to monitor the safety of transit vehicles using on-board safety sensors, processors and communications from the prerequisite On-board Trip Monitoring Equipment package.

On-Board Transit Signal Priority: This Equipment package provides the capability for transit vehicles to request signal priority through short range communication directly with traffic control equipment at the roadside.

On-Board Transit Trip Monitoring: This Equipment package provides the capabilities to support fleet management with automatic vehicle location and automated mileage and fuel reporting and auditing. This package may also record other special events resulting from communication with roadside equipment. This includes only the equipment on board the vehicle to support this function including the vehicle location devices such as GPS equipment, communication interfaces, a processor to record trip length, and the sensors/actuators/interfaces necessary to record mileage and fuel usage.

On-Line Analysis and Mining: This equipment package provides advanced data analysis, summarization, and mining features that facilitate discovery of information, patterns, and correlations in large data sets. Multidimensional analysis, selective summarization and expansion of data details, and many other advanced analysis services may be offered by various implementations of this equipment package.

Parking Data Collection: This equipment package collects and stores parking information that is collected in the course of parking system operations performed by the Parking Management Subsystem.

This data can be used directly by operations personnel or it can be made available to other data users and archives in the region.

Parking Electronic Payment: This Equipment package supports electronic payment of parking fees.

Parking Management: This Equipment package provides the capability to detect and classify properly equipped vehicles entering and exiting the parking facility, and to maintain database information with parking availability and pricing structure information. This capability shall be provided through the utilization of active/passive tag readers and database software containing parking pricing structure and current availability. Wireline communications with clearinghouse operators (the Financial Institution terminator) and the back office (the parking service provider terminator) enable processing of financial transactions and external coordination.

Parking Surveillance: This Equipment package provides the capability to detect and classify vehicles entering and exiting the parking facility and measures parking facility occupancy to support parking operations and traveler information services.

Personal Basic Information Reception: This Equipment package shall provide the capability for travelers to interface with the ISP Subsystem Basic Information Broadcast Equipment package and receive formatted traffic advisories including accurate traveling information concerning available travel options and their availability, and congestion information from their Personal Information Access Subsystem to include their homes, place of work, major trip generation sites, personal portable devices, and over multiple types of electronic media such as facsimile machines, portable AM/FM radios, and a pager processor.

Personal Interactive Information Reception: This Equipment package shall provide the capability for travelers to interface with the ISP Subsystem Infrastructure Equipment packages including the Interactive Infrastructure Information Equipment package, and the Infrastructure Provided Route Selection, Yellow Pages and Reservation, and Dynamic Ridesharing Equipment packages. These capabilities shall be provided using the Personal Information Access Subsystem equipment such as cellular telephone, interactive TV, Personal Computer, and pager with alpha display using communication medium and equipment such as two-way radio, CATV, and wireless data transceivers.

Personal Location Determination: This equipment package determines current location information and provides this information to other equipment packages that use the location information to provide various ITS services.

Personal Mayday I/F: This Equipment package shall provide the capability to initiate a distress signal and cancel a prior issued manual request for help using the Personal Information Access Subsystem. This capability shall be provided using equipment such as a processor to automatically dial the Emergency Management Subsystem and provide location.

Remote Basic Information Reception: This Equipment package shall provide the capability for travelers to interface with the ISP Subsystem Basic Information Broadcast Equipment package and receive formatted traffic advisories including accurate traveling information concerning available travel options and their availability, and congestion information at the Remote Traveler Support Subsystem.

Remote Interactive Information Reception: This Equipment package shall provide the capability for travelers to interface with the ISP Subsystem Infrastructure Equipment packages including the Interactive Infrastructure Information Equipment package, the Infrastructure Provided Route Selection, Yellow Pages and Reservation, and Dynamic Ridesharing Equipment packages. These capabilities shall be provided using the Remote Traveler Support Subsystem equipment such as interactive TV and kiosk using communication medium and equipment such as CATV and wireline and wireless data transceivers.

Remote Mayday I/F: This Equipment package provides the capability to report an emergency and summons assistance. The equipment includes a traveler interface that facilitates generation of a distress signal under duress and wireline communications that carries this distress signal and allows follow-up verification and determination of the nature of the emergency and the required response. This equipment package notifies either the Emergency Management or Transit Management Subsystem depending on the implementation.

Remote Transit Fare Management: This Equipment package provides the capability for the traveler to use a common fare medium for all applicable surface transportation services, to pay without stopping, have payment media automatically identified as void and/or invalid and eligibility verified. This may be implemented as a payment instrument reader at a kiosk. In addition, capability to provide expansion into other uses for payment medium such as retail and telephone and for off-line billing for fares paid by agencies shall be supported.

Remote Transit Information Services: The Equipment package furnishes transit users with real-time travel-related information at transit stops, multi-modal transfer points, and other public transportation areas. It provides transit users with the latest available information on transit routes, schedules, transfer options, fares, real-time schedule adherence, current incidents, weather conditions, and special events. In addition to tailored information for individual transit users, this equipment package supports general annunciation and/or display of imminent arrival information and other information of general interest to transit users.

Roadside Data Collection: This equipment package collects traffic, road, and environmental conditions information for use in transportation planning, research, and other off-line applications where data quality and completeness take precedence over real-time performance. This equipment package includes the sensors, supporting roadside infrastructure, and communications equipment that collects and transfers information to a center for archival.

Roadside Electronic Screening: This Equipment package provides the Commercial Vehicle Check Subsystem the capabilities for two-way communication with approaching properly equipped commercial vehicles at mainline speeds, reading tags for automated vehicle identification and credential checking. There will be a capability to appropriately screen all vehicles, not just those that are equipped. This Equipment package shall be able to process the data from the commercial vehicles along with accessed database information to determine whether a pull-in message is needed or to generate random pull-in messages with provisions for facility operators and enforcement officials to have manual override capabilities. Support shall be provided to both interstate and intrastate carriers.

Roadside Safety Inspection: This Equipment package provides the Commercial Vehicle Check Subsystem the capabilities for operators to automate the roadside safety inspection process including the

support of use of hand held devices to rapidly inspect the vehicle and driver. In addition this Equipment package provides the Roadside Check Subsystem the capabilities for operators to automate the roadside safety inspection process including the support of automated mainline speed reading of on-board safety data to rapidly screen the vehicle and driver. This Equipment package shall also provide the capabilities to collect, store, maintain, and provide safety data and access historical safety data after receiving identification from vehicles at mainline speeds or while stopped at the roadside. Results of screening and summary safety inspection can be written back onto the tag. The capabilities to process safety data and issue pull-in messages or provide warnings to the driver, carrier, and enforcement agencies shall be provided. These capabilities have a prerequisite of the Roadside Electronic Screening Equipment package and shall be provided primarily through the utilization of an additional safety database.

Since a vehicle may cross jurisdiction boundaries during a trip, this equipment package supports the concept of a last clearance event record (aka trip ticket) carried on the vehicle s tag. The last clearance event record reflects the results of the roadside verification action. For example, if the vehicle is pulled over in State A and undergoes credential, weight, and safety checks, the results of the clearance process are written to the vehicle s tag. If the vehicle continues the trip and passes a roadside station in State B, the State B station has access to the results of the previous pull-in because it can read the last clearance event record written by the State A roadside station.

Roadside Signal Priority: This Equipment package shall provide the capability to receive vehicle signal priority requests and control roadside signals accordingly.

Roadside WIM: This Equipment package allows for roadside high speed weigh in motion. This package can be fixed to a location or mobile. It can include an interface to the credential check package and augment electronic credentials check with electronic weight check or it can be a stand alone package with display.

Roadway Basic Surveillance: This Equipment package provides the capabilities to monitor traffic flow in major intersections and on main highways for urban areas and to monitor road conditions using fixed equipment such as loop detectors and wireline communication.

Roadway Environmental Monitoring: This Equipment package measures environmental conditions and communicates the collected information back to a center where it can be monitored and analyzed. A broad array of general weather and road surface information may be collected. Weather conditions that may be measured include temperature, wind, humidity, precipitation, and visibility. Surface and sub-surface sensors can measure road surface temperature, moisture, icing, salinity, and other measures. Air quality monitoring can include point monitoring of individual vehicles as well as general monitoring of standard air quality measures.

Roadway Freeway Control: Ramp meters, CMS and other freeway control effects which will control traffic on freeways.

Roadway Incident Detection: This Equipment package provides incident detection capability to reside at the roadside. For example, advanced CCTVs with built-in incident detection algorithms would allow the actual detection function to be roadside rather than transmitting images to a center for visual or automated detection.

Roadway Probe Beacons: This Equipment package monitors traffic and road conditions by collecting information from passing vehicles that are equipped with a transponder or other short-range communications device. The probe data collected by this equipment package may include link travel times, average speeds, road conditions, and any other data that can be measured and communicated by passing vehicles. This equipment package consists of roadside equipment that communicates with passing vehicles using dedicated short range communications, collects the information provided by the vehicles, and forwards this information back to the Traffic Management Subsystem.

Roadway Signal Controls: This Equipment package provides the capabilities to control traffic signals at major intersections and on main highways for urban areas. This Equipment package is generally constrained to a single jurisdiction.

Roadway Traffic Information Dissemination: This Equipment package provides the roadside elements of traffic information dissemination including DMS and HAR.

Secure Area Monitoring: This Equipment package provides the capability to monitor the safety of transit users at Remote Traveler Subsystem locations. It collects surveillance images and data and relays this information back to the Transit Management Subsystem.

Standard Rail Crossing: This Equipment Package manages highway traffic at highway-rail intersections (HRIs) where operational requirements do not dictate advanced features (e.g., where rail operational speeds are less than 80 miles per hour). Either passive (e.g., the crossbuck sign) or active warning systems (e.g., flashing lights and gates) are supported depending on the specific requirements for each intersection. These traditional HRI warning systems may also be augmented with other standard traffic management devices. The warning systems are activated on notification by interfaced wayside equipment of an approaching train. The equipment at the HRI may also be interconnected with adjacent signalized intersections so that local control can be adapted to highway-rail intersection activities. Health monitoring of the HRI equipment and interfaces is performed; detected abnormalities are reported through interfaces to the wayside interface equipment and the traffic management subsystem.

TMC Freeway Management: Control system for efficient freeway management including integration of surveillance information with freeway road geometry, vehicle control such as ramp metering, CMS, HAR. Interface to coordinated traffic subsystems for information dissemination to the public.

TMC Incident Detection: This Equipment package provides the capability to traffic managers to detect and verify incident. This capability includes analyzing and reducing the collected data from traffic surveillance equipment, including planned incidents and hazardous conditions.

TMC Incident Dispatch Coordination/Communication: This Equipment package provides the capability for an incident response formulation function minimizing the incident potential, incident impacts, and/or resources required for incident management including proposing and facilitating the dispatch of emergency response and service vehicles as well as coordinating response with all appropriate cooperating agencies.

TMC Multi-Modal Coordination: This Equipment package provides the capability of signal control at the traffic management subsystem to provide signal priority for transit vehicles.

TMC Probe Information Collection: This Equipment package provides the capability to accept and process probe vehicle information. This capability shall be provided through the use of additional hardware and probe vehicle control and tracking software.

TMC Regional Traffic Control: This Equipment package provides capabilities in addition to those provided by the TMC Basic Signal Control Equipment package for analyzing, controlling, and optimizing area-wide traffic flow. These capabilities provide for wide area optimization integrating control of a network signal system with control of freeway, considering current demand as well as expected demand with a goal of providing the capability for real-time traffic adaptive control while balancing inter-jurisdictional control issues to achieve regional solutions. These capabilities are best provided using a Traffic Management Center (TMC) to monitor and manage freeway ramp meters and intersection traffic signals and software to process traffic information and implement traffic management measures (e.g., ramp metering, signalization, and traffic coordination between both local and regional jurisdiction). The TMC shall be able to communicate with other TMCs in order to receive and transmit traffic information on other jurisdictions within the region.

TMC Road Weather Monitoring: This equipment package assimilates current and forecast road conditions and weather information using a combination of weather service information and an array of environmental sensors deployed on and about the roadway. The collected road weather information is monitored and analyzed to detect and forecast environmental hazards such as icy road conditions and dense fog. This information can be used to more effectively deploy road maintenance resources, issue general traveler advisories, and support location specific warnings to drivers.

TMC Signal Control: This Equipment package provides the capability for traffic managers to monitor and manage the traffic flow at signalized intersections. This capability includes analyzing and reducing the collected data from traffic surveillance equipment and developing and implementing control plans for signalized intersections. Control plans may be developed and implemented that coordinate signals at many intersections under the domain of a single traffic management subsystem.

In advanced implementations, this package collects route planning information and integrates and uses this information in predicting future traffic conditions and optimizing the traffic control strategy for these conditions. These capabilities are achieved through real-time communication of logged routes from an Information Service Provider. The planned control strategies can be passed back to the Information Service Provider so that the intended strategies can be reflected in future route planning.

TMC Traffic Information Dissemination: This Equipment package provides the capability to disseminate incident related information to travelers, potential travelers, and private information service providers. These capabilities shall be provided using a workstation type processor within a facility connected to traveler information providers by utilizing existing wireline links.

Toll Data Collection: This equipment package collects and stores toll information that is collected in the course of toll operations performed by the Toll Administration Subsystem. This data can be used directly by operations personnel or it can be made available to other data users and archives in the region.

Traffic and Roadside Data Archival: This equipment package collects and archives traffic, roadway, and environmental information for use in off-line planning, research, and analysis. The equipment

package controls and collects information directly from equipment at the roadside, reflecting the deployment of traffic detectors that are used primarily for traffic monitoring and planning purposes rather than for traffic management.

Traffic Data Collection: This equipment package collects and stores traffic information that is collected in the course of traffic operations performed by the Traffic Management Subsystem. This data can be used directly by operations personnel or it can be made available to other data users and archives in the region.

Traffic Maintenance: This Equipment package provides monitoring and remote diagnostics of field equipment to detect field equipment failures, issues problem reports, and tracks the repair or replacement of the failed equipment.

Transit Center Fare and Load Management: This Equipment package provides the capability to accept collected data required to determine accurate ridership levels and implement variable and flexible fare structures. Support shall be provided for the traveler for use of a fare medium for all applicable surface transportation services, to pay without stopping, have payment media automatically identified as void and/or invalid and eligibility verified, and allow for third party payment. In addition, capability to provide expansion into other uses for payment medium such as retail and telephone and for off-line billing for fares paid by agencies shall be supported. This Equipment package also supports the capability for two-way voice communication between the transit vehicle driver and a facility, two-way data communication between the transit vehicles and a facility, sensor data to be transmitted from the transit vehicles to a facility, and data transmission from individual facilities to a central facility for processing/analysis if desired. These capabilities shall be provided through a workstation type processor with GUI, high capacity storage, ride share software housed in a building with dialup lines and wireline telephone and require integration with an existing Transit Center Tracking and Dispatch Equipment package.

Transit Center Fixed-Route Operations: This Equipment package enhances the planning and scheduling associated with fixed route transit services. The package allows fixed-route services to develop, print and disseminate schedules and automatically updates customer service operator systems with the most current schedule information. Current vehicle schedule adherence and optimum scenarios for schedule adjustment shall also be provided.

Transit Center Information Services: This equipment package collects the latest available information for a transit service and makes it available to transit customers and to Information Service Providers for further distribution. Customers are provided information at transit stops and other public transportation areas before they embark and on-board the transit vehicle once they are enroute. Information provided can include the latest available information on transit routes, schedules, transfer options, fares, real-time schedule adherence, current incidents, weather conditions, and special events. In addition to general service information, tailored information (e.g., itineraries) are provided to individual transit users.

Transit Center Multi-Modal Coordination: This Equipment package provides the transit management subsystem the capability to determine the need for transit priority on routes and at certain intersections and request transit vehicle priority at these locations. It also supports schedule coordination between transit properties and coordinates with other surface and air transportation modes.

Transit Center Paratransit Operations: This Equipment package provides the capability to automate the planning and scheduling, allowing improvements in paratransit routes and services to develop, printing and disseminating schedules, and automatically updating customer service operator systems with the most current schedule. In addition, this Equipment package provides the capability to assign drivers to routes in a fair manner while minimizing labor and overtime services, including driver preferences and qualifications, and automatically tracking and validating the number of work hours performed by each individual driver. These capabilities shall be provided through the utilization of dispatch and fleet management software running on a workstation type processor.

Transit Center Security: This Equipment package provides the capability to monitor key transit locations and transit vehicles with both video and audio systems automatically alerting operators and police of potential incidents and supporting traveler activated alarms. The monitoring equipment shall also include capabilities to assist in responding to terrorist incidents.

Transit Center Tracking and Dispatch: This Equipment package provides the capabilities for monitoring transit vehicle locations and determining vehicle schedule adherence. The Equipment package shall also furnish users with real-time travel related information, continuously updated with real-time information from each transit system within the local area of jurisdiction, inclusive of all transportation modes, from all providers of transportation services, and provide users with the latest available information on transit routes, schedules, transfer options, fares, real-time schedule adherence, current incidents conditions, weather conditions, and special events. This Equipment package also supports the capability for two-way voice communication between the transit vehicle driver and a facility, two-way data communication between the transit vehicles and a facility.

Transit Data Collection: This equipment package collects and stores transit information that is collected in the course of transit operations performed by the Transit Management Subsystem. This data can be used directly by operations personnel or it can be made available to other data users and archives in the region.

Transit Garage Maintenance: This Equipment package provides advanced maintenance functions for the transit property. It collects operational and maintenance data from transit vehicles, manages vehicle service histories, and monitors drivers and vehicles. It collects vehicle mileage data and uses it to automatically generate preventative maintenance schedules for each vehicle by utilizing vehicle tracking data from a prerequisite vehicle tracking equipment package. In addition, it provides information to proper service personnel to support maintenance activities and records and verifies that maintenance work was performed. This equipment package receives special events and real-time incident data from the traffic management subsystem and assigns operators to vehicles and transit routes. Garage maintenance also receives information about incidents involving transit vehicles from the TMC in order to dispatch tow trucks and other repair vehicles.

Transit Garage Operations: This Equipment package automates and supports the assignment of transit vehicles and drivers to enhance the daily operation of a transit service. It provides the capability to assign drivers to routes or service areas in a fair manner while minimizing labor and overtime services, considering driver preferences and qualifications, and automatically tracking and validating the number of work hours performed by each individual driver.

Vehicle Location Determination: This equipment package determines current location information and provides this information to other equipment packages that use the location information to provide various ITS services.

Vehicle Mayday I/F: This Equipment package shall provide the capability for an in-vehicle manually initiated distress signal with cancel a prior issued manual request for help feature. This capability shall include automatically identifying that a collision had occurred using equipment such as collision detection sensors with interface to mayday type equipment that would automatically detect vehicle problems and for some cases, automatically send appropriate distress signals to the Emergency Management Subsystem.

Vehicle Probe Support: This Equipment package includes capabilities for the probe vehicle to identify its location, measure traffic conditions such as link travel time and speed and possibly environmental hazards such as icy road conditions, and transmit these data to either the ISP or TMC.

Vehicle Toll/Parking Interface: This Equipment package shall provide the capability for vehicle operators to pay toll without stopping their vehicles and pay for parking without the use of cash. These capabilities shall be provided through the use of equipment such as an active tag interface and debit/credit card interface.